2012 IUFRO CONFERENCE DIVISION 5 FOREST PRODUCTS

INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

8 › 13 JULY'12 - ESTORIL CONGRESS CENTRE, LISBON, PORTUGAL

FINAL PROGRAM, PROCEEDINGS AND ABSTRACTS BOOK

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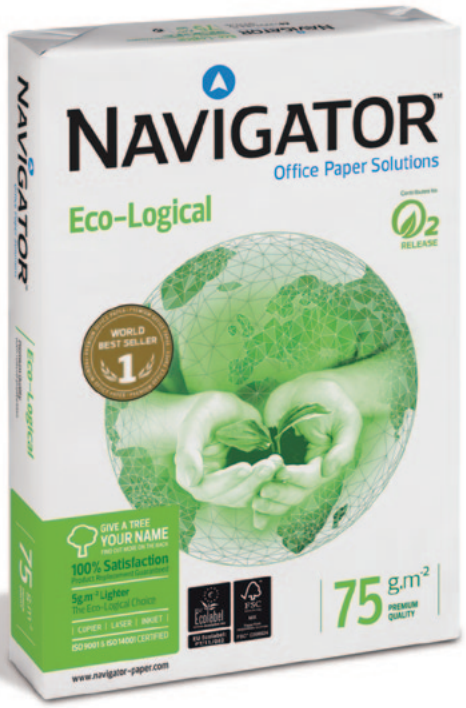

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ORGANIZING ENTITIES

IUFRO

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Instituto Superior de Agronomia
Universidade Técnica de Lisboa

Centro de Estudos Florestais (CEF)

DIVISION 5 - FOREST PRODUCTS

Coordinator
Andrew Wong, Malaysia

Deputies:
Jamie Barbour, United States
Dave Cown, New Zealand
Pekka Saranpää, Finland

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Conference Co-Chair
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Scientific Committee
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Dave Cown (New Zealand)
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Pedro Cardoso, THE (local PCO)

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WELCOME MESSAGE

from IUFRO Division 5 Coordinator and Conference Chairman

Dear friends and colleagues,

The IUFRO Forest Products conference is an important scientific meeting for the IUFRO Division 5 research community and others, being held every 4-5 years for several years now. On behalf of IUFRO Division 5 (Forest Products), we as respectively, Coordinator of IUFRO Division 5 and conference Chairman, are delighted to welcome you to this 2012 All Division 5 conference in Estoril, Portugal. We are honored that the IUFRO conference has the support not only of The Instituto Superior de Agronomia (ISA) and The Forest Research Centre (CEF) within The Technical University of Lisbon, but also from several major national and international sponsors and scientific organisations.

Planning for this conference has been building steadily over the last two years since the local hosts won the bid to host this meeting, and has involved a considerable amount of coordination and hard work from the International Organizing Committee and the professional conference organizer appointed by the Local Organizing Committee. The week's conference proceedings would not have been possible without the passionate efforts of all concerned. Also, we do recognize all D5 Unit Coordinators and deputies. Without your expertise and the time you have spent to organize the sessions this conference would not have been possible. Thanks to you the IUFRO Division 5 is rather unique by having a regular Forest Products Conference. Besides being a gathering of many of the world's forest products scientists (not necessarily IUFRO members alone) under one roof to foster networking and useful contacts among your peers, the conference gives opportunities to present new findings/technologies overall that would be beneficial to society. It is a platform to contribute directly to the overall structure and goals of D5 and to help influence IUFRO policy through participation at its research unit business meetings.

This is designated as a "Green Conference" and you may have noted that the 5 conference themes take into account also the relevant thematic areas of the 2010-2014 IUFRO Strategy. The conference will address these issues affecting forest products in its various technical sessions and by keynote speakers: Forests for People; Resources for the Future; Bioenergy; Forest and Climate Change and Wood in Construction. This is a unique opportunity for you to consider linking your on-going research and presentations to both the conference themes and also contribute to the current 8 thematic areas of the 2010-2014 IUFRO Strategy. Scientific progress in forest products research is advancing with new tools and technology for research, novel areas of research encompassing areas of nanoscience, molecular biology, biotechnology and genetics, bioenergy, environmental aspects – the buzz words that are fast becoming the mainstay of forest products research in the 21st century. Nevertheless, traditional wood technology research continues to be relevant and impact upon the future well-being of the global environment.

IUFRO – The International Union of Forest Research Organizations – is a non-profit, non-governmental international network of forest research scientists, and is a major organization with wide networks of internationally recognized researchers sharing common grounds – to foster global cooperation in forest-related research and promote understanding of technical, economic and social aspects of its research and utilization of forests and their multiple wood and non-wood resources. IUFRO members are thus encouraged, through their research activities, to continually help make IUFRO more visible globally in forest science and promote science-based knowledge to a wider audience in line with the goals of the current IUFRO Strategy. We would similarly encourage non-member delegates to consider joining IUFRO and contribute to the goals of D5 and IUFRO overall.

As you will take this opportunity during the conference week to interact and develop international cooperation, and also to be part of the IUFRO network, we wish all delegates a most fruitful and eventful conference.

Andrew Wong
Coordinator, IUFRO D5
University Malaysia Sarawak
Kota Samarahan, Sarawak, Malaysia

Pekka Saranpää
Conference Chair
Deputy Coordinator, IUFRO D5
Finnish Forest Research Institute, Vantaa, Finland

DIVISION 5
FOREST PRODUCTS
PRODUITS FORESTIERS - PRODUCTOS FORESTALES - HOLZ UND ANDERE FORSTPRODUKTE

Coordinator: Andrew Wong, Malaysia
Deputies: Jamie Barbour, United States; Dave Cown, New Zealand; Pekka Saranpää, Finland

5.01.00 Wood quality
Qualité du bois
Calidad de la madera
Holzqualität
C Pekka Saranpää, Finland
D Pauline Fernández, Chile
D Jianxiong Lu, China
D Elspeth MacDonald, United Kingdom
D Katsuhiko Takata, Japan

5.01.04 Wood quality modelling
Modélisation de la qualité du bois
Modelación de la calidad de madera
Modellierung der Holzqualität
C Jean-Michel Leban, France
D Joseph Gril, France
D Heli Peltola, Finland
D Christine Todoroki, New Zealand

5.01.07 Tree ring analysis
Analyse des cernes
Análisis de anillos de crecimiento
Jahrringanalyse
C Margaret Devall, United States
D Paolo Cherubini, Switzerland

5.01.08 Understanding wood variability
Comprendre la variabilité du bois
Entender la variabilidad de la madera
Holzvariabilität verstehen
C Barbara Lachenbruch, United States
D Paul McLean, United Kingdom
D John Moore, New Zealand

5.02.00 Physiomechanical properties of wood and wood based materials
Propriétés physiomécaniques et utilisations du bois et des matériaux dérivés du bois
Propiedades fisiomecánicas y aplicaciones de la madera y de materiales compuestos en base a madera
Physiomechanische Eigenschaften und Anwendungen von Holz und Holzwerkstoffen
C Xiping Wang, United States
D John Moore, New Zealand
D Lihai Wang, China

5.02.01 Non-destructive evaluation on wood and wood-based materials
Evaluation non déstructive du bois et des matériaux dérivés du bois
Evaluación no destructiva de madera y materiales compuestos en base a madera
Nicht zerstörende Evaluierung von Holz und Holzwerkstoffen
C Xiping Wang, United States
D Roger Meder, Australia
D Houjiang Zhang, China

5.02.02 Fundamental properties of wood and wood-based materials
Propriétés fondamentales du bois et des matériaux dérivés du bois
Propiedades fundamentales de madera y materiales compuestos en base a madera
Grundlegende Eigenschaften von Holz und Holzwerkstoffen
C Hongmei Gu, United States
D Raquel Goncalves, Brazil

5.03.00 Wood protection
Protection du bois
Protección de la madera
Holzschutz
C Donatien Pascal Kamdem, United States
D Gyu-Hyeok Kim, Korea (Rep)
D Adya P. Singh, New Zealand
D Andrew Wong, Malaysia

5.03.05 Biological resistance of wood
Résistance biologique du bois
Resistencia biológica de la madera
Biologische Beständigkeit von Holz
C Nasko Terziev, Sweden
D Jinzhen Cao, China
D Sung-Mo Kang, Korea (Rep)

5.03.06 Wood protection for quarantine, food packing and trade in wood
Protection du bois dans la quarantaine, l'emballage et le commerce du bois
Protección de la madera para cuarentena, embalaje de alimentos y comercio de maderas
Holzschutz zur Erfüllung von Quarantäne-, Lebensmittelverpackungs- und Holzhandelsvorschriften
C Magdalena Kutnik, France
D Hugh Bigsby, New Zealand
D Donatien Pascal Kamdem, United States

5.03.07 Wood protection under tropical environments
Protection du bois sous les tropiques
Protección de la madera bajo condiciones tropicales
Holzschutz in den Tropen
C Marie-France Thevénon, France
D Osvaldo Encinas, Venezuela
D Andrew Wong, Malaysia

5.03.10 Protection of cultural artefacts
Protection des artefacts culturels
Protección de objetos culturales
Schutz von Kulturgegenständen
C Wibke Unger, Germany
D Geoffrey F. Daniel, Sweden
D Donatien Pascal Kamdem, United States
D Marie-France Thevénon, France

5.03.11 Protection by surfacing and finishing
Protection du bois par le revêtement et la finition
Proteger la madera con recubrimientos y acabados
Holzschutz durch Beschichtung und Finish
C Philippe Gerardin, France
D Andre Merlin, France
D Martino Negri, Italy

5.04.00 Wood processing
Transformation du bois
Transformación de la madera
Holzbearbeitung
C Marius Barbu, Romania
D Mihaela Campean, Romania
D Jegatheswaran Ratnasingam, Malaysia

5.04.06 Wood drying
Séchage des bois
Secado de la madera
Holztrocknung
C Diego Elustondo, Canada
D Agron Bajraktari, Republic of Kosovo
D Süleyman Korkut, Turkey
D Gan Kee Seng, Malaysia

5.04.07 Adhesives and gluing
Collage des bois
Adhesivos y encolado
Holzverleimung
C Hui Pan, United States
D Warren Grigsby, New Zealand
D Shujun Li, China
D Tohmura Shin-ichiro, Japan

5.04.08 Sawing, milling and machining
Sciage et usinage
Aserrado y maquinado
Sägen und Holzbearbeitung
C Roger Hernandez, Canada
D Pierre-Jean Meausoone, France
D Takeshi Ohuchi, Japan

5.04.13 Industrial engineering, operations analysis and logistics
Ingénierie industrielle, analyse des opérations, et logistique
Ingeniería industrial, análisis de operaciones y logística
Industrielle Verarbeitung, Verfahrenstechnik und Logistik
C Henry Quesada-Pineda, United States
D Omar Espinoza, United States
D Roger Moya Roque, Costa Rica

5.05.00 Composite and reconstituted products
Composites et produits reconstitués
Materiales compuestos y productos reconstituidos
Verbundwerkstoffe und Leimholzprodukte
C S. Salim Hiziroglu, United States
D Marius Barbu, Romania
D Zhiyong Cai, United States
D Tatsuya Shibusawa, Japan

5.06.00 Properties and utilization of plantation wood
Propriétés et utilisation du bois provenant des plantations
Propiedades y utilización de madera proveniente de plantaciones
Eigenschaften und Verwendung von Plantagenholz
C Roger Meder, Australia
D Yafang Yin, China

5.06.01 Utilization of dry area timber
Utilisation du bois provenant des terres sèches
Utilización de madera proveniente de zonas áridas
Verwendung von Holz aus Trockengebieten
C Nick Pasiecznik, France
D George Muthike, Kenya

5.06.02 Utilization of planted teak
Utilisation du teck provenant des plantations
Utilización de madera de teca proveniente de plantaciones
Verwendung von Teakholz aus Plantagen
C P.K. Thulasidas, India
D vacant

5.06.03 Utilization of planted eucalypts
Utilisation de l'eucalyptus provenant des plantations
Utilización de madera de eucaliptus proveniente de plantaciones
Verwendung von Eukalyptusholz aus Plantagen
C Jose Nivaldo Garcia, Brazil
D Roger Meder, Australia
D Yongdong Zhou, China

5.07.00 Energy and chemicals from forest biomass
Energie et produits chimiques de la biomasse forestière
Energía y productos químicos de la biomasa forestal
Energie und chemische Produkte aus forstlicher Biomasse
C vacant
D Hyeun-Jong Bae, Korea (Rep)
D Fuxiang Chu, China
D Alan Rudie, United States

5.10.00 Forest products marketing and business management
Commercialisation des produits forestiers et développement de l'entreprise
Comercialización de productos forestales y gestión de empresas
Vermarktung von Forstprodukten und Betriebsführung
C Eric Hansen, United States
D Paul Dargusch, Australia
D Rob Kozak, Canada
D Toshiaki Owari, Japan
D Anne Toppinen, Finland
D Richard Vlosky, United States

5.10.01 Wood culture
Culture du bois
Cultura de la madera
Holzkultur
C Howard N. Rosen, United States
D Victoria Asensi Amoros, France
D Monlin Kuo, United States
D Yang Ping, Japan
D Jinling Su, China
D Mario Tomazello Filho, Brazil

5.11.00 Non-wood forest products
Produits forestiers non-ligneux
Productos forestales no leñosos
Nichtholz-Forstprodukte
C A.L. "Tom" Hammett, United States
D James Chamberlain, United States
D Madhav Karki, Nepal
D Pawel Staniszewski, Poland
D Paul Vantomme, Italy

5.11.02 Medicinal forest products
Produits forestiers médicinaux
Productos forestales medicinales
Waldprodukte in der Medizin
C Carsten Smith Olsen, Denmark
D Giridhar A. Kinhal, Nepal

5.11.03 Edible forest products
Produits forestiers comestibles
Productos forestales comestibles
Nahrungsmittel aus dem Wald
C Susan J. Alexander, United States
D Sarah W. Workman, United States

5.11.05 Bamboo and rattan
Bambou et rotin
Bambú y ratán
Bambus und Rattan
C Jinhe Fu, China
D Johan Gielis, Belgium
D Lay Thong Hong, Malaysia

5.12.00 Sustainable utilization of forest products
Utilisation durable des produits forestiers
Utilización sostenible de productos forestales
Nachhaltige Verwendung von Walderzeugnissen
C Robert Deal, United States
D Ying Hei Chui, Canada
D Choi Don Ha, Korea (Rep)

5.14.00 Forest products education
Formation en matière de produits forestiers
Educación en productos forestales
Ausbildung im Bereich der Walderzeugnisse
C Rupert Wimmer, Germany
D Aldo Ballerini, Chile
D Jamie Barbour, United States
D Sudipta Dasmohapatra, United States

BEST POSTER AWARDS

The Scientific Committee wishes to encourage scientists to display outstanding posters during the IUFRO Division 5 conference.

An Awarding Body will evaluate all the posters exhibited during the poster sessions, based upon the following selection criteria:

1. Presentation: layout (attractiveness, legibility, creativity)
2. Content: innovative ideas and value of subject matter
3. Presenter's ability to convey the message

The awards will be presented at the Conference dinner, on July 11 and consist of a certificate and a gift sponsored by 3DCork – www.3dcork.com

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REGISTRATION DESK

DAY	TIME
Sunday, July 8	14h-18h00
Monday, July 9	08h-18h00
Tuesday, July 10	08h-18h00
Wednesday, July 11	08h-13h00
Thursday, July 12	08h-18h00
Friday, July 13	08h-16h00

TECHNICAL VISITS JULY 11

Departure time: 12h15

Technical Visit 1 - Corticeira Amorim

Technical visit 2 - Espirra Estate (Portucel Soporcel Group)

Technical visit 3 - Industrial Plant "About the future" (Portucel Soporcel Group)

Technical visit 4 - Companhia das Lezírias

Technical visit 5 - Pinhal de Leiria

SOCIAL EVENTS

WELCOME RECEPTION, JULY 9

Venue: Estoril Conference Centre
Time: 17h30
Description: Wine and cheese cocktail and poster viewing will take place at ground floor of Estoril Conference Centre

ACCOMPANYING PERSONS' TOUR, JULY 10

Meeting point: Registration desk at conference centre
Time: 09h30
Description: Tour of Lisbon

This program will combine a walking tour in the city centre that will allow guests to discover hidden corners of the cities old quarters.

Shopping in the city centre is a pleasure: there are different spaces tailored to a wide array of tastes, so we will allow some free time for shopping.

Lunch will take place at Terreiro do Paço square.

After lunch the tour will continue to Belém area closely associated with the age of the discoveries. Discoveries led to empire, wealthy, exploitation and colonization, all now in the past. Today Belém's exquisite buildings and museums displays celebrate navigational skills in general as much as the feats of Portugal's courageous mariners. Panoramic tour to Jerónimos Monastery, Belém Tower and Monument of Discoveries.

The tour finishes with a tasting of Pastéis de Belém, one of Portuguese most famous patries.

CONFERENCE DINNER, JULY 12

Venue: Casino do Estoril
Time: 19h30
Description: Casino do Estoril is the oldest casino in Portugal and the biggest in Europe. Apart from the main activities, there is also an art gallery specialized in modern painting and sculpture.

Upon arrival guests will have a welcome drink in the beautiful gardens followed by 3 course dinner in the main room.

Please note that NO TRANSPORTATION will be provided by the Organization.

PROGRAM AT A GLANCE

Time	SUNDAY 8	MONDAY 9	TUESDAY 10	WEDNESDAY 11	THURSDAY 12	FRIDAY 13
0800-0830		Registration, welcome coffee	Registration			
0830-0900			Jack Saddler Keynote 2	Klaus Richter Keynote 3	Madhav Karki Keynote 4	Rich Vlosky Keynote 5
0900-0930						
0930-1000		**OPENING CEREMONY**	BREAK			
1000-1030			5 Technical session rooms	IAWS Academy lecture	7 Technical session rooms	7 Technical session rooms
1030-1100						
1100-1130		Eduardo Rojas-Briales Keynote 1		Sub plenary Biorefinery		
1130-1200						
1200-1300		LUNCH				
1300-1330		7 Technical session rooms	6 Technical session rooms	In-congress tour / technical visits	6 Technical session rooms	6 Technical session rooms
1330-1400						
1400-1430	Registration and Poster Fixing					
1430-1500						
1500-1530		BREAK			BREAK	
1530-1600		6 Technical session rooms	5 Technical session rooms		RG Business meeting	Technical Group Reporting
1600-1630						
1630-1700					Poster Session 2	
1700-1730						
1730-1800		**Wine and Cheese Cocktail** Poster Session 1	RG Business meeting			Resolutions / Closing
1800-1830						
1830-1900						
1900-1930						
1930-2000		**IAWA SOCIAL HOUR**	**IAWS DINNER**		**CONFERENCE DINNER**	
2000-2030						

PROGRAM DAY BY DAY

JULY 9

TIME	SESSION NAME			ROOM	RG
08h00-09h30	Registration & welcome coffee				
09h30-11h00	**OPENING CEREMONY**			Auditorium	
TIME	**SESSION NAME**	**MODERATOR**	**ABSTRACT REF.**	**ROOM**	**RG**
11h00-12h00	Eduardo Rojas-Briales - Global and European Challenges of Forests Moving towards Green Economies	Pekka Saranpaa	KN01	Auditorium	Plenary 1
LUNCH					
13h00-15h00	Wood Quality	Pekka Saranpaa	OP001, OP002, OP003, OP004, OP005, OP006	Auditorium	5.01.00
	Properties and utilisation of plantation wood – Wood Quality and Utilisation	José Nivaldo Garcia	OP007, OP008, OP009, OP010, OP011, OP012	E	5.06.00
	CT and X-ray Applications to Wood Processing	Franka Bruechert	OP013, OP014, OP015, OP016, OP017, OP018, OP019	F1-F3	5.02.00
	Natural durability	Nasko Terziev & MF Thevenon	OP020, OP021, OP022, OP023, OP024	F7	5.03.00 / IRGWP
	Wood processing – Adhesives & Surface	Marius Barbu	OP025, OP026, OP027, OP028, OP029, OP030	C1-C3	5.04.00
	Non-wood Forest Products	Tom Hammett	OP031, OP032, OP033, OP034, OP035, OP036	F4-F6	5.11.00
	Cork	Miguel Cabral	OP037, OP038, OP039, OP040, OP041	CA-C6	Cork 1
COFFEE BREAK					
15h30-17h30	Composite and Reconstituted Products	Salim Hiziroglu & Marius Barbu	OP042, OP043, OP044, OP045, OP046	Auditorium	5.05.00
	Physiological and adaptive changes in wood	Barry Gardiner	OP047, OP048, OP049, OP050, OP051	E	5.01IAWA
	Energy and Chemicals from Forest Biomass	Hyeun-Jong Bae & Jamie Barbour	OP052, OP053, OP054, OP055, OP056	F1-F3	5.07.00
	CT and X-ray Applications to Wood Processing	Udo Sauter	OP057, OP058, OP059, OP060, OP061, OP062, OP063	F4-F6	5.02.00
	Pulp & Paper-Biorefinery and Wood Chemistry	Dominique Lachenal	OP064, OP065, OP066, OP067, OP068	F7	5.15.00
	Wood processing – Drying	Marius Barbu	OP069, OP070, OP071, OP072, OP073, OP074	C4-C6	5.04.00
17h30-19h30	**WINE AND CHEESE COCKTAIL** / Poster Session 1				
19h30-20h30	**IAWA SOCIAL HOUR**				

JULY 10

TIME	SESSION NAME	MODERATOR	ABSTRACT REF.	ROOM	RG/WP
08h30-09h30	Jack Saddler – The Biorefining Story: Progress in the commercialization of biomass-to-fuels and chemicals (The influence of the biomass fedstock on the process and products)	Jamie Barbour	KN02	Auditorium	Plenary 2
COFFEE BREAK					
10h00-12h00	Environmental and developmental controls on wood quality	Barb Lachenbruch	OP075, OP077, OP078	Auditorium	5.01.08
	Wood processing – Sustainability	Marius Barbu & Henry Quesada Pineda	OP079, OP080, OP081, OP082, OP083, OP084	E	5.04.00
	Sustainable utilization of forest products	Bob Deal & Jamie Barbour	OP085, OP086, OP087, OP088, OP089, OP090	F1-F3	5.12.00
	Non-destructive Evaluation Techniques	Xiping Wang	OP091, OP092, OP093, OP094, OP095, OP096	F4-F6	5.02.00
	Forest Products Marketing and Business Management	Rich Vlosky	OP307, OP097, OP098, OP099, OP100, OP101	F7	5.10.00
LUNCH					
13h00-15h00	Emerging wood preservatives	Philippe Gerardin & Joran Jermer	OP102, OP103, OP104, OP105, OP106	Auditorium	5.03.00/ IRGWP
	Genetic options for altering wood quality	Hisahi Abe	OP107, OP108, OP109, OP110, OP111	E	5.01.08
	Composite and Reconstituted Products	Salim Hiziroglu & Marius Barbu	OP112, OP113, OP114, OP115, OP116	F1-F3	5.05.00
	Properties and utilisation of plantation wood – New Materials from Plantation Wood	Yin Yafang	OP117, OP118, OP119, OP120, OP121, OP122	F4-F6	5.06.00
	Non-destructive Evaluation Techniques	Roger Meder	OP124, OP125, OP126, OP127, OP128, OP129	F7	5.02.00
	Turning by products in Biomaterials	Marie-Pierre Laborie	OP130, OP131, OP132, OP133, OP134, OP135	C1-C3	5.07.00
COFFEE BREAK					
15h30-17h30	Forest Products Marketing and Business Management	Eric Hansen	OP136, OP137, OP138, OP139, OP140, OP141	Auditorium	5.10.00
	Non-wood Forest Products	Tom Hammett & Madhav Karki	OP142, OP143, OP144, OP145	E	5.11.00
	Within-tree variability in wood quality and anatomy	Sabine Rosner	OP146, OP147, OP148, OP149, OP150	F1-F3	5.01.IAWA
	Integrating forest products with ecological services	Jamie Barbour	OP151, OP152, OP153, OP154, OP155, OP156	F4-F6	5.12.00
	Pulp & Paper-Nanocrystalline Cellulose	Raymond C. Francis	OP157, OP158, OP159	F7	5.15.00
17h30-18h30	RG Business Meeting - Wood Quality			E	5.01.00
	RG Business Meeting - Physiomechanical properties of wood and wood-based materials			F1-F3	5.02.00
	RG Business Meeting - Wood Protection			F4-F6	5.03.00
	RG Business Meeting - Wood Processing			F7	5.04.00
	RG Business Meeting - Composite and Reconstituted Products			C1-C3	5.05.00
	RG Business Meeting - Properties and utilisation of plantation wood			C4-C6	5.06.00
19h30 - 22h00	**IAWS DINNER**				

JULY 11

TIME	SESSION NAME	MODERATOR	ABSTRACT REF.	ROOM	RG
8h30-9h30	Klaus Richter - Wood in Construction – Including Multi-Storey Building	Dave Cown	KN03	Auditorium	Plenary 3
10h00-11h00	Lennart Salmén - The wood fibre structure – how to be utilized?	Rupert Wimmer	SP01	Auditorium	5.01/IAWS Academy Lecture
COFFEE BREAK					
11h00-12h00	Jorge Colodette – The Brazilian Forestry Industry Focusing on Eucalypt	Tarja Tamminen	SP02	Auditorium	Subplenary 1
	Helena Pereira – The importance of biomass structure and chemical composition for biorefineries	Tarja Tamminen	SP03	Auditorium	Suplenary 2
12h15-19h00	**TECHNICAL VISITS**				

JULY 12

TIME	SESSION NAME	MODERATOR	ABSTRACT REF.	ROOM	RG
08h30-09h30	Madhav B. Karki – Enhancing the contribution of non-timber forest products in supporting green economy and sustainable development in mountain countries	Andrew Wong	KN05	Auditorium	Plenary 4
COFFEE BREAK – **Sponsored by Forest Stewardship Council (FSC) www.fsc.org**					
10h00-12h00	Flexwood	Luc LeBel	OP160, OP161, OP162, OP163, OP164, OP165	Auditorium	5.01.01
	Wood quality modeling	Geoff Downes	OP166, OP167, OP168, OP169, OP170	E	5.01.04
	Properties and utilisation of plantation wood – Teak	Henri Bailleres	OP171, OP172, OP173, OP174, OP175	F1-F3	5.06.00
	Recent development in wood protection	Cao Jinzhen & DP Kamdem	OP176, OP177, OP178, OP179, OP180, OP181	F4-F6	5.03.00 / IRGWP
	Energy from the forest, IUFRO's Biomass Task Force	Jamie Barbour & Hyeun-Jong Bae	OP182, OP183, OP184, OP185, OP186, OP187	F7	5.07.00
	Emerging wood preservatives (2)	Magdelena Kutnik & Andew Wong	OP188, OP189, OP190, OP191, OP192, OP193	C1-C3	5.03.00 / IRGWP
	Sawing, milling and machining – Tools	Jega Ratnasingam & Roger Hernandez Pena	OP194, OP195, OP196, OP197, OP198, OP199	C4-C6	5.04.08
LUNCH					
13h00-15h00	Composite and Reconstituted Products	Salim Hiziroglu & Marius Barbu	OP200, OP201, OP202	Auditorium	5.05.00
	Properties and utilisation of plantation wood – Lesser known species (particularly those from Africa)	P.K.Thulasidas	OP204, OP205, OP207, OP209, OP211	E	5.06.00
	Wood variation: utilization and identification	Paul McLean	OP212, OP213, OP214, OP215	F1-F3	5.01.08
	Fractionation of raw wood material for biobased products	Tarja Tamminen	OP216, OP217, OP218, OP219, OP220	F4-F6	5.07.00
	Protection of wood packaging	D Pascal Kamdem & Nasko Terziev	OP221, OP222, OP223, OP224, OP225, OP226	C1-C3	5.03.00 / IRGWP
	Wood Culture 1	Mario Tomazello	OP227, OP228, OP229, OP230, OP231, OP232, OP233	C4-C6	5.10.01
COFFEE BREAK – **Sponsored by Forest Stewardship Council (FSC) www.fsc.org**					
15h30-16h30	RG Business Meeting - Energy and Chemicals from Forest Biomass			E	5.07.00
	RG Business Meeting - Forest Products Marketing and Business Management			F1-F3	5.10.00
	RG Business Meeting - Non-wood Forest Products			F4-F6	5.11.00
	RG Business Meeting - Sustainable utilization of forest products			F7	5.12.00
	RG Business Meeting - Forest Products Education			C1-C3	5.14.00
	RG Business Meeting - Pulp & Paper			C4-C6	5.15.00
16h30-18h00	Poster Session 2				
19h30-22h30	**CONFERENCE DINNER**				

JULY 13

TIME	TITLE	MODERATOR	ABSTRACT REF.	ROOM	RG/WP
8h30-9h30	Rich Vlosky – Creating Competitive Advantage in a Global Recession	Helena Pereira	KN06	Auditorium	Plenary 5
COFFEE BREAK					
10h00-12h00	Wood quality	Pekka Saranpää	OP234, OP235, OP236, OP237	Auditorium	5.01.00
	Biodiversity and wood products paths to compatibility	Bob Deal & Jamie Barbour	OP238, OP239, OP240, OP241, OP242, OP243	E	5.12.00
	Tree ring analysis	Margaret Devall	OP244, OP245, OP246, OP247, OP248, OP249	F1-F3	5.01.07 / IAWA
	Field Performance of treated wood	MF Thevenon & Aree Abdluquader	OP250, OP251, OP252, OP253, OP254, OP255	F4-F6	5.03.00 / IRGWP
	Pulp & Paper-Pulp Bleaching	Ken Kaw	OP256, OP257, OP258, OP259	F7	5.15.00
	Properties and utilisation of plantation wood – Biomass Characterisation	José Nivaldo Garcia	OP260, OP261, OP262, OP263, OP264	C1-C3	5.06.00
	Wood Culture 2	Howard Rosen	OP266, OP267, OP268, OP269, OP270, OP271	C4-C6	5.10.01
LUNCH					
13h00-15h00	Protection of Cultural Artifacts	Wibke Unger	OP272, OP273, OP274, OP275, OP276, OP277	Auditorium	5.10.01 / 5.03.00 / IRGWP Special Session
	Wood quality from complex stand structures	Elspeth McDonald	OP278, OP279, OP280, OP281, OP282, OP283	E	5.01.00 Special Session
	Forest Products Education	Rupert Wimmer	OP284, OP285, OP287, OP288, OP289, OP290	F1-F3	5.14.00
	Pulp & Paper – Pulping	Eugene I-Chen Wang	OP291, OP292, OP293, OP294, OP295, OP296	F4-F6	5.15.00
	Processing of plantation wood and innovative technologies	Jega Ratnasingam & Marius Barbu	OP297, OP298, OP299, OP300, OP301, OP302	F7	5.04.08
	Cork	Helena Pereira	OP303, OP304, OP305, OP306	C1-C3	Cork 2
COFFEE BREAK					
15h30-17h30	**TECHNICAL GROUP REPORTING**			E	
17h30-18h00	**RESOLUTIONS / CLOSING**			Auditorium	

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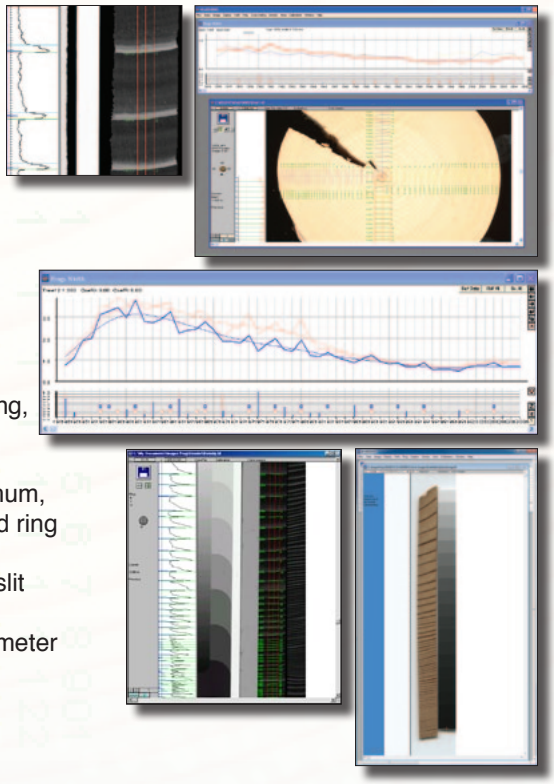

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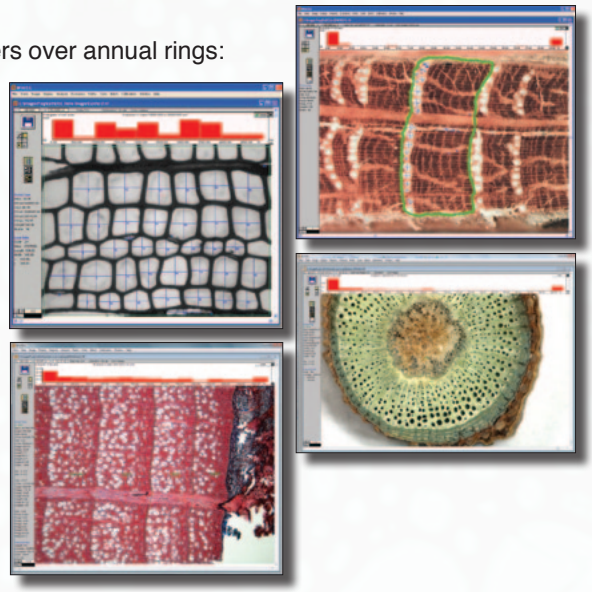

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PROCEEDINGS

KN01

Global and European Challenges of Forests Moving towards Green Economies

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ABSTRACT

This paper describes key driving forces for and opportunities and consequences of using forests and forest products to move toward a green economy. The concept of sustainability is identified as a crucial element in unlocking the full potential of forests – as a provider of global renewable raw material and energy, as well as a natural resource for the enjoyment of future generations and for maintaining vital ecosystems acting as green infrastructure. Risks associated with achieving a forest-based green economy are identified, and mitigating factors of these risks are proposed. Improving communication is seen as essential to changing perceptions of the central role of forests and the forestry sector in transitioning to a green economy.

Keywords: forests, forestry, green economy, renewable raw materials, sustainable development, low carbon economies, bio-based economies, green employment.

1. INTRODUCTION

Green economy (UNEP 2011), green growth, low carbon economies and bio-based economies are related emerging concepts with a focus on new pathways leading to long-lasting economic development in an environmentally and socially acceptable way. This approach is essential to reduce the effects of climate change, as it requires less material input, especially non-renewable raw materials, decouples economic growth from energy consumption, and lowers emissions of carbon and other greenhouse gases.

The present global economic crisis might be seen as a challenge in moving towards a green economy, but it could also offer huge opportunities, in part because the cost of non-renewable energy materials such as oil has not dropped, as in previous crises, and because new sources of employment could be identified to reduce unemployment.

The forestry sector's activities are often seen as old-fashioned and less attractive by the younger generation, which weakens its competitiveness in labour markets. The effect of this perception draws the younger generations to urban centers, as rural areas are seen as less desirable for living. Green economies that encourage the use and processing of forest products may be at a strategic advantage to turn around this perception and unlock the full economic and social potential of forest-dominated rural areas. It should be recalled that heavily forested areas are generally the most disadvantaged ones because of harsh climate, poor soils or difficult orography (i.e., mountains).

2. DRIVING FORCES OF GREEN ECONOMY

The key driving force of a green economy is the interrelated energy and climate change challenge. Halting and eventually reversing climate change provoked by CO2 and other greenhouse gas emissions by identifying alternative sources of energy while significantly improving energy efficiency is the single feasible response.

The need for a green economy is also supported by the near exhaustion of fossil fuels such as oil and the technical risks of energy from other sources (e.g., nuclear). The problem of fuel is magnified by a burgeoning population – from 7 billion people at present to a projected 9 billion in 2050 – and by the growth of the middle classes in emerging economies. Both factors drive up the demand and consumption of energy and raw materials.

Population growth and a rise in standards of living increase demand for food and heighten competition for land. At the same time, climate change and unsustainable land-use practices have degraded a considerable area to the point at which it is no longer suitable for agriculture and requires sustained investment to recover them as functional forests.

But it is not only the fossil-carbon-based economy that is coming to an end; the approach of addressing challenges in an artificially isolated way is becoming outdated. In the 20 years since the UN Conference on Environment and Development (UNCED) in Rio in 1992, where the concept of sustainability was branded by the environmental community, the three pillars of sustainability (environmental, social and economic) have been generally seen in an isolated way. Society has come to realize, however, that the challenges faced by humankind in terms of climate change, sustainable energy supply, food security, poverty, urbanization, deforestation and land degradation, conserving biodiversity, and improving water quality can only be addressed if the three pillars of sustainability are approached in an integrated, holistic way.

3. FORESTRY AND GREEN ECONOMY

Forests are not a major focus of the Rio+20 Conference. This might be somewhat disappointing, considering that forests played a central, albeit contentious, role in the 1992 UNCED Summit, where discussions were centred on the formation of a global forest convention in parallel with the establishment of other Rio conventions (i.e., climate change, biodiversity and desertification)(Pons Ràfols 2004).

But this should not provoke precipitated conclusions about forests' role in the future of sustainability. The main substantive issues discussed in Rio are strongly related to forests: jobs, energy, cities, food , water and disasters including implicitly related issues like land degradation, climate change, poverty alleviation, water; biodiversity, green economy or renewable raw materials. Forests alone will not solve any of those challenges,

but without them, none of these challenges will be solved. Figure 1 shows how the substantive issues identified in the Zero draft of the Rio+20 Declaration are mapped around FAO's three global goals (food security, poverty alleviation, and sustainable management of natural resources) , 90 percent of which correspond to either FAO's core competences or shared or border competences, many of them related to forests

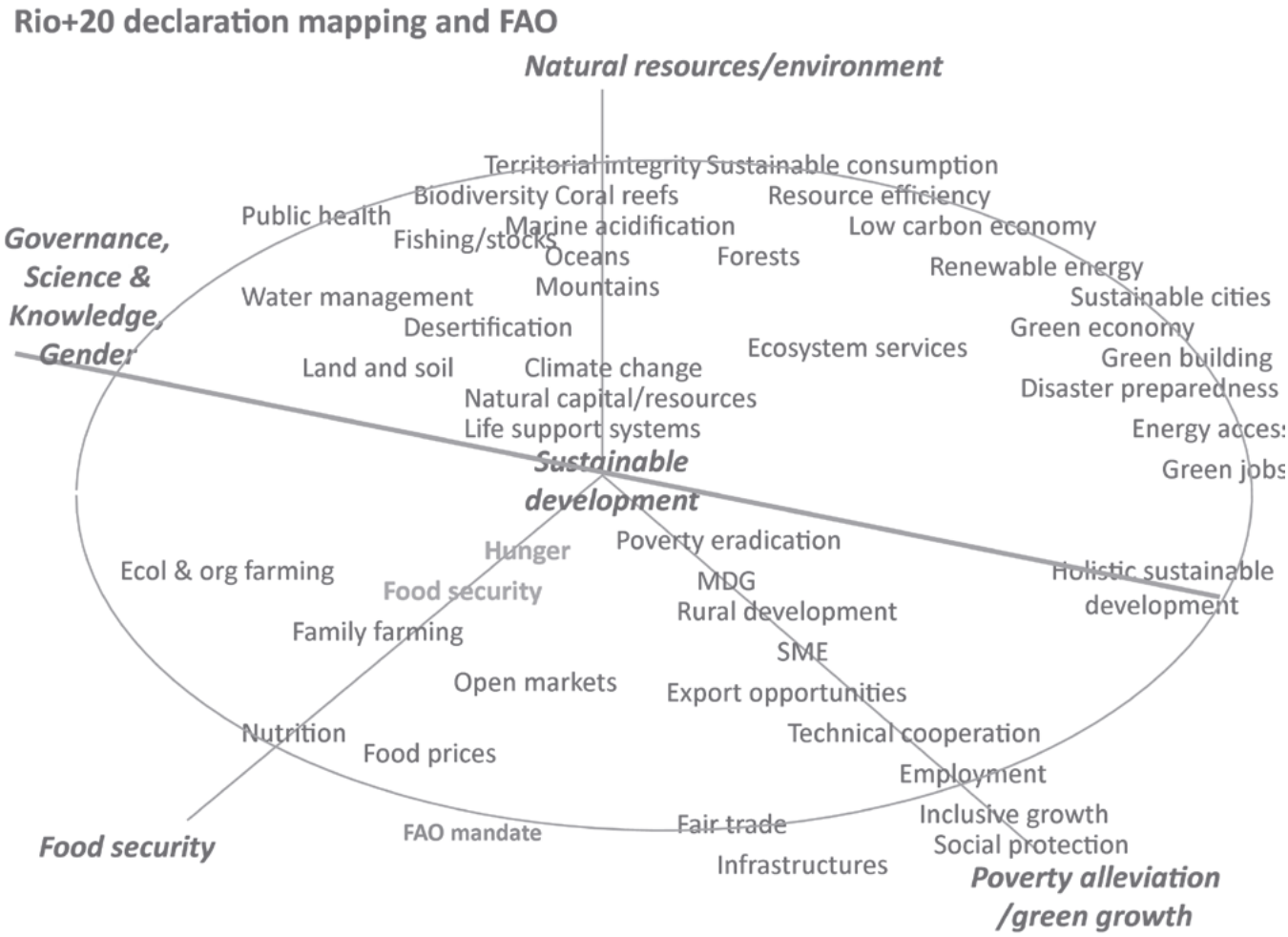

Figure 1: Rio+20 declaration mapping and FAO. From UNDESA 2012.

Forests located upstream filter and retain water and hold between 50 and 90 percent of all terrestrial biodiversity. Moreover, forests provide the most relevant renewable energy today – fuel wood –with 57 percent of total energy supply in Africa in 2009 coming from such a resource (IEA 2011). Forests store approximately the same amount of carbon as that which is contained in the atmosphere and are a crucial resource for maintaining the world's atmospheric balance . While other resources such as oceans may sequester a large amount of carbon in the long term (figure 2), forests are easier and cheaper to manage as a way to mitigate climate change and have the additional value of helping to reduce energy consumption from non-renewable energy sources.

Preindustrial CO2	**2029 GtCO2**
Increase of the CO2 concentration to present	**+767 GtCO2**
Emissions -2050 -60% (70%)	**+728 GtCO2**
Emissions 2050-2150 -80% (20%)	**+443 GtCO2**
Net-Afforestation 2010-2060 500 M ha grown up to 2150 (10 M ha/a)	**-297 GtCO2**
Increased stocks existing forests up to 2150 (+20%)	**-478 GtCO2**
Balance	**3193 GtCO2 (+14% 2010)**
Marine sequestration (8,3 GtCO2) GtCO2/a) 2010-2150	**- 1163 GtCO2**
Balance	**2030 GtCO2**

Figure 2: Carbon balance long term scenarios including optimal forest cover restoration and reduction of carbon emissions

Wood is the first global renewable commodity available for industrial processing. Around 3.2 billion m3of wood are annually obtained from

the world's forests (FAO 2010). Its huge potential for substitution for non-renewable raw materials has by far not been realized.

Deforestation has dropped steeply during the past few decades, in part because of urbanization, which has reduced the pressure on land in many rural areas, the culmination of population growth in many countries and policies for preserving and restoring forests in key countries, especially in Asia. The growth of forests in Asia, Europe, the Near East and North America offers a significant space for higher forest yields in a mid- to long-term perspective (FAO 2010).

On the other hand, the present rate of utilization of wood from the world's forests is far from optimal. Improved harvesting, processing and management of wood resources could raise the value added of products, create jobs, and reduce carbon emissions at a higher rate than at present.

Sustainable use of forest products is carbon neutral and can contribute to temporary enlargement of carbon stocks when forest products are in their final form (building structures, furniture, books). Forest products can also act as a substitute for non-renewable raw materials with high carbon emissions and be finally be used as fuel, substituting direct emissions from fossil fuels.

4. CONCEPTUAL FRAMEWORK

"Sustainability" was originally defined nearly 300 years ago by Carlowitz (1713) and developed further with the forest inventory and management planning techniques of Cotta (Bauer, 1980). The approach was originally centred in its vertical axis, which emphasizes the intergenerational deal assuring the preservation of the forest resource for future generations in a very advanced way (figure 3). There has been a limited uptake of the term, perhaps because of the narrow English translation of the German term Nachhaltigkeit or the French durabilité as "sustained yield", which captures only the productive segment of the concept. Yet sustainability was one of the key intellectual and applied contributions to humankind of the Enlightenment. It was not until the modern environmental movement rediscovered this original forest principle that it first gained popularity. "Sustainability" was reintroduced by the Bruntland Report in the discourse at the UNCED Summit in 1992 (UN General Assembly, 1987; v. Weizsäcker, 1997).

During the 20th century, sustainability in forestry had already been expanded to the multifunctional or horizontal perspective following the social progress (soil and water protection, recreation, biodiversity, climate). While the vertical axis reflects the balance between generations, the horizontal reflects the balance between different social groups and territories. In this context, forestry has been several steps ahead, accumulating a wealth of experience regarding the application of the sustainability principles and dealing with an integrated approach to the three pillars, which has formed part of the emerging discourse at the Rio+20 Conference.

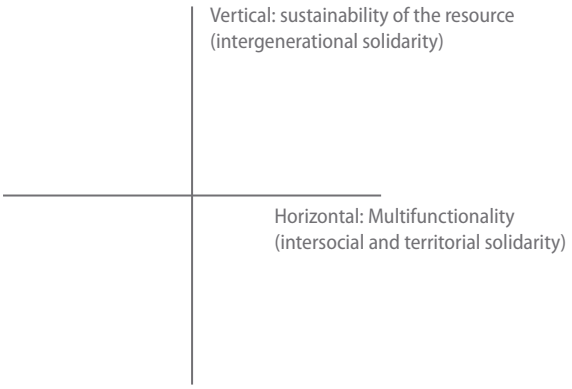

Figure 3: Axes of sustainability

5. OPPORTUNITIES FOR FORESTRY

Increasing demand for forest products will improve the profitability of sustainable forest management, which will have long-lasting positive effects on forest resources. In the case of wood, traditional uses like building material, furniture, packaging or paper will be complemented by new products emerging from technological developments driven by bio-based economies. For instance, bio-plastics, intelligent paper, nano-cellulose and engineered structural wood are examples of emerging wood-based products. Nevertheless, the most likely effective contribution of forests to climate change is related to the substitution of wood-based products in the building sector, as non-renewable materials such as concrete, steel, aluminum and plastic are extraordinarily energy intensive. Sustainable building is one, if not the most, important opportunity for upscaling forests' role in green economies, especially in the context of a growing population, the concentration of which is shifting fast from rural to urban environments in emerging and developing countries.

Regarding energy, chips, pellets and liquid fuels produced from lignin are growing dramatically, or are expected to do so in coming years. This emerging green energy will be able to supply the market with carbon-neutral fuel.

In the realm of non-wood forest products, bamboo and cork are the main products that have huge potential to contribute to sustainable building. Bamboo is already in widespread use in many Southeast Asian countries, and its use and application could expand to other tropical and subtropical countries as the key raw material to substitute non-renewable building materials. In addition, bamboo has significant co-benefits, such as earthquake resistance, lower price, higher availability, fast-growing supply and a decentralized and small-and-medium-enterprise (SME)-oriented supply chain.

If environmental services such as provision of water, soil protection, carbon (REDD+), biodiversity and landscapes – which form a veritable green infrastructure--are valued, recognized and rewarded, an upstream cash flow that balances and maintains the natural environmental service downstream will be assured. The provision of those services that are currently seen as a positive externality of forest management will increase forest cover as well as the supply of forest products by the introduction of payment for environmental services schemes.

Despite the growing demand for food, the Global Partnership on Forest Landscape Restoration has identified more than 2 billion ha of land available for forest restoration without affecting food security (Minnemater et al. 2011). In fact, a number of countries and organizations have committed themselves to restoring at least 150 million ha by 2020, in the frame of the Bonn Challenge . Recovering forest cover of that size (2 billion ha) would represent an increase of 50 percent of the present forest cover, with corresponding improvements in and additional benefits for rural livelihoods, increases in supply of forest products, and positive by-effects in environmental services.

Forests are the backbone of the economy in remote and disadvantaged areas characterized by poor sites or located in mountainous and boreal zones. Forestry is the single activity that even in the eventual case of lack of profitability cannot be abandoned (owing to issues such as pests and wildfires), while it has always to valorize sites that are not competitive to other land uses including agriculture. There are many opportunities for forests to provide livable standards for rural populations living in the most disadvantaged areas both in developed and developing countries (figure 4). The crucial role of forestry in spatial cohesion needs further attention both from research, statistical, policy and communication perspective.

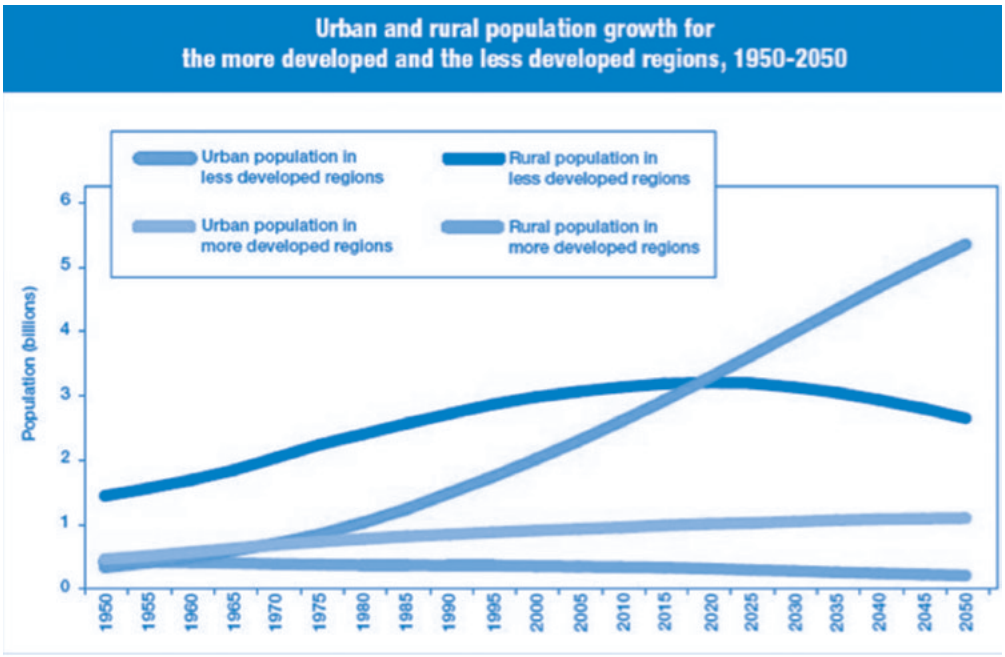

Figure 4: From UNFPA 2010.

Green growth opportunities related to forests can take place mostly in local environments in a decentralized manner and based on SMEs, while the potentially substituted non-renewable raw materials are characterized by strong concentration in big industrial facilities. At the same time, non-renewable raw material generating high amounts of waste can be significantly reduced due to the opportunity to produce carbon neutral bio-energy at the end of the cascade use.

6. RISKS FOR FORESTRY

Nevertheless, there are risks related to those opportunities. The risk of forest overuse is theoretically possible if ownership rights are unclear or law is not enforced. When land ownership is stable, rising prices of renewable resources such like wood have always increased their availability in the long run.

A second risk is related to social perception. The shift towards substitution of energy intensive non-renewable materials with forest-based products needs support in terms of finance (e.g., R&D, investments, taxes) or adoption of norms, for instance through regulations such as promoting wood use in buildings or shifting toward communal heating systems based on local forest products supply. Negative public perceptions regarding such issues will make political decisions more difficult to enact.

The excitement about the potential of wood might also create suboptimal uses. Cascade use of wood should be prioritized in a way to boost its value in end products and employment rates as well as to optimize life cycles and optimize the substitution of carbon emissions. Energy use should be restricted to low value sub-products from industry and forest management (first thinnings, shrubs, logging residues) and final products unable to be recycled. Demand for such products will contribute significantly to the profitability of the entire forest-based value chain. Incentives for renewable energies need to be adapted accordingly.

Another risk is related to the lack of implementation of payment of environmental services coming either from national policies and actions or REDD+ projects. Frequently, the value of the externality is not included in the form of payment or those using the service continue to act

as free riders (Olson, 1965). In case of burnable, young, degraded or low direct profitability forests, it will be difficult for them to reach their full potential and they might even degrade further. A typical example for that is found around the Mediterranean region (Merlo & Rojas, 2000).

Uncoordinated actions between industry, agriculture and forest sectors may lead to projects that are not feasible, over-investments, or failures to recognize the mutual benefits of a joint raw material supply approach.

Options for huge plants are being discussed, for instance in the case of substituting coal used for electricity by wood (Schulze et al. 2012). This option, however, would require long distances to transport products, and would result in low carbon efficiency, as the present efficiency rate of electricity produced out of wood is less than 30 percent, and later be transformed in a significant part into thermic use gain. This would enormously reduce the environmental performance of wood as energy source for electricity. The use of forest products for energy should be performed via decentralized thermic cogeneration or large consumers of thermic energy.

Finally, the pressure to set aside land as a conservation measure may become a challenge in areas with prevailing semi-natural forests. This debate is more ideological than substantive in nature and would reduce significantly the availability of forest products without a proven significant contribution to improve environmental services. In light of the present and predictable shortage of land in the coming decades, measures to set aside land for conservation should be restricted to the absolute minimum and biodiversity considerations should be integrated into the management of existing semi-natural forests (Putz et al. 2012).

7. HOW TO BEST ADDRESS OR MITIGATE THE RISKS?

A first issue to address is reviewing and adapting ownership rights to meet the present conditions. The distribution of rights tends to be very inertial and anchored on historical conditions, and needs to be adapted to new socioeconomic and cultural frames.

Increasing demand for forest products will require strengthened monitoring mechanisms at the local and national levels through forest management plans and national forest inventory. Both will need to be more integrated into national forest policies including through the use of law enforcement and incentives such as payment for environmental services. There are clear co-benefits of improving the quality of public policy interventions while reducing legal insecurity both for private actors and enforcement as well as their related costs. Payment for environmental services needs to be designed in a way that fosters and does not discourage sustainable forest management.

Biodiversity needs to be integrated into sustainable forest management instead of splitting the landscape into wilderness and very intensively utilized areas. This will require research-based information for optimal combination of the different forest functional demands.

Regarding forest products, it is critical to avoid suboptimal use of them. Integrated regional and sub-regional approaches are needed to encapsulate agriculture, forestry, industrial and waste sources and focus on direct thermic decentralized energy use while optimizing the use of forest products along the value chain (cascade use). Big consumers of thermic energy need to be accommodated through land use authorization or grants for existing facilities to shift towards forest chips.

Research and development (R&D) is essential for moving forward the production of first generation bio-fuels to 2nd and 3rd generation bio-fuels based on sub-products. Further development of bio-based products based on wood requires sustained R&D efforts.

Finally, wood requiring longer transportation distances should be moved via train or ship transportation in order not to lose its unique carbon performance.

8. CONCLUSIONS

As societies in all regions become more urbanized, progressively losing their traditional rural roots, communication about forests is needed to turn around perceptions about the use of forests and the application of forest products. Forests are an essential resource for helping countries transition to a green economy and support must be given at all levels in order for this to be fully realized. Superficial approaches might impede the social acceptance of several of the proposed measures. In the long run, social perception can become more relevant than a real fact (Fabra-Crespo et al., 2012). Only a proactive and consistent communication approach – the 2011 International Year of the Forests being an excellent example – and engaging a significant part of population in forest management as forest owners are promising strategies aiming to assure a supportive social environment for forests at this crucial crossroads.

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KN02

The Biorefining Story: Progress in the Evolution of the Forest Products Industry to a Forest-Based Biorefining Sector

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Keywords: Biofuels, bioenergy, biorefinery, conventional and advanced biofuels.

ABSTRACT

Continued global insecurity around oil supplies has helped keep oil prices volatile and relatively high, influencing the ongoing and significant investment in both conventional (sugar, starch, plant, and animal-oil-derived ethanol and diesel) and advanced (biomass-derived or 'drop-in' like) biofuels and chemicals. It is likely that 'pioneer' advanced biofuel plants will first use biomass residues as their initial feedstock as it is currently difficult to justify the investment in energy crops when there is no clear market for their use. It is also likely that agriculture-based advanced biofuel plants will be predisposed towards using a biochemically based process as sugar- and starch-based processes already use much of the equipment and processes that are conducive to the use of enzymes and microorganisms. In contrast, wood-based processing such as in pulp and paper manufacturing will be predisposed to using thermochemically based processes which build on already existing expertise in areas such as combustion, gasification and pyrolysis. The biorefinery concept has been proposed as a means to extract maximum value from lignocellulosic materials, with the higher value physical/chemical components used for biomaterials and chemicals and whatever is left used for bioenergy/biofuel production. The continued development of new conversion technologies has encouraged these nascent, newer biorefineries to assess a range of lignocellulosic feedstocks with the hope of producing additional value-added bioproducts and more efficient recovery of bioenergy. There are a number of complementary platforms for processing lignocellulosic feedstocks, including traditional platforms (i.e., existing pulping and starch-to-ethanol processes) as well as emerging technologies that are either biological, thermochemical or hybrid-based. However, there is as yet no clear candidate for 'best technology pathway' between the competing routes. Monitoring of larger-scale demonstration projects is one of the activities undertaken by IEA Bioenergy Task 39 to try to derive an accurate, comparative data base. Even at oil prices in excess of $100 a barrel, advanced biofuels will likely not become fully commercial for five to ten more years without significant government support. The expertise, progress, and goals of the member countries and companies involved with IEA Bioenergy Task 39 will be used to describe progress in the biorefining area and our attempts to commercialise advanced biofuels.

BACKGROUND

As oil becomes scarcer and more difficult and expensive to source and process, forestry-derived biomass is gradually shifting from being more of a sectoral resource (e.g., for products such as housing, furniture, pulp, and paper) to potentially becoming a major feedstock for the rapidly evolving 'biorefinery sector'. Trends such as the unstable but generally increasing oil prices, global sustainability concerns including climate change and the ongoing economic malaise have all contributed to the growth in both interest and investment in what is generally termed the 'bioeconomy'.

Oil and its derivatives have been the lifeblood of most of the world's industrial economies since the middle of the last century. However, increasing demand for a finite resource is driving up its cost and the environmental risk of its extraction, while all fossil fuels are known to be the primary cause of increasing greenhouse gas (GHG) emissions. At the same time the established forest-based industrial sector has been going through some major upheavals with the US housing crisis greatly reducing traditional uses such as lumber for housing, while longer term trends, such as the rapid increase in digital media use, significantly reducing the market for products such as newsprint and writing paper. There is a growing realisation that the convergence of the five 'F's' (fuel, food, feed, fiber, and fertiliser), will result in increasing competition for resources from nontraditional competitors. In countries such as Brazil, oil companies such as Petrobras have invested heavily in sugar-cane-to-ethanol production while at the same time becoming world leaders in deep-water oil drilling and extraction. Energy companies such as BP and Shell have invested heavily in a variety of technologies and companies, from wood pellets, through biomass-to-ethanol to algal biofuels. Chemical companies such as DuPont have acquired companies such as Danisco/Genencor, to diversify into areas traditionally associated with a food company (Danisco) which itself had recently acquired the world's second biggest enzyme company (Genencor). Thus, as various companies and sectors look to expand, the traditional industrial users of the world's forests can anticipate other groups to increasingly look at whether a sustainably produced feedstock (such as a tree), which sequesters carbon from the atmosphere, might provide an alternative approach to making their traditional products of chemicals, fuels, and energy. The OPEC-generated oil crisis of the 1970s and the more recent concerns about GHG emissions have motivated significant R, D, D & D (research, development, demonstration, and deployment) investments in the bioenergy sector over the last few decades. However, there is an increasing realisation that, in the same way that the lower volume but higher value co-products such as plastics, chemicals, dyes, etc., make an oil refinery economically viable (with the bulk products of diesel/gasoline/petrol being of generally lower value), any future bioenergy sector will also require these higher value co-products (biomaterials, biochemicals, etc.) as the basis of a future biorefinery sector.

The agriculture sector is very much at the forefront of this evolution. In the 'swinging sixties' (1960–1969) the issue of the day was not energy but overpopulation and the world's ability to feed all of its people. Oil was thought to be so plentiful and infinite that oil and chemical companies such as BP, ICI and Shell invested in "single-cell-protein" that was derived from the growth of microorganisms on oil derivatives such as methanol. However, primarily through what has been termed the 'green revolution', agricultural productivity per hectare has increased steadily over the last 50 years to the extent that agriculture is now the primary source of the most used renewable biofuels such as biodiesel and bioethanol! In the same way that agriculture provides food, fuel, feed, chemicals, nutraceuticals, etc., it is increasingly likely that, as well

as continuing to produce 'traditional' products such as lumber and pulp and paper, the forest sector will also evolve into a biorefinery mode of operation with bioenergy being one of the major complementary markets that will be developed.

Over the last couple of decades a range of biomass conversion technologies have been investigated that have used both forestry and agricultural feedstocks to try to produce fuels and chemicals. These biofuels/bioproducts can compete economically with current oil-derived products while proving to be much more desirable from an environmental and social perspective (i.e., lower carbon emissions, gains in rural employment, etc.)

In the next section we discuss the rapidly evolving bioenergy sector (and biofuels in particular), the potential for the forest sector to become a leading player, and some of the work that organisations such as IEA Bioenergy have played in trying to catalyse the development of a forest-based biorefinery.

THE CURRENT FOREST SECTOR

As mentioned earlier, the forest sector is facing major challenges while new conversion technologies, emerging markets and increasing requirements for the sustainable production and use of materials/products are creating a strong drive for transformation in the sector. Traditional forest products such as construction and pulp and paper represent a 'business as usual' modus operandi for the forest-based sector, but they are not sufficient to ensure substantial future growth and revenues for the sector. A change is required to address these challenges and to harness the opportunities of diversifying the product range of the forest industry. This diversification can be achieved by selectively extracting further value from lignocellulosic biomass such as thermal value (bioenergy), chemical functionality (chemicals and fuels) and novel structural applications such as biomaterials like nanocrystalline cellulose. Ideally, the future forestry facilities will be able to exploit a range of value categories from their biomass feedstock and, depending on market conditions, the future forest-based biorefinery sector will be able to move to the product streams that offer the highest economic as well as environmental/social values.

Of the various businesses that constitute the current forest products sector, the pulp and paper industry is best positioned to evolve into a biorefinery approach that would allow easier diversification of its product streams. Most pulp mills already have in-house expertise and assets needed to enhance the fractionation of the cellulose, lignin, hemicellulose, extractives, and other components of forest biomass using a variety of approaches (e.g., Kraft lignin, dissolving pulp). The sector also has well-established expertise in handling and recycling chemicals as well as dealing with waste streams and water recycling. These assets can be readily leveraged to manufacture lignin and cellulose-derived products beyond traditional pulp and paper products into the wider biorefinery approach.

It should be noted that paper and packaging companies accounted for most forest-based revenue generated globally; the top 10 P&P companies are listed in table 1. Despite the considerable size and global reach of many of these companies, their investment in innovation and the limits to their product diversification tend to be in their traditional market areas, aiming at the production of whiter paper or stronger tissue paper, rather than making use of their expertise in sustainably producing, accessing and processing the biomass feedstock into different products and markets. Those companies that have diversified to some extent, such as Kimberly-Clark, have developed high-value speciality products (e.g., laboratory and medical consumables). It should be noted that this is currently the company with the highest net income on a global basis (table 1).

Table 1: PricewaterhouseCoopers Top Global Forest, Paper & Packaging Industry Companies

Rank 2010	Company name	Country	Sales US $ millions	Net income (loss) US $ millions
1	International Paper	US	25,179	644
2	Kimberly-Clark	US	19,746	1,843
3	Svenska Cellulosa (SCA)	Sweden	15,202	773
4	Stora Enso	Finland	13,671	1,021
5	Oji Paper	Japan	13,097	284
6	Nippon Paper Group	Japan	12,502	343
7	UPM— Kymmene	Finland	11,848	745
8	Smurfit Kappa	Ireland	8,865	66
9	Mondi Group	UK	8,269	297
10	Metsalito	Finland	7,139	226

Source: PricewaterhouseCoopers, 2011

Over the last 100 years, at the same time as the forest products sector has been developing the various products that we now take for granted (kraft/mechanical/dissolving pulps, engineered wood products, etc.), the energy sector was evolving from a coal-based sector to one increasingly dependent on oil. There was also an increasing realisation that, although energy applications would continue to grow, lower volume but higher value co-products such as chemicals and plastics would increasingly become the profit centre of the 'oil refining sector'. More recently both cost (oil is getting more expensive and environmentally 'risky' to access and process) and environmental/social concerns have encouraged traditional coal- and oil-based sectors to consider if their current hydrocarbon-based operations could evolve into one based more on sustainably produced carbohydrates.

THE POTENTIAL, EVOLVING FOREST BIOMASS PROCESSING SECTOR

Over the last 50 years or so, the world's economy has become less dependent on the resource and manufacturing industries with 'white collar' industries such as banking, insurance, and education becoming bigger players in the 1980s through 2000. Since 2000, the growth of companies such as Apple, Google, and Facebook have also been contributing to the manufacturing sector's diminished influence. When the world's top companies are reviewed (table 2), although companies such as Toyota are still in the top 10, the fact that a retailer, Wal-Mart, is number one is quite telling. What is also apparent is that the world's increasing need for energy results in oil companies still predominating as the biggest and often most profitable companies. In contrast, the world's forest products companies might be considered to be 'middle-sized' players, with the company with the greatest revenue in 2009, International Paper, listed as number 362 in the world in terms of revenue (table 2).

Table 2: Top global companies by revenue

Rank 2009	Company name	Country	Sales US $ millions	Net income (loss) US $ millions
1	Wal-Mart Stores	US	408,214	14,335
2	Royal Dutch Shell	The Netherlands	285,129	12,518
3	Exxon Mobil	US	284,650	19,280
4	BP	UK	246,138	16,578
5	Toyota Motor	Japan	204,106	2,256
7	Sinopec	China	187,518	5,756
10	China National Petroleum	China	165,496	10,272
11	Chevron	US	163,527	10,483
14	Total	France	155,887	11,741
17	ConocoPhilips	The Netherlands	139,515	4,858
362	International Paper	US	23,366	663

Source: CNN Money, 2011

Over the last decade or so, there is growing recognition that we need to think in human generational terms, rather than just short-term 'profitability' over the next financial quarter, with nontraditional forest-based players such as oil and chemical companies increasingly assessing the viability of producing their traditional fossil-fuel-derived products from biomass. There have also been parallels in the way the oil- and forest-based sectors have evolved. Historically, the structural characteristics of wood result in its primary application in markets such as housing, furniture, and bridges with applications such as pulp and paper being developed relatively more recently (in the last 50 years or so). Similarly, oil was predominantly used for its energy/fuel applications with its potential as a chemical/polymer/plastics feedstock becoming fully realised at the same time as the processes such as kraft and thermochemical pulping were being commercialised in the 1950s and 1960s. There are also parallels when the volume and value of the products that can be derived from a forest- or oil-based feedstock are compared (figure 1). In the oil-based sector, transportation fuels (diesel/petrol/gasoline) represent the main product in terms of volume (70 percent) while co-products and value-added materials such as plastics represent only 4 percent of the product volume. These nonfuel product categories contribute almost as much to the annual revenues of the industry as do the total fuels component (figure 3). The importance and use of wood as a structural material is reflected in both the high volume and value of solid-wood products (plywood, OSB, engineered wood, lumber, etc.) as well as pulp, paper and packaging products. In contrast, the current chemical and energy products/uses represent a lower volume and an even lower value forest product. However, the recent high value of dissolving pulp (although somewhat stabilised in recent months) has indicated how valuable a true forest-based biorefinery might be when pulp is valued more as a 'biomaterial' or 'chemical/polymer' feedstock rather than just a source of paper products. Although forest products companies such as Borregaard, Neucel, Tembec and Lenzing have shown how a biorefinery can operate and evolve into marketing a range of speciality pulps, chemicals and fuels, a strategy that is being increasing pursued by forest companies is to form partnerships with companies that better understand the markets into which the bioenergy/biomaterials can be sold. Examples of such bioenergy collaborations include Catchlight, which is the Chevron-Weyerhaeuser joint venture in the US and the Stora Enso-Neste oil collaboration in Scandinavia. Both collaborations are focussed on developing the biofuels/bioenergy area with the forest-based company better understanding the logistics, costs and complexity of sourcing, collecting and processing the biomass, and the energy company better understanding the markets and likely value that can be extracted from the renewably sourced carbon (table 3).

Table 3: Examples of collaborations between the petroleum and forest products industries

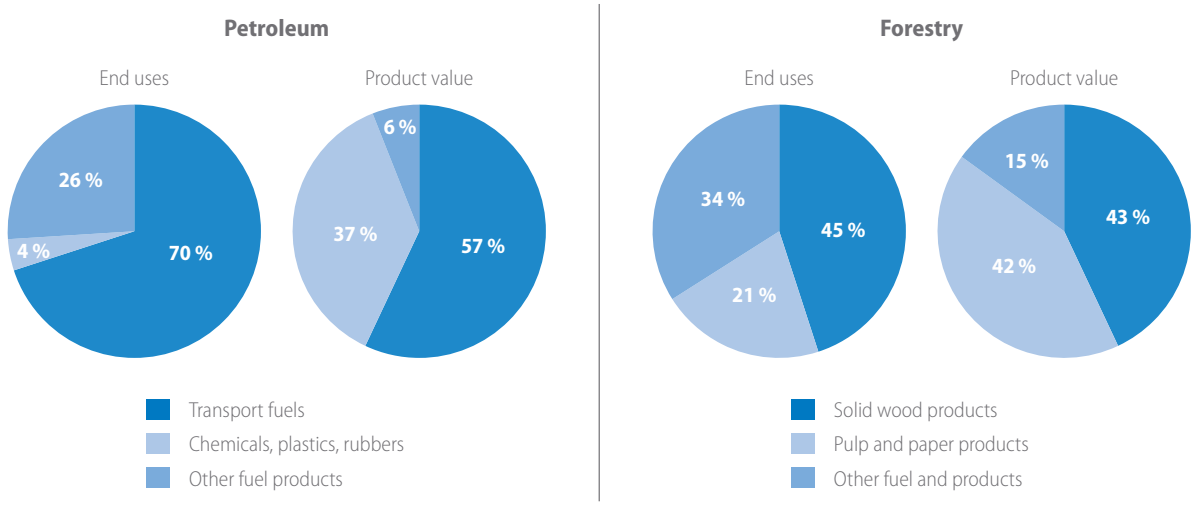
Oil refiner company ($m revenue in 2010)	Fibre expert company ($m revenue in 2010)	Country	Type of collabouration	Year initiated
Neste Oil (11,890)	Stora Enso (13,671)	Finland	50/50 investment on a demonstration facility in Varkaus	2009
Chevron (198,198)	Weyerhaeuser (6,552)	USA	50/50 Joint Venture named "Catchlight Energy"	2008

Source: Company Web sites and annual reports.

As well as forming partnerships with traditional forest products companies, oil and chemical companies are also strategic investors in technology providers such as Amyris (Total), Codexis and logen (Shell) as well as purchasing companies (BP's purchase of Verenium) and investing in longer term R&D centre's (BP's investment in the Energy Biosciences Institute). These types of substantial short- and long-term investments indicate that, while it will likely take a while, 'Big Oil' is assessing the potential of moving from depleting stocks of hydrocarbons to a renewable and hopefully sustainable carbohydrate feedstock!

From a sustainability point of view, the oil refiners find themselves under continuous pressure to develop "greener" fuel blends (e.g., compulsory ethanol blending in the US) and "greener" (biodegradable and/or renewable) materials. In this context, the scope for the petroleum and forestry industries to collabourate is projected to increase.

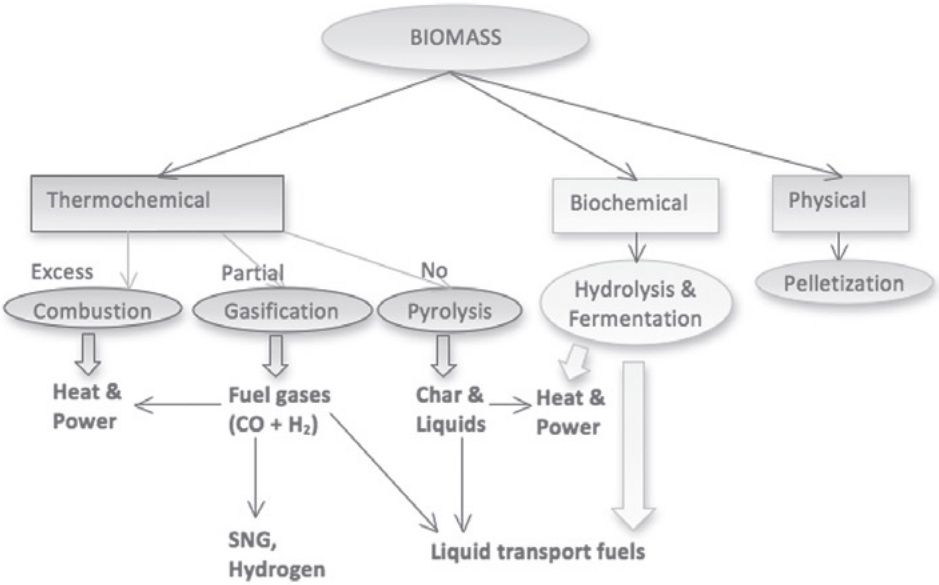
Figure 1: Comparison of value and volume distribution in the forest and petroleum industries Source: adapted from Browne et al., 2012.



Case Study: Development of Conventional (First Generation) and Advanced (Second Generation) Biofuels

As mentioned earlier, biofuels are the most widely used renewable alternative to oil-based transportation fuels such as diesel and petrol/gasoline. Biofuels can generally be defined as liquid transportation fuels that are derived from crops (such as sugarcane, corn, rapeseed, or sunflowers) or biomass (such as forestry and agricultural residues or energy crops such as switchgrass, fast-rotation trees, or algae). In direct response to the OPEC oil crisis, pioneering countries such as Brazil and the US greatly expanded their production of 'traditional' or 'conventional' biofuels such as sugarcane or ethanol derived from corn. Other countries such as Germany quickly followed suit by greatly expanding its production of oil seed-bearing crops such as rape/canola. These so-called 'first generation' biofuels technologies (now better defined as 'conventional' or traditional biofuels production) have helped establish much of the infrastructure and policies that are in place to make bioethanol, and to a lesser extent biodiesel, significant commercial realities in many parts of the world. Countries such as Brazil continue to improve on many aspects of sustainability as well as the economics of making ethanol from sugarcane. However, in other parts of the world, various economic and social (e.g., food versus fuel) considerations have encouraged the development of 'advanced' biomass-based biofuels technologies based on biochemical, thermochemical and hybrid process routes (sometimes referred to as second- or third-generation biofuels). The technology pathways to biofuels and bioenergy from biomass are depicted in figure 2.

Figure 2: Pathways to energy products from biomass



Source: Adapted from BPN, 2011

INTERNATIONAL BIOFUEL TARGETS AND THE QUEST FOR ECONOMIC VIABILITY AND SUSTAINABILITY

As mentioned earlier, there has been significant investment in the development of renewable liquid transportation fuels with various countries developing mandates, directives, targets and roadmaps to facilitate the commercialization of biofuels (BD, 2011). The recently developed IEA (International Energy Agency) biofuels roadmap (IEA, 2011) is one example of a globally concentrated effort to prepare an action plan and determine global biofuel volume and specification targets. As detailed in the report, if the world aspires to reach the GHG reductions that are described in the "Blue Map" Scenario (energy-related CO2 emissions are reduced by 50 percent in 2050 relative to their 2005 level), biofuels use will have to grow from its current 2 percent share of global transportation energy to over 25 percent by 2050. In this way it is estimated that about 2.1 Gt CO2 emissions per year could be reduced. Although production of some conventional biofuels such as sugarcane-derived ethanol are expected to continue to grow, as they can be produced both sustainably (good GHG savings) and economically (Brazil's experience and increasingly efficient production techniques), future advanced biofuels such as energy-dense hydrocarbon-type diesel and jet fuels will likely be produced by thermochemical means such as by Fischer-Tropsch conversion of gasified biomass and pyrolysis oils.

IEA BIOENERGY TASK 39: AN EXAMPLE OF AN INTERNATIONAL FORUM THAT CAN PROMOTE BIOREFINERY COLLABOURATIONS

An international example of an organization that facilitates collaboration and information exchange in the biofuel-biorefinery sector is IEA's Task 39. The Task is focused on biofuel commercialisation in a biorefinery approach and operates for the interests of its member countries and the overall mission of the IEA. The origins of the International Energy Agency (IEA) coincided with the first of several 'oil price disruptions' initially caused by the OPEC oil crisis of the 1970s. Since then, the IEA has evolved from an agency that tried to better anticipate oil price disruptions to now having a mandate to 'improve the world's energy supply and demand structure by developing alternative energy sources and increasing efficiency of energy use'. The work of IEA Bioenergy Task 39, 'Liquid biofuels' (http://www.task39.org) is very much at the forefront of the renewable fuels strategy of many countries. With dwindling petroleum reserves and soaring transportation fuel demand from China, India, and other emerging economies, the world needs alternatives such as biofuels and biomaterials. This organization and other global collabouration efforts are indispensable tools in ensuring the success of the evolving bioeconomy.

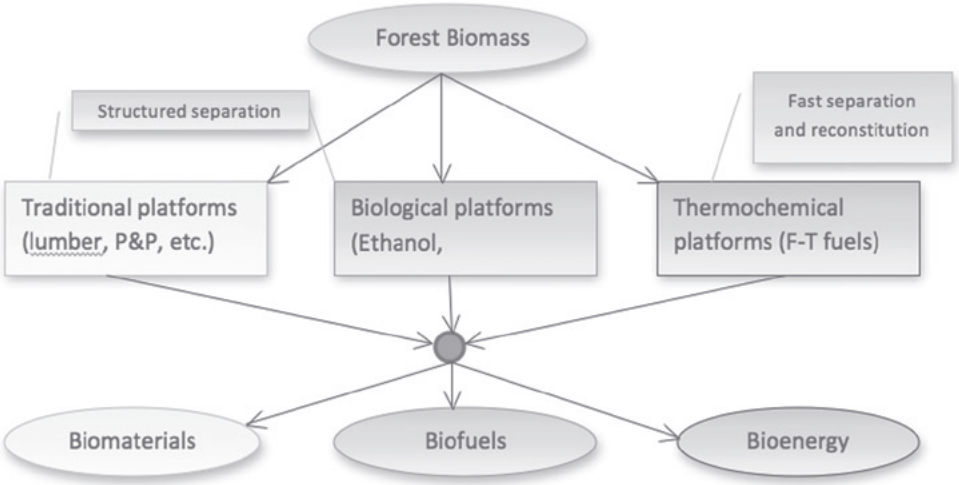
WHAT IS THE LIKELY STRUCTURE/OPERATION OF FOREST-BASED BIOREFINERIES?

Just like oil refineries, biorefineries can provide a wide range of molecules and materials that act as the precursors or products for transportation fuels and commodity/specialty chemicals. Bioenergy, biofuels and biomaterials are the main categories of products that can be produced from forest-derived biomass depending on the feedstock and the process involved (figure 3). It is likely that traditional high-value products such as engineered wood or specialty pulps will continue to be the mainstay of many forest-based biorefineries. Nature designed trees to be primarily composed of 'structurally robust polymeric components' such as cellulose, hemicellulose and lignin and it thus makes sense to first take advantage of wood's 'structural' characteristics before conspiring its chemical/energy potential!

There are several conversion technology platforms that are current and potential candidates for a forest-based biorefinery employing either thermochemical processes such as pyrolysis/gasification or biological processes such as microorganisms/enzymes (biochemical platforms). Although both the thermochemical and biochemical platforms have the capacity to produce fuels, chemicals and to generate power (figure 3), the biochemical approach tends to fractionate the cellulose, hemicellulose, lignin, extractives, etc. through processes such as pretreatment while the thermochemical process carries out this fractionation after all of the biomass has been pyrolysed or gasified first. In either type of biorefinery, the 'energy products' such as biopower and biofuels are likely to result in the greatest product volume while biomaterials/biochemicals such as xylitol or nutraceuticals will have significantly smaller markets but with much higher value. In this way it has been suggested that the forest-based biorefinery can develop a diverse range of products, analogous to an oil refinery, and therefore be in a much better position to deal with both market fluctuations and market opportunities. Future forest-based biorefineries should also be 'flexible' or 'modular' in their design so that they can readily shift from one product stream to another, depending on market prices. Some excellent examples of the development of the biorefinery concept can be seen over the last 20 years in the US corn and the Brazilian sugar-based industries. In the early 1980s, Brazil was the first country to try to become less dependent on imported oil by aggressively developing an ethanol industry based on its considerable sugarcane industry. However, the Brazilians soon found out the advantages of being able to diversify their product mix by shifting to more sugar production when the value of sugar is high (as it currently is) or to ethanol production whenever the international price of oil is high. Similarly, the US corn sector is still a substantial animal feed supplier with corn's use as an ethanol feedstock only recently superseding this traditional market for corn. Thus when oil prices are high (as they are currently) ethanol will continue to look attractive, with the concomitant high price for animal feed resulting in famers planting more corn than other less-profitable crops such as soya. It should be noted that the different biorefinery platforms have advantages and disadvantages. For example, the traditional and biological platforms tend to have lower throughput rates but achieve cleaner product streams (e.g., purer ethanol and chemicals), while the thermochemical platforms tend to provide faster throughput but poorer separation and quite heterogeneous product streams (e.g., pyrolysis oils). In general, each biorefinery platform will involve some form of compromise or tradeoff at more than one level. As a result it is difficult to identify a 'best technology pathway'.

Although several pulp mills could be evolved into more of a biorefinery mode of operating, via either a thermochemical or biochemical approach, it is likely that 'pioneer' plants will first use any energy produced in-house via direct combustion, combined heat and power, or black liquor gasification types of approaches. Pulp mills have existing equipment that can be easily retrofitted to perform either pretreatment or biochemical conversion (e.g., pulping digestors) or pyrolysis/gasification (e.g., black liquor gasification) for thermochemical conversion. Although these technologies can fractionate biomass and produce value-added biorefinery-type products, they are likely to be more mid- to long-term solutions for the forest sector. Biopower is already being used within several pulp mills in existing operation units such as lime kilns and black liquor gasifiers, although most older pulp mills are rarely self-sufficient in power generation and they often have to buy natural gas or electricity to complement their in-house power.

Figure 3: Potential forest based biorefinery platforms



FEEDSTOCK-PROCESS COMPATIBILITY AND LOGISTICS ASPECTS

In comparison to oil, biomass is a feedstock that is less energy dense, higher in moisture, much more heterogeneous, dispersed in its distribution and, somewhat surprisingly, often requiring more of a 'social license' for its collection does drilling for oil! Accordingly, biorefinery facilities will have some logistic challenges, which will undoubtedly influence the choice of technology platform, feedstock and markets that might be pursued. For example, thermochemical facilities are likely to be more amenable to scale-up because, in contrast to biochemical processes, they can process highly densified and more hydrophobic forms of biomass such as torrified pellets or bio-oils, which in turn can be transported longer distances than raw biomass (Stephen et al., 2010). Similarly the seasonality of fibre harvest, moisture and ash content, accessibility of fibre, bulk density, and amenability to densification are other characteristics that can vary between different feedstocks and should be taken into account when choosing a biorefinery technology. Matching the right technology to the appropriate feedstock and securing the availability of the raw material will be paramount to the sustainable and profitable operation of a successful forest-based biorefinery.

THE FOREST PRODUCTS ASSOCIATION OF CANADA'S (FPAC) 'BIOPATHWAYS' STRATEGY

In North America, the current, ongoing financial crisis was partially precipitated by the subprime mortgage crisis that resulted in housing starts (predominantly made out of wood) going from record highs around 2007/2008 to almost record lows in recent history. The evaporation of this core market and the increasing value of the Canadian dollar versus the US dollar resulted in dire financial/employment conditions for the Canadian forest products sector. As one part of an evaluation of how the sector might survive and evolve, the Forest Products Association of Canada (FPAC), with financial support from the Canadian Forest Service's (CFS) of the federal Natural Resources Canada (NRCan) and input from the recently merged R&D organisation, now termed FP Innovations (formerly Forintek, Paprican, FERIC and part of CFS), created the Canadian Forest Innovation Council (CFIC), which helped identify the need to develop a 'biopathways' strategy. The work carried out within the Biopathways project involved a detailed and thorough evaluation of potential strategies for renewal and diversification of the Canadian forest products sector. In its initial work the group assessed both traditional and emerging manufacturing pathways in three selected regions within Canada (northern Ontario, interior British Columbia and the Lac St. Jean region of Quebec) (BPN, 2011). This initial study indicated that, generally, the pathways that maximise greatest return on capital expended (ROCE) are the ones that combine current sawmill operations with bioenergy and engineered wood products (EWP) applications and markets, while current pulp and paper operations are best blended with bioenergy and biorefinery technologies and applications. However, it was also apparent that the strategies that maximise ROCE are not necessarily the ones that maximise employment indicators and vice versa. It was also evident that different pathways perform differently in each of the three regions studied. These recommendations again indicated that there is no 'best technology pathway' and that the desired 'win-win' situations have to be carefully assessed and customised to the industrial and social background of each region. However, the study strongly emphasised the urgent need for renewal in the forest products sector as the opportunities are too great to miss out on and 'business-as-usual' would be unlikely to be successful in the future. The report indicated that, on average, a new technology added to an existing pulp mill will improve ROCE by 3.7 percent, GDP contribution by 10 to 25 percent, and employment by 1 to 4 percent (BPN, 2011). Overall, the report recommended that (a) better integration of traditional and novel technologies/products/markets, (b) increased cross-sectoral synergies and (c) better leveraging of existing infrastructure will be key components for the future success of the evolving forest sector. It was also noted that policy support, improved communication between sectors (such as the Catchlight joint venture between Weyerhaeuser and Chevron), increased investment in R&D and hiring new people with the skills and training needed for the future biorefining sector, are all essential components to ensuring the success of the proposed biopathways strategy. More recently, a network of university-based networks working in the forest products sector has been formed (the FIBRE network, http://www.reseauxfibrenetworks.ca) with the goal of helping commercialise university-derived research while training the highly qualified personnel (HQP) that will be needed by the future forest products/biorefining sector. The better integration and close collaboration between FPAC, NRCan, FP innovations and the universities is seen as key to ensuring the effective development of Canada's future forest-based biorefining sector.

CONCLUSIONS

The forest-based biorefinery will continue to have traditional products and markets (lumber, engineered wood, pulp and paper) at its core, making use of wood's inherent structural characteristics. However, the increasing costs (economic, environmental and social) of using fossil-fuel-derived feedstocks to make many of the products from an oil refinery will encourage oil/chemical companies to continue to evaluate carbohydrates as a possible replacement for hydrocarbon-based feedstocks. The commercialisation of the forest-based biorefinery comes with a number of challenges, several of which could be addressed through selected partnerships and collaborations, leveraging the relative expertise of sectors such as the forest products and the chemical/oil refining industries. There is considerable potential for the forest products sector to 'learn' from the strategies of the oil refinery, and more recently the agriculture-based biorefinery sectors. It can do this by extracting the maximum value from biomass by supplementing fossil-fuel energy sources with biomass-derived energy and developing high-value co-product streams such as nanocrystalline cellulose and nutraceuticals. Although various thermochemical and biochemical-based processes are currently being evaluated as the basis of a 'biorefinery platform', there is as yet no 'best technology platform' and the choice of process is more likely to be influenced by feedstock specificity and the peculiarities and logistics of each region. Although the biorefinery approach to processing forest-derived biomass is poised to play a central role in the future of the forest products sector, part of its success will depend on the careful selection of technology and markets that will capture the synergistic opportunities between complementary industries and other stakeholders. These collabourations and synergisms can be facilitated via national networks such as the Canadian Biopathways Network and international networks such as the Bioenergy Implementation Agreement (IA) of the International Energy Agency (IEA).

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KN03

Wood in construction—including multi-storey building

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Keywords: Timber construction, engineered wood products, prefabrication, multi-storey timber building

ABSTRACT

Wood is a traditional and modern building and construction material. Recent developments have underlined a growing importance of wood and wood-based products as structural elements in modern building and civil engineering applications. Statistics confirm that the use of wood for single- and multi-storey residential, as well as commercial buildings, has increased in the last decade, especially in European countries. This positive trend is likely to continue. The reasons for this change in the acceptance of wood as efficient and superior construction material are manifold and will be briefly outlined: further development of engineered wood products; highly productive processing technologies; prefabrication and systematization; flexibility in geometries and design; energy efficiency of materials and systems; adapted building regulations; refined codes and standards; and significance of sustainability values. Despite this remarkable progress, the wood value-chain needs further and continuous qualification in order to meet future requirements. At present, the economic competitiveness of timber-based buildings often lags behind the technical, aesthetical, and ecological benefits, which in facts impedes a revealed preference for timber building systems in both public and private decision processes. Several product, process, and organizational innovations for an enhanced competitiveness of multi-level timber construction are discussed.

INTRODUCTION

Wood is a multifunctional biocomposite. It is produced under exceptional environmentally friendly conditions by photosynthesis, the basic process for all life on Earth. In addition to the production of wood, trees and forests fill a multitude of beneficial environmental functions. Because the primary industrial processing steps of wood consume relatively little fossil-fuel energy and produces no harmful emissions or waste, timber is regarded as an environmentally advantageous material. Mankind has long been familiar with and in many cases dependent on the utilization of wood. The two principal functions of wood until today are the use as raw material and source for heat and energy. The direct conversion of major parts of available forest resources into heat for cooking and firing, mainly in the developing countries, consumes more than half of the 3.5 billion m3 of roundwood harvested annually. Thus, the potential volume available for material use, which is considered to be the priority option of wood utilization owing to the higher provision of benefits to the environment, employment and economy, is unfavorably shortened.

Between 50 and 70 percent of the industrially harvested roundwood is converted into timber and wood products, which are mainly used in buildings as structural components, insulating material, appearance wood products, and furniture. Building and construction industries are the dominant sectors in which the most added values are given to solid forest products, both on a regional and global scale. In Europe, for example, wood industries throughout the supply chain support more than 2 million jobs and generate almost 200 billion € to the European economies every year.

WOOD AS A BUILDING MATERIAL: CHALLENGES

It is widely recognized that timber is a very efficient building material, not least in regard to its technical and mechanical properties but also because it is a highly sustainable material. Compared to other building materials, wood is a better choice when all phases of the life cycle of structures are considered, i.e., production, use, and options for end-of life utilization, because its manufacture requires less energy and fossil fuel than other building materials. Timber is a widely available natural resource in many regions of the world. Even in the beginning of the 21st century, there is, with proper forest management, a potential for a continuous and sustainable supply of raw timber material in coming decades. In addition, timber is a rather advantageous building material because of its many unique characteristics and properties, such as

- High strength and stiffness and low mass at the same time
- Excellent heat and sound insulation properties
- Ability to absorb and release moisture, thus contribute to a healthy living climate in houses
- Important fire safety characteristics, although being flammable itself
- Natural and highly variable appearance, allowing construction and decoration functions to be combined in the same element.

Despite its beneficial technical and environmental properties, timber often is still not used to its full potential in the building and construction sector. Several studies reveal that wood products have not been well perceived by builders and architects (O'Connor et al. 2004). Because of its biological origin, the structure, appearance and integrity of timber resources are subject to considerable variability, combined with an elevated risk of biological (deterioration) and physical degradation (fire) under improper exposure conditions. Some mechanical properties of timber are rather poor in certain design situations. These unsatisfactory properties include tension and compression strength perpendicular to the grain, shear strength, stiffness properties, energy dissipation capacity, and natural defects.

Therefore, many building developers, architects, and structural engineers do not consider timber to be a competitive building material compared with concrete, steel, aluminum, or masonry. Attributes such as high performance regarding reliability, serviceability, and durability are not directly associated with timber as a building material. One of the main reasons for this is that timber is a highly complex material. It

requires a significant amount of expertise to fully appreciate the potential of timber as a structural building material. This indirectly points to another reservation that timber building often is subjected to in Europe: cost comparisons of timber-based and mineral-based building component and structures show that the former tend to be more expensive. In cost estimations for identical constructions, price differences around 10 percent costs more for timber solutions are reported (Mikkola 2010). This situation is reported to be reversed in North America, where wood is an economical choice compared to the higher priced steel and concrete structural components (Cheung 2010).

Besides the price discussion, a further critical limitation for large-scale timber construction is a lack or reserve of primary contractors to build using wood. In Europe, wood builders and common carpentry firms are usually too small to act as primary contractors and they can participate only as carpenters. The main contractors rarely have sufficient experience with timber construction regarding its technology, logistics, and procedures and are raising the costs because they fear problems and contract penalties (Winter and Fadai 2012).

MARKET SHARES AND OPTIONS FOR FUTURE EXPANSION

To overcome these drawbacks, wood scientists, timber engineers, and wood product industries are continuously developing knowledge and concepts for a more reliable, robust, and economical use of timber in residential, nonresidential, and industrial buildings. Especially in central Europe, where the material portfolio in the building and construction sector in the 20th century was dominated by concrete, steel, and masonry, over the past decades timber is achieving an amazing revival as structural building material. By volume and value, most of the timber is used in single-family timber houses with up to two levels, and increasingly for engineered structural elements. In Europe, the market share of residential timber houses varies largely. In Scandinavian countries and Scotland, timber framing is the dominant construction type for single-family houses with a market share of from 60 to 90 percent (Tykkä et al. 2010). In Central Europe, the numbers are still much below 50 percent, but recent surveys report increasing numbers, e.g., for Austria (Stingl et al. 2011). Regarding multi-family (i.e., multi-story) residential houses, the importance of wood as the main structural material is generally much lower and ranges between 2 and 10 percent (Tykkä et al. 2010). In North America, the market share of timber products in nonresidential structures is 4 percent, compared to 71 percent in residential buildings (RISI 2008).

Throughout the globe, urban managers are planning for shifting demographics and rising land costs by turning to denser and taller housing. Thus, the dominance of multi-storey residential construction in urban environments will continue to increase in coming decades, whereas the share of single-family houses might decline accordingly. In consequence, residential timber housing industries, especially in Europe, are forced to develop efficient and competitive timber-based multi-storey building technologies and urban construction systems, to counteract a further decrease in consumption of wooden building materials. In addition to technical innovations, current building policies in many countries aim to promote sustainable development and manage climate change, resulting in harmonized building codes that place functional requirements, such as fire resistance and thermal insulation, on the building's performance. This indirectly supports the application of timber application to multi-storey constructions, because timber frame systems show superior thermal insulation values compared to competitive construction materials. Another favorable property of timber based multi-storey systems is its behavior in earthquakes (Ceccotti 2008). Owing to the reduced mass and large number of mechanical fasteners used in timber frame construction, their behavior in repeated loading conditions is very ductile, hence favorable for earthquake loading. Shake table tests on a six-storey building recently have shown the excellent behavior of wood-frame construction when subjected to earthquake loads (Schädle and Blass 2010).

The recent efforts of industry, research, and policies have contributed to innovations and advanced concepts, which shall provide the basis for a cumulative application of timber as multifunctional element in multi-storey houses with more than three levels in urban environments. Meanwhile, several six- to nine-storey timber buildings have been erected in Europe (Serrano 2010; Kaufmann and Nerdinger 2011), North America (Cheung 2010), and Asia. The highest-storey buildings still have a pilot character and are gaining public attention via media reports. They confirm the technical feasibility of high-rise timber houses with a high quality and safety standard. Future planning and technologies even focus beyond the 10-storey level (Kaufmann 2012; van de Kuilen et al. 2012). However, it is of utmost importance for the further exploitation of the superior technical and environmental values of timber-based materials and construction systems to expand the applications from still-isolated pilot buildings into a larger number of applications. The following summarizes the challenges and potentials.

INNOVATIONS FOR COMPETITIVE MULTI-LEVEL TIMBER CONSTRUCTION

Cost and quality competitiveness are key challenges to foster timber products as structural elements in multi-family houses. When designing multi-storey wood frame buildings, technical key factors are fire safety, structural performance (strength and serviceability/deflection checks), dimensional stability, and sound transmission. Successful economical concepts need to combine product, process, and organizational innovations.

PRODUCT INNOVATIONS

The supply of wood-based composites and engineered wood products is indisputably linked to the production of multi-level timber systems. Although their production is consuming higher amounts of fossil-fuel energy, and airborne emissions from adhesives need to be controlled, the structural, technical, and economical advantages of these nearly homogeneous materials outweigh existing reservations. In the last two decades, cross-laminated timber (CLT) boards have supplemented the wood-based panels used traditionally in timber frame systems. They consist of several layer-glued softwood timber planks in which the direction of the grain in adjacent layers is perpendicular to each other. Their strength and physical properties and the production formats allow use of the the elements directly in walls and floors, thus reducing the number of layers required for framing systems. This will result in enhanced building flexibility, cost competitiveness, and eco-efficiency in terms of end-of-life options.

Triggered by the variety of new wood-based panels, the development of innovative byproducts such as adhesives, sealants, liner sheets, protective and fire-retardant coatings, fasteners, and connecting systems took place. Their integration upgrades the single materials to building systems. Although not regarded as main components, they play an important role in regards to quality as well as economical and ecological sustainability of the timber systems.

A further aspect of product innovation is related to the symbiotic combination of timber with other building materials. The use of relatively stiff materials such as concrete, steel, glass, or fiber-reinforced polymers (FRP), in combination with wooden elements, can significantly enhance the stiffness of timber structures and thus the overall capacity of the construction.

PROCESS INNOVATIONS

Modern and innovative timber construction firms have implicitly recognized that traditional project and site-based construction approaches are an incongruity. The firms have consequently established in-house prefabrication, including developement of lean production processes to ensure high quality and precision as well as effectiveness. Today, complete frame wall elements as well as whole building modules are prefabricated under controlled climate conditions, including all building equipment and services. Rational and high-capacity transport and crane systems are available for fast assembling on the building site. Dimensions of 4 meters in width and up to 20 meters in length are possible. The larger the elements are, the more efficient is the building process, because of reduced lengths of joints and connections.

Efficient prefabrication requires a high level of detailed pre-planning and standardized processes. Close cooperation between the sales, production and transport departments is necessary. Generally, this results in reliable delivery times and in higher product qualities. In addition, more and more companies invest in IT-automated technologies, enabling computer-assisted sawing and profiling techniques, laser-controlled manufacturing lines, and on-line design production. This goes in line with the availability of quality-controlled and technically defined wood-based products. Application of new technologies with high level of automation and standardization still allows a high variety in product design at acceptable costs. Despite the reduced assembly time at the building site, it is undisputable that each timber system company has an own and experienced team of construction workers to assemble the building. Prefabrication of elements has shown to be applicable not only for new buildings, but also in the improvement of heat insulation of historic facades.

The combination of prefabrication and lean building design of timber-based systems results in improved efficiency and cost-minimizing construction practices: construction cost tends to be a key determinant for choice of building material and construction technology. Minimizing construction costs is therefore a competitive necessity.

ORGANIZATIONAL INNOVATIONS

Owing to the adaptation of building policies, there is no formal policy barrier to the enhanced use of wood in European construction, including multi-storey apartment houses (Bregulla et al. 2003). Properly designed timber constructions are up to the task of fulfilling fire safety requirements for timber structures, but there still exist major differences regarding the use of timber as construction material in multi-storey buildings and the number of stories approved by national authorities. However, there are concerns that there may be local variations in building codes, and the forest products industry should be actively involved in removing this barrier in the EU and many North American states. Examples from many recent approvals to accept structural timber in multi-storey buildings are based on an organizational combination of active and passive fire-safety concepts, including efficient sprinkler systems, alarm sensors, encapsulation systems, and specifically protected evacuation and rescue pathways.

Life cycle costing and environmental life cycle assessment of multi-storey timber buildings are further aspects that require closer cooperation between the building practitioners. Recent comparative studies on the life cycle assessment and carbon footprint of multi-storey industrial buildings made of timber, steel, and concrete show the positive ratings to be expected for wood-based structures (Buchanan et al. 2012). It is obvious that such studies need to be supplied with proper and transparent data from the industries. It is also important to have data and knowledge on the long-term behavior of the multi-storey buildings. Thus, a quality control system that includes the planning, construction, and use phases and inquiring the satisfaction of the user is certainly recommended, to have a vital basis for technical improvements.

A related organizational innovation for multi-storey building management is to document in a user manual the technical and material details and the required maintenance work of the housing components. Because all the technical information is readily available from the manufacturing units, such a building manual will be a valuable source of information for the generation that is faced with the end-of-life utilization of the building components. Regarding the options for the future end-of-life utilization, a clear preference shall be given to the material-first use, which shall extend the carbon storage effect to other products. Today's timber system building companies can prepare for this strategy by introducing a design-to-reuse concept that allows easy dismantling of the components and refrains from the use of harmful substances in fire and protection treatments. It can be forecasted that a re-use or a recycling into particles and fibers of carbon-storing wooden materials will be a realistic option after the building has been dismantled. Any documentation about the original material composition and the auxiliary products used will be helpful for an efficient cascading of the biomass used in today's construction.

CONCLUSIONS

At the beginning of the 21st century, the world economy is facing serious challenges. The financial stability of important economic regions in the Western world is out of control while transitional countries with large population are economically growing and claiming their right to gain the same welfare and prosperity as Western nations. Populations in the developing counties are continuously growing, and further pressures on the availability and distribution of natural resources are forecasted. The fair, more efficient, and sustainable management of our natural resources and strategies to attenuate the negative effects of climate change are identified as key factors in the 21st century. Forest resources are expected to play an important role in this context, because of its renewability and regional availability, the many environmental

benefits provided during growth and use, i.e., its carbon storage function, and its multi-functionality. Using wood as structural material for energy-efficient and durable buildings is regarded to be the priority option in the forestry-wood value chain: process and heating energy is low, carbon is stored for longer times in the products, indoor climate is positively influenced, and the options for re-use and recycling as well as for energy use at the end of the material life cycle are preserved. In order to significantly increase the application of timber products in the building sector, multi-storey houses in urban environments are the target market, following the mission: plant a second timber forest in the cities. Wood product industries and the wood building companies have developed high-capacity products and processing technologies that allow, supported by a liberalization of construction policies in many countries, the production of multi-storey timber buildings of up to nine levels, generating a lot of public interest in local news media. It is now necessary to further refine the developed processes in order to reach economic competitiveness and to get multi-storey timber buildings accepted as a common and best choice building technique. This needs further innovations on the product, process, and organizational levels.

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KN04

KEYNOTE PAPER

Enhancing the contribution of nontimber forest products in supporting green economy and sustainable development in mountain countries

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ABSTRACT

Efforts to sustainably manage the world's nontimber forest resources, especially in the developing world, have not achieved the desired goals. Balancing the three pillars of sustainable development—social, environmental, and economic—has been one of the key challenges. Although the traditional impediments—population growth, poverty, and ignorance—continue to have an influence, new drivers of change such as climate change, globalization, and migration have added new problems and some opportunities. The markets for natural products, especially pharmaceuticals, food, and nutrition products, are growing. Medicinal and aromatic plant products alone are estimated to command a market of more than USD $80 billion. But with the rise in demand for nontimber forest products (NTFPs), there is also a rise in biodiversity loss and an increase in the number of poor people dependent on forest products for livelihoods. It is necessary to develop a sustainable growth strategy that can secure an equitable living standard for forest-dependent people while preserving ecosystem resources. For such a development model, which is now called green economy, the importance of natural capital or ecosystem services will be high. Here the role of NTFPs cannot be overstressed. Many local economies, especially in mountain ecosystems, are highly dependent on NTFPs and associated natural resources. Their role can be enhanced through green technologies and generating green jobs. Many countries—both developing and developed—already have institutions and governance systems that are implementing sustainable management of NTFPs, ensuring an equitable flow of benefits to the people involved. Many of these traditional institutions that have evolved over generations have led to a number of good practices that have been helping indigenous communities to cope with financial, ecological, and social changes and challenges, protecting against the consequences of unavoidable changes in the external environment. In the Hindu Kush Himalayan region, pro-poor value chain development pilots conducted by research and development organizations have been successful. With an expected increased investment in forestry, there is a real need for more systematic research and knowledge generation on the role and potential of NTFPs in assisting the attainment of sustainable development goals.

Keywords: nontimber forest products, sustainability, biodiversity, poverty reduction, green economy.

BACKGROUND

Mountains occupy 24 percent of the global surface area and are home to 12 percent of the world's population. They have ecological, socioeconomic, spiritual, and cultural significance, not only for those living in mountainous areas, but also for people living beyond (Schild 2008). The international community recognized the importance of mountains at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil in 1992 with the adoption of Chapter 13 in Agenda 21, which underscores the role of mountains in global sustainable development. Mountain ecosystems are among the most varied and richest in the world terms of species (e.g., Vare et al. 2003; Moser et al. 2005; Spehn and Korner 2005). Mountains support about one-quarter of the planet's biodiversity and have nearly half of the world's biodiversity hotspots (Singh 2011). Mountain systems provide niche habitats for many rare and/or endangered endemic species (ICIMOD 2011).

Mountain communities are mainly traditional societies. They have developed and maintained vast knowledge and experience on the use of natural resources including plant resources. Much of the mountain's rural economic activities, however, are based on unsustainable use of natural resources, resulting in deforestation, loss of biodiversity, and degradation of natural habitats. Cultural and traditional knowledge and values are also fast vanishing. Proper documentation and screening of traditional knowledge on natural resource management and use can improve forest resource management. The harmony between cultural diversity and natural resources developed through centuries, and the resulting culturally compliant utilization systems also needs to be studied and documented for wider dissemination and application.

The common factor that cuts across all forest and biodiversity dependent communities in the mountainous regions is the existence of high poverty and deprivation amidst rich biodiversity. Hence, there is a need to provide forest and biodiversity-based employment and sustainable livelihoods to the poor and marginalized communities, while ensuring conservation of forests and natural habitats, which are becoming increasing threatened. In this context, the role of nontimber forest products (NTFPs) becomes extremely important, because cutting and using timber products increases carbon intensity.

Sustainable use and management of biodiversity resources such as NTFPs is a high-priority topic in sustainable mountain development agenda. In recent years, the environmental and economic roles of NTFPs are becoming increasingly significant owing to better understanding and appreciation of their role in promoting low-carbon economic growth. Growing market preference for green and natural products and emphasis on efficient and sustainable use of natural resources has also highlighted the added importance of NTFP development. In recent years, NTFPs have gained much needed recognition along with the realization of the need to conserve forests and protect the trees and wild animals. In many countries, proper harnessing of NTFP resources has been providing a powerful incentive to local communities to protect forest tree cover while harvesting forest undergrowth only. In fact sustainable management of NTFPs has been helping to achieve sustainable management of forest resources in many countries.

CURRENT STATUS OF THE KNOWLEDGE IN NTFP MANAGEMENT

There is no universally accepted definition of the term 'nontimber forest products'. FAO uses the term 'nonwood forest products' and defines them as "products of biological origin other than wood derived from forests, other wooded land, and trees outside forests; they may be gathered from the wild, or produced in forest plantations, agro-forestry schemes and from trees outside forests" (FAO 1999). Ahenkan and Boon (2011) have done an excellent compilation and analysis of the semantics and the difficulties in defining NTFPs. In some countries, NTFPs are also referred to as minor or special forest products (Hammett 1999). In some definitions, NTFPs include nonconsumptive ecosystem services enjoyed by humanity such as ecological/environmental, cultural and religious, and tourism and recreation values (Walter 1998).

In this paper, the NTFPs found in mountain and hilly ecosystems are considered to comprise nontimber floral, faunal, and recreational products, including fuel wood, wood crafts, animal fodder, and compost materials; medicinal, aromatic, and dye plants; wild mushrooms, floral greens, decorative greenery, and wild foods (nuts and seeds, berries, oil seeds, etc.); craft species; and products of ecotourism value derived from forests, rangelands, and protected areas. They also include game animals, furbearers, etc. NTFPs are increasingly considered high-value ecosystem goods and services that can transform the economies of forest-rich developing countries into low-carbon or green-growth-based economies. This is the main argument of this paper.

LIVELIHOOD IMPORTANCE OF NTFPS IN MOUNTAINS

Poverty in developing mountainous countries is generally linked with small, fragmented, or no land holdings, accompanied by low productivity. Dependence on collection and gathering of NTFPs from forests to ensure food security goes largely unnoticed, and is not accounted in the calculations of gross national product. Some of the products meet a global demand (e.g., edible nuts, honey, bamboo, and cane products); others reach specific markets (e.g., crude herbs, aromatic and chemical products), while some NTFPs are collected and consumed locally. Forest-dependent communities across the mountainous regions derive their sustenance from NTFPs in periods of financial stress, and have used them as raw materials for producing items of daily use in normal times. In least-developed mountainous countries such as Nepal, Bhutan, and Myanmar, NTFPs provide food, medicine, nutrition, and cash income to poor and vulnerable households. NTFPs are extracted primarily from the wild for meeting the food, medicine, and supplementary cash needs for the subsistence of poor households in these countries. NTFPs such as bamboo and rattan are also used in rural and urban homes for construction and manufacturing purposes, and are traded in local, regional, and international markets. The role of the medicinal and aromatic plant resources in the economy of developing countries becomes even greater when high-value service sectors such as health, neutraceuticals, organic and certified products, and ecotourism are taken into account and linked to overall sectoral development of forest conservation and development (Karki 2003, 2004; Karki et al. 2004);

MARKET POTENTIALS AND CONSTRAINTS

It is estimated that more than 150 NTFPs are traded in international markets (FAO 1997). Among these, medicinal and aromatic plant products alone are estimated to command a market of more than USD $80 billion (Karki and Nagpal 2004). The World Health Organization (WHO 2002) estimates that 80 percent of the global population relies on plant-based medicines for primary health care needs. Agrawal (2009) estimates the global market potential for NTFPs to be as high as USD $225 trillion by 2050. It is clear that NTFPs, besides providing multiple intangible benefits, also have huge economic potential and generate cash incomes, particularly for women and families that do not have access to agricultural lands and major markets, particularly in developing countries. However, the inadequacy of market-related information and negotiation skills with the upstream producers in dealing with market forces, as well as unequal power relationships or lack of a level playing field between buyers and sellers, disadvantages the growers, collectors, and local traders of NTFPs in mountainous regions. The supply chain of NTFP products is unnecessarily long, with a large number of commission agents eating into the returns that could go to the farmers. These are the major obstacles to the small-scale producers and growers of NTFPs that prevent them from benefitting from higher values. Forest users, landowners, harvesters and processors, and policymakers can influence how NTFP resources are managed through the knowledge, practices and policies they suggest, design and implement, if they can all work within one single framework linking producers to markets and consumers.

The annual revenue from the sale of more than 33,000 tonnes of NTFPs is estimated to be between 13 and 26 million USD (GoN 2010). Most of the products are exported to India in crude or semiprocessed form. But in the last few years, semiprocessed or processed NTFPs are being exported to both India and other countries. Essential oils are the major exported commodities among processed herbs that are extracted from more than 18 aromatic plants (Prakrit 2007). The oils are mostly exported to Japan, the US, Germany, Belgium, and many other countries.
The other NTFPs exported are handicraft items whose value was about Rs 300 million in 2004/2005 (Acharya 2006). The NTFPs thus are the major exports of Nepal. Nepal however also is one of the biggest consumers of processed medicinal products, most of which are imported from India, which is growing at an annual rate of 20 percent, (Ghimire et al. 2008a,b). Therefore, there is a tremendous possibility of improved management, processing, and value addition of herbal products and other NTFPs in Nepal that can help alleviate poverty by creating income generating opportunities locally (based on WWF, Nepal).

EMPLOYMENT, HEALTH AND INCOME POTENTIAL OF NONTIMBER FOREST PRODUCTS

The NTFP sector is a very important source of rural employment. According to FAO (1997, 1999), NTFPs contribute about 50 percent of forest revenue and 70 percent of income through export of different food, medicine, and aroma products (Sekar et al. 1996). In India, the NTFP sector, including bamboo and rattan, medicinal plants, and other subsectors, is estimated to employ poor people for more than 100 million person days (Tewari 2004) mainly in rural areas; about 200 to 300 million villagers depend on NTFPs to varying degrees. NTFPs also contribute 10 to 40 percent of income to the 50 million tribal households in India (FAO 1997). In Indonesia, the rattan industry has been providing employment for 200,000 people. Large numbers of people are employed in Vietnam and Bangladesh. In Malaysia, the rattan subsector is

a major source of employment and was estimated to contribute 14.8 percent of the economic activity in the country (FAO 1997). In Nepal, rural mountain communities derive up to 50 percent of their total family income from NTFPs (Pyakurel and Baniya 2011). Thus NTFPs can significantly help in livelihood diversification of vulnerable mountain communities affected by downturns in other resource sectors as a result of land and forest degradation, which is often aggravated by growing climate variability.

Ayurveda, the oldest medical system in the Indian subcontinent, and traditional Chinese medicine (TCM) have alone reported using approximately 2,000 to 3,000 medicinal plant species. The Charak Samhita, an ancient handwritten document on herbal therapy in India, reports on the production of 340 herbal drugs and their indigenous uses based on wild collection of NTFPs (Prajapati et al. 1993). Worldwide, it is estimated that approximately 25 percent of all pharmaceutical drugs are derived from plants, and many others are synthetic analogues built on prototype compounds isolated from plant species (Rao et al. 2004).

GREEN ECONOMY: KEY ISSUES IN MOUNTAINS

A green economy is defined by the United Nations Environment Programme (UNEP) as one that results in 'improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities'. Accordingly, the basic requirements of a green economy are low carbon production, resource efficiency, and social inclusiveness.

To date, there is no unified view among the mountainous countries on what represents and drives a green economy and there is also no clarity on what it means for the mountains. The green economy concept offers ample opportunities for application in mountain ecosystems simply because mountain ecosystems and production systems are already largely low carbon or 'green'.

There is therefore a need to come up with specific and strategic approaches to implement green and low-carbon economy concepts in the mountains, and to identify opportunities from developing and least-developed country contexts for promoting green economics. There is also a need for new global policies and finances to support poverty reduction and sustainable development through green economics and good governance solutions. The key outcome that can be desired for mountains in a green economy is an ecosystem services-based economy that is both pro-poor and pro-growth and addresses the issues of ecological fragility, social inequity (creating employment for the poor and reducing inequality and marginality) and economic development (by reducing poverty and costs of living) through interventions owned and managed by mountain communities and supported by national and regional agencies.

There are also risks and constraints in promoting green economics on a mass scale. Green and low-carbon solutions in mountain regions need to create jobs, help produce surplus quality products, promote access to national and international markets, and prioritize poverty reduction, good governance, and equity in the supply/value chains. Further, the transition to a green economy in developing and least-developed mountain countries should not constrain countries from pursuing their own development paths.

There is a need for a separate programme of work for promoting green economy in mountains under the UNCSD process, one that develops green growth pathways that recognize the proper value of natural capital and rewards mountain farmers and other resource users for their sustainable practices in producing ecosystem goods and services, including ecotourism-related benefits.

GREEN ECONOMY: OPPORTUNITIES THROUGH NTFP MANAGEMENT

The green economy we talk about today has been around for a very long time. Communities and societies in forest- and biodiversity-rich developing countries that were forced by technological and other resource constraints and by the inaccessibility, marginality, and fragility of their environment to live at subsistence level have developed cultural norms, social contracts, and management systems to ensure their livelihoods and the sustainability of the resource base. The original idea of the green economy as developed by ecologists and environmentalists was largely based on sustainable extraction and utilization of natural products while meeting high social standards. This approach, however, was limiting the kind of economic growth that the current green economy approach expounds. Medicinal and aromatic plants (MAPs) conservation and development and organic agriculture efforts practiced in Bhutan, India, and Nepal provide examples of growth models based on this kind of economic development approach. Karki (2011) recently conducted a comprehensive assessment of successful case studies in the Asia Pacific mountain regions in the context of sustainable mountain development in which forest and NTFP management figure prominently. The case studies suggest that NTFPs are the most important biological resources for socioeconomically uplifting poor and marginal communities.

NTFP sector development has impact on all three pillars of sustainable development—ecological, economic, and social—in a balanced manner. NTFPs meet the criteria for green economy and green growth in that the resources are plentiful, management technologies are simple and accessible to poor and enterprising communities, and markets (especially for herbal medicines, neutraceuticals, and organic food) are growing worldwide.

NTFP-BASED GREEN ECONOMY: CHALLENGES AND OPPORTUNITIES FOR MOUNTAINOUS REGIONS

Mountainous countries will face numerous challenges in adapting and adopting green economy policies. Different countries are interpreting green economics differently and are embarking on different approaches to promote green growth concepts and practices for sustainable development. Green economics can be a means to achieve sustainable development in mountains, and NTFPs can provide a head start. However, the common challenges mountain countries are confronting or will face in future are: How to document good green-economy-relevant NTFP management cases on which the future development pathways can be charted? How effective are the current approaches, and what lessons can be learned from the experiences, particularly in terms of management systems, and their successes and failures? Although NTFPs can be viewed from the perspective of economic development, they must also be considered in terms of biodiversity conservation. The supply of wild plant NTFPs is dwindling given the threats of increasing demand, a rapidly increasing human population, and rampant destruction of plant-rich habitats.

Medicinal and aromatic plants provide a good example. At the current rate of consumption and use, the status of many medicinal plants is severely threatened, with risk to future benefits and knowledge. Although cultivation is playing an increasing role in the supply of MAPs, most will be obtained from wild collection in the foreseeable future; thus their sustainable management is essential. There is no 'Golden Rule' that can be applied universally to ensure conservation and sustainable medicinal plant management, because what is defined as conservation and sustainability will vary with type of plant, part used, locality, and other factors.

Bhutan banned the export of medicinal plants and other NTFPs in 1988 as a measure to conserve biodiversity and to prevent uncontrolled exploitation of these resources. The 'Framework for Collection and Management of Non-Wood Forest Products' (RGoB 2009) has permitted communities to collect medicinal plants and other NTFPs for noncommercial uses, considering conservation and sustainability of the resources. The government has identified seven species as 'extremely rare' and 26 species as 'rare' and has launched conservation and management initiatives for protecting them.

In China, the State has protected 116 species of medicinal plants used in TCM (CCTHM 1995). The government has proposed six large Important Plant Areas (IPAs) for medicinal plants and other NTFPs in the Chinese Himalayan region, covering an area of 434,200 km^2 (Hamilton and Radford 2007). There are 2,400 nature reserves covering 14.8 percent of the total land and 60 percent of the country's plant species that are designated for in situ conservation and management for sustainably harvesting medicinal plants benefiting the local population. Regarding ex situ conservation, there are 10 state-managed Medicinal Plant Gardens and Germplasm Banks; 220 Botanical Gardens (2006), about 5,000 species of medicinal plants and other NTFPs cultivated in these botanical gardens (Pei and Sajise 1993).

In India, Conservation Assessment and Management Plan (CAMP) workshops, following the IUCN criteria, have been organized in major parts of the country, including all the Himalayan states. The National Medicinal Plants Board (NMPB), chaired by the Union Health Minister, was established in 2000 and has prioritized 31 species of medicinal plants for conservation, management, and cultivation. State-level Medicinal Plants Boards have been established in 26 states of the country. Considering the state-level activities for conservation and management of MAPs/NTFPs, in 2004 Uttarakhand declared itself as an Herbal State with a plan of action for the conservation, management, and development of the NTFP sector. The Uttarakhand state government has prioritized 26 species of medicinal and aromatic plants for conservation in the wild and for cultivation. The state is also supporting farmers for cultivating the 26 prioritized species with 50-percent assistance on cultivation cost up to a maximum of 1,000,000 Indian rupees (USD 2000). By 2010, about 8,000 private organic herbal farms had been registered. The state government has established large number of medicinal plant nurseries and provides free planting materials for registered farmers and Van Panchayat (Forest Council) members as a strategy to enrich plantations in the forests. In 1998, the Government of Sikkim imposed a ban on grazing in reserved forests, plantation areas and around water sources areas, and in 2000 it imposed a total ban on lopping of selected trees and collection of selected medicinal herbs. Sikkim has brought 34,000 farmers cultivating 18,000 ha in the organic farming regime.

The Government of Nepal has imposed different levels of restrictions in the collection, trade, and export of some of the highly traded medicinal plants to safeguard them in the wild, and to promote cultivation practices. The CAMP workshop (Tandon et al. 2001) evaluated 51 commercial MAPs and NTFPs for their status in the wild. In 2000, Nepal established the high-level Herbs and NTFP Coordination Committee (HNCC), chaired by the Minister of Forests and Soil Conservation, to formulate and implement MAP/NTFP-related policies and to streamline the NTFP sector in the country. The Herbs and NTFP Development Policy 2004 is a milestone in the country's strategy to conserve and sustainably manage the MAPs and NTFP sectors. It includes six policy objectives, five policy groups, and 28 development strategies. In general, the policy identifies national challenges, opportunities, and priorities, and provides an outline for moving forward. The HNCC has prioritized 30 species of medicinal plants/NTFPs for conservation, research, development, and management, including 12 species recommended for cultivation.

Pakistan, in 2001, assessed the threat of 52 species of commercial medicinal plants following the IUCN criteria. Later in 2010, the government prioritized 24 commercial medicinal plant species (including 12 endangered and 12 vulnerable species) and has made provisions to conserve and manage them through different administrative and management units.

AREA FOR IMPROVEMENT: VALUE CHAIN DEVELOPMENT

The world market for natural products and organically derived NTFPs, including medicinal plant products, has been increasing, and consumers have become more conscious of the source and quality of the products they purchase. According to FAO, organic trade is expanding at the rate of 15 to 20 percent per year, and more than 100 countries currently export certified organic products (Choudhary and Bhattarai 2008). However, the global trade in organic products is hindered by a multitude of standards, regulations, and conformity assessment systems. There are currently two international standards for organic agriculture: the FAO/World Health Organization (WHO) Codex Alimentarius Commission Guidelines-based standards, and the International Federation of Organic Agriculture Movements (IFOAM) basic standards. This means that products certified as organic in one system may not be easily recognized as organic under another, causing problems and increased costs for organic producers and exporters who want to sell in different markets.

The potential for small holders and other marginal community groups to diversify and enhance their livelihoods is particularly significant when harvesters become involved in 'value addition' activities associated with the packaging of goods or the manufacture of secondary products, and when they engage in responsible trade of medicinal plants and other NTFPs. Investigating the market and the means to access it can enable NTFP cooperatives and other farm organizations to understand opportunities and develop strategies to meet the needs of its members and buyers. The objective is to create economic enterprises in which the livelihood base and activities of entire communities are upgraded—and not just a few micro entrepreneurs. Clearly, providing a delicate balance between the two depends on socioeconomic and cultural factors as well as the more obvious technological and biological support systems.

At the local level, improved marketing requires capable organizations such as cooperatives or other farm associations. These organizations can help take decisions of common interest and undertake collective actions. By working together, members of an organization can gain bargaining power with traders and middlemen and maximize their incomes. An organizational marketing strategy can also help reduce risks for producers.

A number of factors influence the ability of producers to respond to customer needs and wants. Some can be influenced by farmers and producers while others are beyond their control. Although small-scale farmers have some marketing skills, they could benefit from the specialized expertise and more efficient marketing made possible through marketing associations. This means that capacity building is needed at village, regional, and national levels to identify promising NTFPs and to manage their harvesting, production, and marketing. Extension workers, nongovernmental organizations, and community leaders can be important agents for introducing marketing to small farmers.

Local knowledge about plants and the innovation system of individuals and communities can be useful tools in search of new ways of conserving and using NTFPs for the benefit of mountain communities themselves as well as for achieving wider sustainable development goals. The approach has to document this knowledge and apply it to bridge the gap between the understanding and needs of government agencies, the public sector, local communities, and the private sector based on systematic NTFP knowledge management. One aim is to provide local NTFP users with viable incentives to refrain from unsustainable harvesting and of NTFPs while providing local and national economic benefits.

ICIMOD has pioneered development of commodity-wise value chains for selected NTFPs in the Hindu Kush Himalayan region. ICIMOD has developed a mountain-specific value chain approach and framework for more participatory and equitable engagement of collectors, producers, local traders, and processors in NTFP value chain development and livelihood improvement.

One project, for example, analysed the prevailing supply chains of Cinnamomum tamala (Indian bay leaf) in Nepal and India (Choudhary et al. 2011). Through awareness raising, training, and capacity building of both producers and buyers, it helped establish a business partnership between poor producers and markets trading in essential oils and spices. This has doubled the income of producers in the Chamoli district of Uttarakhand, India, and the Udayapur district of Nepal. A detailed analysis showed that around 900 tonnes of raw bay leaves were harvested in Udaipur district, Nepal, and 20 to 40 tonnes in the Indian project sites were produced and exported annually. In the Nepal case, a local company, with a buy back relationship with local producers, was using nearly 25 percent of the total bay leaf, producing essential oil. An estimated 2,150 tonnes of bay leaves were sent from Nepal to India every year. Farmers in Nepal earned a gross margin of 11 percent, and traders 34 percent; collectors in India had a margin of 10 percent, and traders 17 percent. The bay leaf value chain has shown that by addressing underlying inequality and power differences between the upstream producers and downstream actors, we can achieve better equity in benefit sharing.

Some of the key issues identified were lack of organizing skills among the producers, lack of market information and access to producers, absence of technologies for value addition, lack of sustainable harvesting and management skills, lack of capacity to conform to market requirements, policy hurdles to access to NTFP resources on government land, and bureaucratic hurdles. Interventions were identified based on the issues identified, using a multi-stakeholder approach integrating poverty and gender dimensions. Market information, especially product prices, was gathered systematically. Partnerships between concerned government line agencies and the research team focused on building the capacity of local institutions in skills such as collection, grading, sorting, and packaging of bay leaves. Training programmes also focused on group formation, bay leaf cultivation and management, sustainable harvesting, and community-based enterprise development. Networks of buyers, local traders, and exporters and producers were formed and strengthened. An effort to improve access to markets by bringing them closer to the production sites was piloted in India.

The value chain interventions led to immediate benefits for the poor producers in terms of increased income, increased knowledge and skills, and gender equality. The outcomes could also be seen in improved education and health of the children of the producer families. Improved harvesting practices lead to improved quality of raw materials and finished products.

With the market for NTFPs, especially medicinal plants, growing in South Asia and particularly in India and China, ICIMOD is scaling up and scaling out these experiences and promoting cross-border learning and sharing of good practices.

CONCLUSIONS AND RECOMMENDATIONS

An NTFP-based green economy not only means products and income, but also provides a basis for integrated and sustainable management of forest resources. Taking the concept forward would call for a balanced and holistic approach to forestry, as well as fundamental institutional changes. Technical inputs combined with traditional knowledge produce an adaptive technology that is based on the cultural, social, environmental, and economic factors that are relevant to the local population; if adopted systematically, it can improve livelihoods.

Local knowledge about plants and the innovation systems of individuals and communities are useful in the search for new ways to conserve and use plants for the benefit of the communities as well as for achieving wider development goals. Given the overlapping benefits of enhancing access to health care, providing livelihoods, and encouraging sustainable use of the environment, it is clear that work to promote the conservation and management of NTFPs and to build on traditional practices can make valuable contributions to achieving the general social advances spelled out in the Millennium Development Goals.

Much has been said about the impact of liberalization on the lives of the poor. But what is really needed is to undertake liberalization from the point of view of the poor. If technology is improved, collection and trade channels are rationalized and made efficient, and the appropriate processing facilities developed in the producing countries, it will be possible to bring about positive change. It is also necessary to develop new products and new uses for known products, with a clear market orientation. In addition, the new attitude of green consumerism resulting from the concern for environmental conservation and the consequent preference for natural products is providing new advantages for NTFPs.

A systematic approach to enhancing the contribution of NTFPs should involve the usual planning cycle: formulation of objectives, preparation of strategy, planning, implementing, monitoring, and appraisal. It requires that managers understand the resource status, that all stakeholders participate in decision making and cost and benefit sharing, and that effective procedures are implemented to resolve conflicts. Finally, policymakers and development agents need to better understand the changing role of forest resources, especially NTFPs, for local livelihoods.

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Competing in the Global Economic Recession

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ABSTRACT

The financial crisis that started in mid-2008 has led to a subsequent economic recession. Although officially declared over, global financial degradation may result in a 'double-dip' recession with no substantive relief in the near term. Consequently, fundamental shifts within global forestry and the forest industry sectors have taken place with disruptions, dislocations, and uncertainties felt through the entire chain from the forest to markets. This is the worst downturn for forest products markets since the first oil crisis in the 1970s. Manifestations have included decreased demand, fluctuating prices and changed exchange rates, increased competition, overcapacity, low profitability, wood supply problems, and competition for raw materials exacerbated by the emerging bio-based energy sector. Although the ability of the forest sector as a whole to experience strong growth during the recession and when recovery begins is doubtful, there are many actions that individual companies can take to create competitive opportunities during the crisis and solidify position when markets strengthen. This paper presents specific actions that can be taken to create or maintain competitive advantage across the forest sector supply chain in this time of crisis.

INTRODUCTION

The macro-environment surrounding the global forest products industry has undergone drastic changes in the recent past. Such changes span from economic to environmental domains. More specifically, emergence of low cost producers, changing trade flows, and an increasing pressure from social and environmental stakeholders, have pushed the global forest sector from being predominantly oriented toward resource extraction and commodity production to embrace an evolved view that better aligns companies with changed expectations. At the turn of the century, many argued that the global sector would operate under what would later be called a green economy, and that the industry would move from an extraction to conservation-based paradigm. For example, forest certification, corporate social responsibility, and carbon markets have all entered the common lexicon of forest resources-based corporate sectors. However, a more conservation-leaning paradigm does not supplant the need for efficient and effective sustainable extraction and processing methods and business management. As the forest products industry was adjusting to these new social and environmental influences, the global economy was hit in 2008 by what would be known as the Great Recession.

The Great Recession, which according to many sources is officially over (The Economist, 2010), continues to reverberate through the global economy. Many fear that a 'W' shaped recession is possible, or that an 'L' shaped prolonged downturn with little growth might be the ultimate path of the economy in the near term (Olson, 2010). The Great Recession has negatively affected nearly all business operations across industries, leaving most companies around the world with reduced organizational resources, lowered inventory, curtailed technology spending, scaled-down core processes, reduced demand for their products, and constrained investment flexibility (Olson, 2010).

As the world emerges from the global recession, one thing that has become clear is that the ability to develop or maintain excellence will ultimately decide which entities survive and remain at the forefront of sustainable success. As has been true with every downturn in the past, the current economic recession presents challenges as well as opportunities. Previous recessions have shown that downturns can create organic and inorganic growth opportunities that are different from those arising in boom times. Some companies indeed are finding opportunities in the aftermath, by entering markets where competitors have weakened and hiring talent that would otherwise not have been available (McKinsey and Company, 2009). Many companies that acted proactively in autumn 2008 or before were able to cushion themselves against the adverse effects of recession, and although they may have sustained lower short-term earnings, are better positioned for survival relative to their peers. It is imperative that post-recession strategies and business practices are honed and executed in order to build corporate strength and resilience.

Moving forward, companies will seek to create competitive advantages and in so doing they will adopt different strategic postures alongside making a variety of strategic adjustments. Although the future of the sector remains unclear, it is important to magnify some key areas at the intersection of economic recession and company responses. In this paper, we outline some key strategic considerations that may help companies both to prepare for and navigate through the crises that downward business cycles present. We begin with a suggestion for in-house business cycle forecasting capabilities to be adopted to better prepare companies for economic shocks. We then draw from previous research and briefly outline how various strategic postures during a recession can affect companies' post-recession performance. In the section that follows, our focus is on the leadership structures conducive to post-recession success, and finally, we discuss some key areas and strategies that can help ameliorate negative changes brought on by the Great Recession.

DEVELOPING A BUSINESS CYCLE ORIENTATION

As opposed to a traditional view suggesting that business cycles couldn't be predicted, an emerging research area focuses on developing tools and strategies for advancing business-cycle management (Navarro, 2004; 2009). The literature suggests that companies must focus on developing and deploying forecasting capabilities, not leaving business cycle forecasting to outsider economists. For example, managers can forecast business cycles by monitoring GDP forecasting equations, stock market trends, and shapes of bond-market yield curves. Together,

these three tools have a well-researched predictive power for business cycle forecasting. In addition, Economic Cycle Research Institute's Weekly Leading Index and The Conference Board's Composite Index of Leading Indicators have provided signals for previous recessions.

In order to develop this business cycle orientation within their companies, managers of forest product companies must proactively engage in understanding macroeconomic issues and focus on improving financial market literacy.

RESPONDING TO RECESSIONS TO MAXIMIZE COMPETITIVE ADVANTAGE

Companies respond differently to economic downturns and pursue different strategies to deal with challenges while remaining competitive. Gulati et al. (2010) classifies companies into four distinct types:

1. Prevention- focused companies—those making primarily defensive moves, more concerned about avoiding losses and minimizing downside risks.
2. Promotion-focused companies—those investing more than their peers in offensive moves.
3. Pragmatic companies—those combining defensive and offensive moves.
4. Progressive companies—those deploying an optimal combination of defense and offense.

Based on their analyses of 4,700 public companies during the past three global recessions, the authors conclude that only about 9 percent of companies come out of a recession stronger than pre-recession levels. Figure 1 summarizes post-recession financial performance of the four different company types.

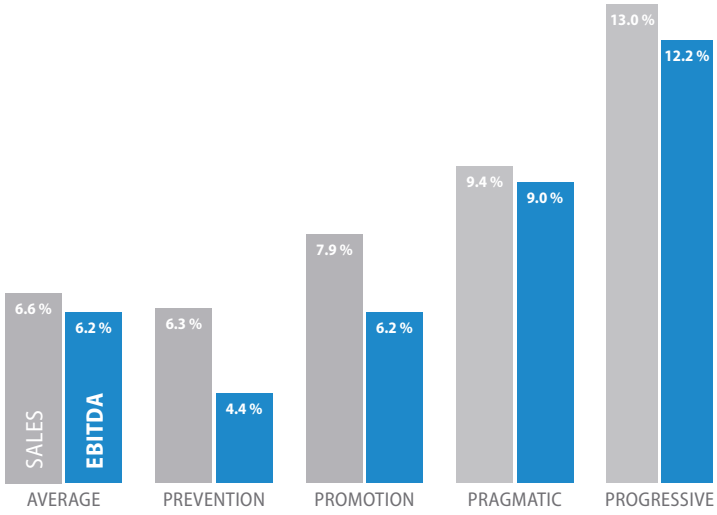

Figure 1: A comparative illustration of the post-recession Sales and Earnings before interest, taxes, depreciation, and amortization (EBITDA) of the four company types (Source: Gulati et al., 2010)

Progressive companies—which deploy an optimal combination of prevention and promotion moves—fared better than companies that are prevention-focused, promotion-focused or those that combine prevention- and promotion-focused approaches (pragmatic). To provide a specific characterization of progressive companies, Gulati et al. (2010) distilled the prevention and promotion strategies into three different combinations of two factors each. As such, prevention-focused moves may include an exclusive focus on either employee reduction or operational efficiency, or a combination of both. Similarly, promotion-focused moves may include an exclusive focus on either market development or asset investment, or a combination of both. A combination of the preventive and promotion focused moves provides a matrix of nine strategic postures (fig. 2). It may be noted from the figure that the optimal combination of prevention and promotion approaches is achieved when a company focuses on increasing its operational efficiency while simultaneously developing new markets and enlarging its asset base.

		PROMOTION-FOCUSED MOVES		
		MARKET DEVELOPMENT	ASSET INVESTMENT	BOTH
PREVENTION-FOCUSED MOVES	EMPLOYEE REDUCTION	**GOOD** SALES 4.6 % EBITDA 6.6 %	**BAD** SALES 3.9 % EBITDA 3.3 %	**WORST** SALES 3.3 % EBITDA -5.2 %
	OPERATIONAL EFFICIENTY	**GOOD** SALES 7.1 % EBITDA 4.2 %	**GOOD** SALES 8.4 % EBITDA 8.4 %	**BEST** SALES 13.0 % EBITDA 12.2 %
	BOTH	**BAD** SALES 5.2 % EBITDA 2.1 %	**BAD** SALES 5.2 % EBITDA -0.5 %	**GOOD** SALES 9.2 % EBITDA 4.6 %

Figure 2: Post-recession financial performance associated with different combinations of company moves during recession

LEADERSHIP AND COMPETITIVE ADVANTAGE

Reeves and Deimler (2009) emphasize that typical company responses during an economic recession include shrinking production capacity, downsizing labor force, reducing discretionary spending, and conserving cash. This 'hibernating' reaction, they argue, is a time-tested proposition and works well if the recession is short in duration. However, regarding the current recession, a growing consensus among economists, business leaders, and governments suggests that the world is in the midst of a prolonged slowdown of unpredictable duration and that even when the upturn comes, the post-crisis strategic and operating environment will almost certainly be quite different.

In the same vein, Heifetz et al. (2009) suggest that the economic recession must not be viewed simply as a rough spell that is over. While the 'emergency' phase of recession is over, wherein companies primarily needed to buy time while striving to stabilize their situation vis-à-vis the external environment, what lies ahead is an 'adaptive' phase of the crisis wherein companies will need to address the underlying causes of the crisis and at the same time build the capacity to thrive in a new reality. Survival strategies—such as shrinking production capacity, downsizing labor force, reducing discretionary spending, and conserving cash—may help companies buy time, but they are not likely to foster sustainable competitive advantage.

In essence, it is argued that organization will not automatically return to normal in the post-recession period. The leadership within organizations instead will have to strategically steer their organizations out of crisis. Organization leaders will need to acquire three fundamental skills: (1) fostering adaptation within their organizations by helping employees identify and develop new practices needed to move forward in the new context; (2) embracing disequilibrium by creating a sense of urgency among employees while simultaneously managing their anxiety so that they do not fight, flee, or freeze, and (3) generating leadership by encouraging people at all levels of organization to lead experiments that will help the organization adapt to changing times. Also, as recovery continues to be slow, it is important to develop an organizational culture that fosters trust between management and employees and among employees.

Owners and CEOs of forest companies must focus on honing their adaptive leadership skills. A reactive posture of waiting for an organizational situation to improve with an improvement in economic conditions will not help organizations out of the crisis. Corporate leaders must recognize that the current crisis brings a point of inflection in global economy—the world after it is unlikely to resemble the one before it, and that they must adapt to lead their organizations in the 'new normal' (Gulati et al., 2010).

INDUSTRY SOPHISTICATION

The recession has changed much for companies but what remains unchanged is a continued necessity for companies to focus on understanding the changes taking place in supply and customer chains, identifying new sources of competition, understanding factors that shape purchase decisions, and learning how to become a source of value to customers (Brown, 2009). Firms in this new market landscape will be confronted with the need to find new rules for seeking economies of scale, reducing development-to-market cycle times, and improving customized product servicing. It is striking that in 1950, there was a 71 percent probability that the top five market-share leaders in a sector were also among the top five for operating margin. By 2007, that likelihood had dropped to 31 percent (Reeves & Deimler, 2009). Sophistication and capabilities have become more broadly diffused although clearly, opportunities for differentiation exist.

While recession has stressed companies in a variety of ways, it also has brought some opportunities that innovative companies may explore and exploit. For example, companies may consider introducing new services, such as financing, that could enhance their value proposition for budget-strapped customers (and final consumers). In addition, forest sector companies must continue to pursue developing technology competence as a source of competitive advantage. In order to develop these capacities, forest products companies must focus on building core competencies at the convergence of market orientation, learning orientation, and entrepreneurial orientation. In practice, developing these core competencies will require not only a shift in top management mind-set but also a significant investment in managerial training and competence development.

Across sectors, technological improvement in the forest products sector has remained at a relatively modest level during the last 40 years. Although some areas such as the use of scanning technology and robotics remain cutting-edge, technological application has not matched the industry need for improving its overall efficiency. Bill Gates once said, "The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency." In the forest sector, this dictum clearly indicates a need to focus on innovation in technology adoption, which in turn, necessitates investment in technology related R&D as well as in advancing a technology-savvy workforce. Hansen (2010) notes the Finnish Forest Cluster Research Program Wood Wisdom and suggests that such programs may provide replicable models for enhancing industry's R&D capacity in a clustered and institutionalized fashion.

Finally, while companies continue to build and harness their core competencies, they must also be wary of core rigidities—the dysfunctional flip side of core competencies—that might hamper innovation and new product development. Similarly, forest companies must focus on enhancing strategic flexibility (Grewal and Tansuhaj, 2001) that would allow them to promptly change their strategic posture and competitive moves in a dynamic and turbulent business environment.

MANUFACTURING

Michael Porter (1987) suggested that a proper link between strategy and manufacturing operations is a key to developing sustainable competitive advantage. To be successful in this globally competitive, rapidly changing environment, organizations must formulate strategic plans that are consistent with their investment in and use of manufacturing technology. In 1969, Wickham Skinner wrote, "a company's manufacturing function typically is either a competitive weapon or a corporate millstone. It is seldom neutral." More recent writings promote the strategic importance of creating and maintaining an appropriate base of manufacturing assets to achieve the competitive capabilities that insure long-term success.

In addition, investing in advanced manufacturing technology (the application of computer-enhanced science to a firm's production system) provides resources that enable a firm to respond to rapid market change and adapt to shorter product life cycles. Producing high-quality, custom-designed products using a manufacturing technology platform can also help achieve economies of scope (Vonderembse et al., 1995).

Specific to key forest products sectors, the conventional approach for improving profits in the lumber and plywood industries is either to improve volume recovery or increase the volume of logs passing through the mill. Today, as the competition for saw logs and peeler logs is getting fiercer and raw material costs are rising, constituting an increasingly higher percentage of the total costs for mills, it has become ever more important for lumber and plywood mills to focus on value recovery and quality of products rather than just outgoing volumes. This was evident when, on average, there was a 22 percent increment in the efficiency of saw mill recovery from 1970 to 2006. This increment was a result of process improvements in chipping technology, thinner kerf saws, curve sawing, and computerized scanning and 'optimization' technology, which have led to better recovery of higher value co-products (Meil et al., 2007). In the plywood sector, manufacturing advances include the use of power drive rolls to decrease spinout, the advent of better lathe technology (which can minimize peeler core diameter), and the use of laser enhanced clipping to aid in the recovery of usable veneer. In the furniture sector, in contrast with making a dichotomous choice between customization and mass production, firms will likely enter an area of mass-customization. Successful firms will develop sophisticated integrated information management systems that aggregate customer preferences, technological adaptation, production economies, delivery schedules, servicing, and end-use improvisations.

SUPPLY CHAINS AND LOGISTICS

A supply chain is the set of business processes and resources that transforms a product from raw materials into finished goods and delivers those goods into the hands of the customer. Supply chains are undergoing a degree of change that rivals the transformation that occurred in the industrial revolution. Historically, companies leveraged a variety of factors to differentiate themselves from their competition, including product features, price quality product availability, and customer service. In today's dynamic market, companies can no longer exploit the same drivers, or must exploit them differently, in order to remain competitive. The nature of competition has forever changed, and more significant change will occur going forward. The confluence of several factors is driving this change, such as shrinking product lifecycles, the Internet, cooperative supply chains, etc. (Sturim, 1999).

Supply chains must deliver the traditional cost-related benefit plus responsiveness, security, sustainability, resilience, and innovation. In recent years, many companies have increasingly relied on their supply chains as a source of new products and processes or improvements in existing ones. Organizations' key innovation tasks have been performed not only internally but also in collaboration with supply chain partners. Supply chains should provide one or more of six basic outcomes: 'cost' responsiveness, security, sustainability, resilience and innovation. Reducing price (initially) and cost (ultimately) are the key objectives. This 'cost' outcome is a combination of monetary cost (the primary performance criterion) and delivery and quality (Melnyk, 2010).

To support supply chain management, Logistics Information Technology (LIT) applications are typically deployed. LIT is used for planning, implementing, and controlling procedures for the transportation and storage of goods and services from the point of origin to the point of consumption. As is true with any innovation, firms generally adopt LIT for the purpose of realizing improved measures of performance. However, the logistics arena may present a unique set of challenges because of the inherent inter- and intra-organizational interdependencies required for the effective transportation and storage of goods and services. Thus, adoption of LIT may not automatically translate into realized improvements in performance for the adopting firm. In most cases, concurrent adoption of LIT with Radio Frequency Identification (RFID) or Electronic Data Interchange (EDI) leads to near-term positive financial results for the adopting firm. However, the benefits of LIT cannot exist in isolation from the effect of buyer-supplier relationships, which is a potential complementary firm resource. The buyer-supplier relationships induce greater levels of effectiveness, efficiency, and resiliency. Therefore most firms interested in using any LIT should first work toward building positive relationships with their trading partners if they hope to achieve maximum benefits from the employment of the technology (Hazen and Byrd, 2012).

INNOVATION

Innovation is an idea, practice, or material artifact perceived to be new by the relevant unit of adoption. However, this definition does not emphasize that innovations vary in the degree of newness to an adopting unit. This spectrum of innovation is captured, in part, by the notion of radicalness. Radical and incremental describe different types of process innovations. Radical innovations are fundamental changes that represent revolutionary changes while incremental innovation extends a current innovative prrocess or practice (Dewar and Dutton, 1986).

In previous recessionary periods as well popular catchphrases like 'evolve or dissolve' and 'innovate or evaporate' were used to communicate the need for firms to be innovative and flexible in meeting changes in the business environment (Tyson, 1997). It has long been recognized, however, that innovation is essential for firms to survive in highly competitive markets. Schumpeter, for example, stated in 1939, 'Like human beings, firms are constantly being born that cannot live. Others may meet what is akin, in the case of man, to death from accident or illness. Still others die a "natural" death, as men die of old age. And the 'natural' cause, in the case of firms, is precisely their inability to keep up the pace in innovation which they themselves had been instrumental in setting in the time of their vigor.' Schumpeter's words resonate today. Firms must keep up the pace in innovation to survive in the long term, but today there is an important difference—the pace is much faster in the information age (Bullard, 2002).

Companies of different sizes emphasize different types of innovation to survive in the marketplace. Indeed, large wood products companies invest intensively in state-of-the-art facilities to maintain an edge in process innovation. This outcome is consistent with the assertions of Schumpeter, who over half a century ago hypothesized that large firms may be best positioned to maintain their competitive advantage by being the most capable innovators. This is consistent with Porter (1996), who writes about the frantic focus on operational effectiveness

(process innovation) by companies. He states that companies view operational effectiveness as a source of competitive advantage, while it is just a requirement to compete and not a strategic option. A company can outperform other firms only if it can establish a sustainable difference, that is to say, only if it can establish a viable strategy.

Smaller companies level the field with larger companies by considering three innovation types: product (new product development or improvement), process (improved processing or manufacturing), and business systems (new or improved business and marketing practices). This means that excellence in product and business systems innovation can be achieved with limited resources. In short, firm size does affect the innovation type pursued, at least in the wood products industry. This suggests that smaller companies must recognize the level of process innovation necessary to remain competitive and only invest to that level. Any remaining resources must be invested to enhance other areas of innovation (Wagner and Hansen, 2005).

CONCLUSION

The recent recession may be technically over, yet its remnants will continue to challenge forest sector companies globally for some time to come. Although the future remains uncertain, stakeholder demands will remain and economic pressures will become more pronounced. Companies will feel the need to be even more innovative and strategic in managing internal and external business affairs. We believe that this recession will hasten the decline of ineffective business models and prompt a reexamination of business strategies. Some of the key strategic, managerial, and tactical issues that we have raised in this paper may help companies as they navigate through this period of continuing economic uncertainty.

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IAWS Academy Lecture

The wood fibre structure – how can it be utilized?

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ABSTRACT

There is increasing demand for utilizing wood as a replacement for products derived from fossil fuels, both in the energy sector and as a replacement for various kinds of materials. In converting the wood into such products in an economically feasible way, new routes have to be explored to a better understanding of the wood ultra-structure. This applies especially to the interaction between the wood constituents in the cell wall, so that they can be separately extracted with a high degree of purity. The highly intermixed structure of the secondary cell wall, by far the major part of the wood structure, is however still not fully understood, posing questions for continued research. In this paper some features of the polymer arrangement in this structure will be discussed, with a focus on the possibility of separating the wood components, specifically cellulose, lignin, and the hemicelluloses xylan and glucomannan.

Keywords: Cellulose, cell wall, fibre, hemicelluloses, lignin, ultra-structure.

INTRODUCTION

Wood is one of the most abundant biomaterials on earth. Over millions of years, trees have adapted to the environment in order to withstand incredibly diverse conditions, with the basic function of the trunk to act as a strong supporting material as well as serve as a transport mechanism for the nutrients of the living tree. In the structural build-up of the fibres, the tree has developed adaptive functions to deal with a variety of conditions, as for example the differentiation into different forms of reaction wood. At the cell wall level, the structural arrangement serves as a material that is both strong and ductile from conditions of low to high temperatures with moisture present in the system. The arrangement is such that the properties in different directions are maximized towards the requirements of the tree as well as having an ability to adapt to the changing environment without adversely affecting the long-term performance of the structure. The question could be raised as to why the cell wall does not delaminate or develop cracks in the structure when exposed to highly varying environmental conditions. This ability of the wood structure to withstand strongly changing conditions also brings about difficulties in making use of the wood material when trying to disintegrate the fibres to extract the different building components.

Today there is an increasing interest in utilizing the building blocks of the wood fibre wall as a resource, not only for energy production but also for new materials, in a desire to replace fossil-fuel-based products. In utilizing the cellulose as raw material for textiles and films, wood-based derivatives are highly requested. There is also a great interest in the possible utilization of hemicelluloses as barrier films and for lignin as a raw material source, possibly as an inexpensive source for carbon fibre production. To separate these constituents in an economically feasible way with good property performance requires however a deepened understanding of the structural features of the cell wall and its organization.

CELL WALL ANISOTROPY

It is well known that the arrangement of the cellulose microfibrils makes up for a highly anisotropic structure of the fibre wall. Thus in general the longitudinal elastic and strength properties highly exceed those in the transverse directions. However, with the minor layers of the S1 and S3 walls with microfibrils at high angles, the cell wall is also provided with high resistance against tubular pressure. With the cross-ply laminate that the double cell wall provides, the wood structure is amazingly adaptive to the environment, whether that relates to temperature or to moisture, in the sense that the relative properties are relatively independent of the composition (Ehrnrooth and Kolseth 1986) and the microfibrillar angle, MFA, (Salmén 2004) in a normal range of MFAs. This provides for high durability of the wood structure in terms of how well it withstands seasonal changes. However, this fact also makes the wooden structure more difficult to rupture as changes in conditions will not as easily lead to cracks being developed. The adaptive structure of the cell wall is also well demonstrated in the handling of ring pores of the fibre wall. Owing to the circular reinforcements around the pores (Khalili et al. 2001) the structure is not at all as vulnerable as what could have been expected from a comparison with the impact of a drilled hole in a laminate construction. Indeed, the elastic properties are about the same for the intact cell wall as of that containing such pores (Bergander 2001). Thus on a microscopic scale, i.e., mm scale, the fibre structure is highly developed to withstand the forces that are imposed by the structure of the tree and to which the tree may be exposed.

CELLULOSE AGGREGATION

The structure of cellulose in the cell wall is highly governed by the biological process creating a cellulose structure that is not thermodynamically the most stable one. Clearly the formation of the cellulose microfibrils by the rosettes in the cell wall and the subsequent immediate formation of the partly crystalline microfibril triggered by the presence of hemicelluloses, in conifers galactoglucomannans, are essential (Terashima et al. 1993). By this process, a 3- to 4 nm-square microfibril structure of cellulose I is formed. These individual microfibrils are then further assembled into aggregates (Larsson et al. 1997; Wickholm et al. 1998) with a broad size distribution up to around 30 nm in width (Bardage et al. 2004) possessing a lenticular structure (Boyd 1982). The surfaces of all these microfibril assemblies are probably still covered by glucomannan while the remaining spaces are successively filled out with a matrix of xylan and lignin (Terashima et al. 2009).

During pulping it is well known that a further increase in cellulose microfibril aggregation occurs as a consequence of loss of restricting spacers between the microfibrils (Duchesne and Daniel 2000; Duchesne et al. 2001; Hult 2001; Hult et al. 2001; Molin 2002; Fahlén and Salmén 2003). The softening of the components occurring at high pulping temperatures also diminishes the restrictions toward aggregation of the free cellulose surfaces, schematically shown in figure 1 (Fahlén and Salmén 2003). Thus the extent of aggregation is dependent both on which hemicelluloses are removed (Salmén 2008) as well as the extent of the removal and the thermal conditions during such processes.

In terms of cellulose processing, a desirable condition would be to have as large as possible a specific surface area, meaning that the smallest average cellulose aggregate size is to be strived for. Thus as the cellulose aggregation occurring during pulping leads to a less accessible cellulose component, a cellulose having reduced specific surface area, this would be an undesirable fact in respect to the disassembly of the fibre structure into valuable bio-products. In order to avoid such a behavior, the spacings between the cellulose microfibrils have to be maintained, also keeping the amorphous polymers stiff enough to prevent the self-aggregating tendency of the cellulose itself. With a target of producing more highly reactive cellulose products to be used as raw materials for textile fibres and films, this provides for development of more adapted pulping procedures that will not necessarily produce fibres that may be suitable in traditional pulping furnishes.

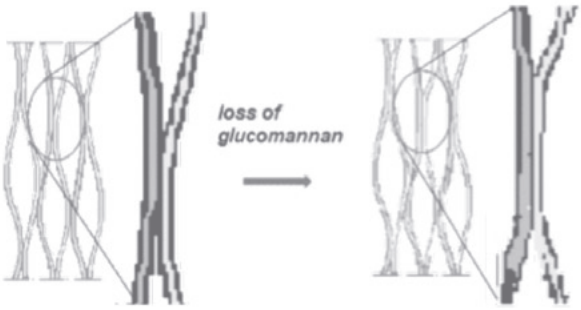

Figure 1: Schematic picture of the increase of cellulose aggregate size resulting from extraction of glucomannan. The increased size is the result of a larger area of contact between adjacent aggregates/fibrils, making on average larger aggregates in cross sections to be viewed.

LIGNIN ARRANGEMENT

Lignin plays an essential role in the structural assembly of the cell wall (Terashima et al. 2009). The lignin is generally considered to provide resistance to compressive forces in the structure, as exemplified by its increasing concentration in "compression wood" where the tree reacts by increasing the capacity to withstand higher compressive forces. It is also likely that lignin, owing to its lower hydrophilicity compared to the carbohydrates, contributes to the water resistance of the structure, serving to keep the cell wall as an integrated structure. The extent to which lignin is interacting with the other wood components in a mechanical sense is still not fully clarified. The existence of covalent bonds between lignin and hemicelluloses, LCCs, have long been debated but their presence in wood, to at least some extent, seems clear (Lawoko et al. 2005). However, the extent of these bonds could be debated at least from a polymer point of view, with lignin supposedly showing a glass transition independent of other components (Olsson and Salmén 1997), pointing to a matrix arrangement with lignin and hemicelluloses acting as individual components. On the other hand, studies suggest that there may well be different types of lignin present in the cell wall (Lawoko et al. 2005; Ruel and Joseleau 2005). Thus it may well be that one of these fractions could have a more intimate mixing with one of the hemicelluloses and thus possess a common softening point at a lower temperature or moisture content than commonly detected for the lignin. As the lignin deposition in the secondary wall takes place after the structural arrangement of the cellulose aggregates have been completed, its arrangement in the remaining spaces in terms of orientation and interaction with the other components could probably be affected by space limitations (Jurasek 1998).

Any directional orientation of lignin molecules in the cell wall structure is a puzzle that has so far not been fully solved. In much of the previous literature it has been taken for granted that lignin is organized as an isotropic structure (Mark 1967). One could argue that the motivation for an orientated structure is not self-evident in reflection of the properties that the lignin provides to the cell wall. However, when considering the way lignin is deposited in the cell wall when the cellulose and hemicelluloses have already been structured and arranged in parallel (Stevanic and Salmén 2009), an organization of the lignin seems more plausible. Recent measurements also indicate that the lignin in the secondary wall could show some degree of orientation, though not to the same degree as that of the carbohydrates (Salmén et al. 2012). Considering the undulating cellulose microfibril structure of the secondary cell wall (Boyd 1982) with the spacing remaining after the cellulose/hemicellulose formation, it could well be that these lenticular pore surfaces act as templates for the lignin formation, forcing it into a somewhat more oriented structure in the direction of the cellulose microfibrils (Salmén et al. 2012) as well as an orientation in the tangential direction of the fibre wall (Atalla and Agarwal 1985), schematically illustrated in figure 2. In contrast to this arrangement, it is not surprising that when examining the orientation of the lignin in the middle lamella region, which poses no structural restrictions, no lignin orientation whatsoever is detected (Salmén et al. 2012). This middle lamella lignin is presumably formed without constraints from the surrounding structure and would more or less resemble a self-organized structure of lignin.

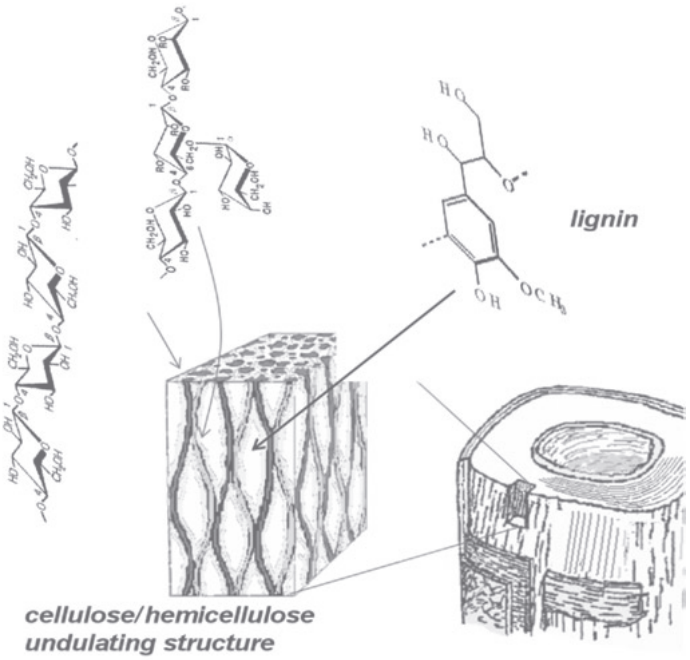

Figure 2: Schematic structure of the secondary cell wall of a softwood tracheid, diameter of about 35 mm with the undulating cellulose/hemicellulose aggregate structure oriented in the fibre direction. For clarity, this illustration is not drawn to scale. Cellulose aggregates have an average diameter of 16 nm with the elliptical spaces in-between having a length-to-width ratio of about 2 and a minor diameter across the ellipse of 5 to 10 nm. The spaces left over after the initial deposition of the cellulose/hemicellulose aggregates will structure the organization of the lignin molecules deposited afterward.

With such an intermixed structure of the wood polymers in the cell wall, it would be assumed that the construction is developed for a maximal utilization of the stress-taking ability of the components to be economically most beneficial for the tree structure. Yet, studies on the micro-level regarding stress transfer when loading wood fibres have not been able to show much of a contribution from the lignin itself. Both Raman and FTIR measurements of stress deformation of lignin have been unsuccessful in detecting straining of the lignin molecule even at very high stresses on the cellulose molecules themselves (Gierlinger et al. 2006; Salmén and Bergström 2009). One could here argue regarding the suitability of the method itself, i.e., whether the sensitivity in the case of the lignin structure is sufficient enough that stresses on the bonds in the aromatic ring could even be noted. However, when examining a primary wall structure where lignin plays a more dominant role in the cell wall organization, straining of the lignin molecule may be seen, as detected from the split in the 1510 cm-1 vibration in a dynamic FTIR-spectrum (figure 3). Thus when the lignin takes part in the stress transfer, a clear straining of the bonds in the aromatic ring structure is readily evident, although not as distinct as that of the cellulose deformations exemplified by the C-OH bending deformation at 1425 cm-1 (Hinterstoisser et al. 2001). The question of why such a deformation is not seen when straining the secondary cell wall may not be readily answered. The undulating structure of the cellulose microfibrils/aggregates could be interpreted as a network structure if considering that microfibrils may act as crosslinks between aggregates. If so, the structure could be interpreted as a honeycomb structure. The lignin/hemicellulose matrix filling the spacings in between the cellulose aggregates may then more or less have a function of providing for compressive resistance during the straining of this honeycomb structure (figure 4). It may then be that during such stresses, the lignin easily relaxes and does not readily show molecular deformations.

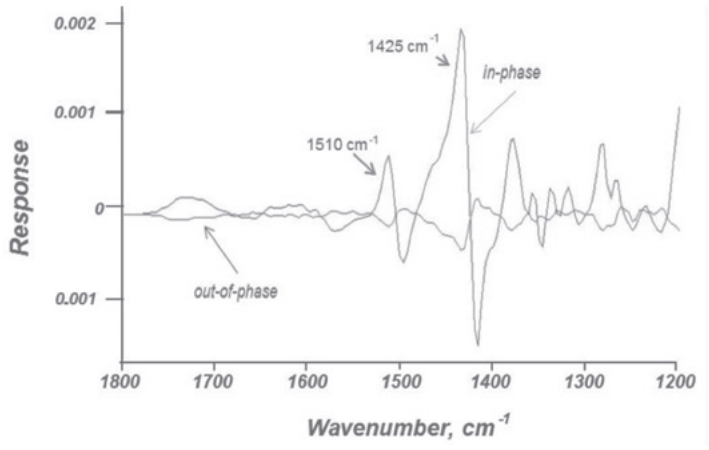

Figure 3: Dynamic FTIR spectra of peeled fines (primary wall) from mechanical pulp fibres showing the in-phase and out-of-phase components as a function of wavenumber in the interval 1800 to 1200 cm-1, 0 percent RH, 25 oC. At 1425 cm-1 the split peak of the cellulose C-OH bending vibration reflects the straining of cellulose while the split peak at 1510 cm-1 of the lignin aromatic ring indicates the stress contribution from lignin

The degree of interaction between lignin and hemicelluloses also affects the ability to separate components. Covalent bonds between lignin and the hemicelluloses xylan and glucomannan LCC-bonds are now well established (Lawoko et al. 2005), although an increase of these may be expected to occur during pulping (Iversen and Wännström 1986). The extent of these bonds certainly affects the disintegration ability. In what way these bonds affect physical properties of the cell wall much depends on the size of the entities of the different molecules involved. With regard to polymeric properties, the ability to act as separate components is based on the ability of the polymer chains to act cooperatively in order to show a behavior representing that of the isolated material. This is usually estimated to require a polymer volume in diameter of about 5 to 15 nm (Kaplan 1976), a space that may only be considered possible if accounting for the longer direction of the lenticular spaces in between the cellulose microfibrils. Taking this shape into account, the fact that lignin has been claimed to show a softening temperature of its own (Olsson and Salmén 1997) may be explainable. The results point to a softening only related to the lignin structure itself with no apparent influence of the hemicellulose composition. With the more recent evidence of different types of lignin existing in the fibre wall (Lawoko et al. 2005; Ruel and Joseleau 2005), a more linear one and a more branched lignin type, as well as the fact that those two types of lignin are specifically interacting with different types of hemicelluloses, in softwood xylan and glucomannan respectively, one may ask if the lignin may really act independently. The isolated softening properties noted for lignin are most probably not explained by claiming that they should relate to middle lamella lignin behavior, owing to several facts. First, the impact of the lignin softening on the properties of wood is considerable, with only a minor part of the total lignin being present in the middle lamella. Second, isolated secondary wall material also shows a distinct lignin softening (Östberg et al. 1990) very similar to that observed for the whole wood material. However, for the hemicelluloses, softening properties are rather vague, usually showing a rather broad softening range in the higher RH-range at room temperature. Although specific softenings have been reported on wood materials (Kelley et al. 1987), it is generally only on isolated hemicelluloses that distinct softenings have been observed (Irvine 1984). On the other hand, regions more dense in xylan have been indicated along the microfibrillar structure (Terashima et al. 2009). Thus it may not be ruled out that spaces available for the different hemicelluloses are too small for an isolated softening to be apparent. Moreover, at least some of the hemicelluloses may act in cooperation with the lignin. Thus a breaking of bonds between lignin and hemicelluloses is probably a necessity for being able to extract isolated components in higher degrees and in purer form. The close connection between the matrix components of the cell wall is also demonstrated by the fact that treatments with specific hemicellulose enzymes not only improve the dissolution of the degraded hemicellulose but also enhance the dissolution of the other matrix components (Azhar et al. 2011; Fahlén and Salmén 2005).

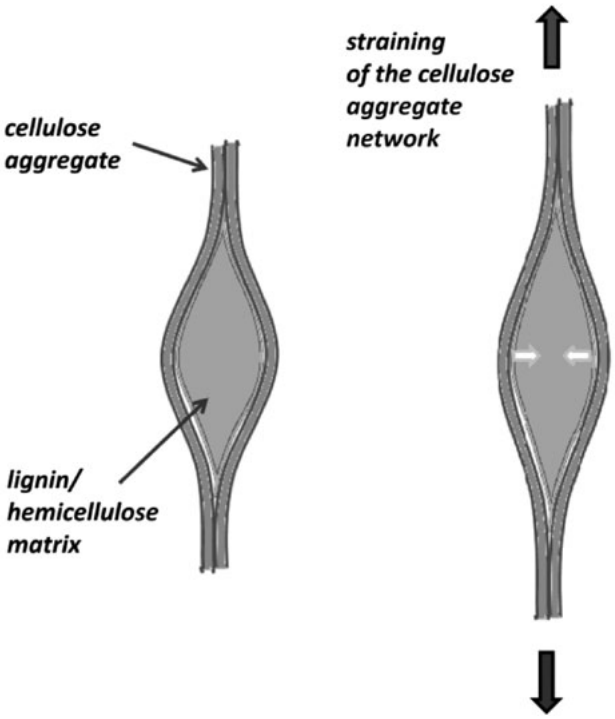

Figure 4: Schematic picture of the straining of the cellulose aggregate network indicating the compressive resistance of the lignin/hemicellulose matrix.

CONCLUSIONS

It is clearly evident that the secondary cell wall of wood fibres is a highly intermixed composite material for which the very detailed structure is not yet fully understood. Bonds between lignin and the hemicelluloses are clearly a fact that will adversely affect the ability for disintegration, particularly after pulping when the degree of such bonds may have increased. The most important factor affecting the separation of the major component, the cellulose, is the fact that increased aggregation has to be avoided. In doing so, new pulping processes have to be adapted, with the principle of extracting lignin and hemicelluloses at lower temperatures in order to inhibit the self-organizing tendency of the cellulose. However, such an extraction also has to take into account ways to stabilize the structure with spacers in between cellulose microfibrils to facilitate further processing without later aggregation.

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SP01

The Brazilian forestry industry: focusing on eucalypt

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ABSTRACT

Brazil has 8.51 million km2 of territorial area, 9198 km of coastline, and a tropical climate, and it is divided into six biomes: Amazon (49.29 percent), 'cerrado' (23.92 percent), Atlantic forest (13.04 percent), 'caatinga' (9.92 percent), 'pampa', (2.07 percent) and 'pantanal' (1.76 percent), from which 61 percent is preserved (519.6 million ha) The occupation of the Brazilian soil consists of 20.8 percent pasture, 7.7 percent agriculture, 0.8 percent forested areas, 61.0 percent natural forests, and 9.7 percent other areas. The total forested area (7.0 million ha) is small, when compared with countries like China and India, which have 45.1 and 32.6 million ha, respectively. In 2011, the main cultivated species in the country were Eucalyptus spp. (69.6 percent), Pinus spp. (23.4 percent), Acacia mearnsii and Acacia mangium (2.10 percent), Hevea brasiliensis (2.36 percent), Schizolobium amazonicum (1.22 percent), and Tectona grandis (0.97 percent). From 2005 to 2010, the planted forest area growth was 27.9 percent (4). The main factor that boosted this growth was the demand of the pulp and paper projects. In recent decades, scientific and technological advances have resulted in significant improvements in productivity, resistance to diseases, uniform degree of the forest plantations, wood quality, etc., especially of Eucalyptus spp., which has excellent adaptability to the edaphoclimatic conditions in the country. The current average productivity of Eucalyptus spp. and Pinus spp. are of 40.1 and 36.9 m3/ha·year, respectively. In some regions of the country the productivity of Eucalyptus spp. can reach 100 m3/ha·year. The Brazilian forestry industry uses mainly planted forests, and the pulp and paper industry consumes only this type of wood. The energy sector (charcoal and firewood) uses wood from natural forests. The pulp and wood panel sectors are more technologically advanced in relation to the other wood products sectors. In 2011, the forestry sector contributed with 3.1 percent of Brazilian exports, 19.2 percent of the trade balance, 0.5 percent of total taxes, and 4.7 million direct and indirect jobs. The Gross Value of the Forestry Production (GVFP) was US$28.4 billion. From this amount, the pulp and paper sector contributed with 57.1 percent, the furniture sector 19.1 percent, and the industrialized wood panels sector with 10.1 percent

1. INTRODUCTION

Brazil has forest vocations owing to its elevated territorial extension of 8.51 million km2 (1) and edaphoclimatic conditions that are exceptionally adequate for forest cultures. Decades of scientific and technological development have resulted in elevated forest productivity and high uniformity and quality woods, especially in the clonal forests of Eucalyptus spp.

The current average productivity of Eucalyptus spp. is 40.1 m3/ha·year (2), reaching values of up to 100 m3/ha·year in certain regions of the country (3). Of the total of planted forests in the country (7.0 million ha), 69.9 percent is of Eucalyptus spp. (2). The Brazilian forest-based industry uses mainly planted forests of Eucalyptus spp., which is the main focus of this article.

This paper discusses Brazilian planted forests, the program of wood quality, forestry legislation and forest-based industries, including the mains sectors, and technology levels, as well as the market for Brazilian forest products.

2. THE BRAZILIAN FOREST SECTOR

2.1 NATIVE FORESTS

Brazil has 8.51 million km2 of territorial area, 9198 km of coastline, a tropical climate, six biomes (Table 1), 49 already classified ecoregions, incalculable ecosystems, and the largest river system in the world. It is the country with the largest biodiversity on Earth, containing at least 70 percent of the world's plant and animal species (1). In 2009, Brazil had 61 percent of its total area preserved (519.6 million ha), 80.0 percent of the Amazon, 51.16 percent of 'Cerrado', 22.25 percent of Atlantic Forest, 53.38 percent of 'Caatinga', 36.06 percent of 'Pampa' and 83.14 percent of the 'Pantanal' (1).

Table 1: Area and remnant of the Brazilian biomes (1, 4, 5).

Biome	Total area in 2004, km2	Total area, percentage	Preserved area in 2009, percentage
Amazon	4 196 943	49.29	80.00
'Cerrado'	2 036 448	23.29	51.16
Atlantic Forest	1 110 182	13.04	22.25
'Caatinga'	844 453	9.92	53.38
'Pampa'	176 496	2.07	36.06
'Pantanal'	150 355	1.76	83.14
Brazil area	8 514 877	100	61.00

In 2010, the occupation of the Brazilian soil consisted of 20.8 percent pasture, 6.8 percent agricultural areas, 0.8 percent planted forests, and 61.0 percent natural forests (2). Of the agricultural area, 2.8 percent is composed of soybean and 0.9 percent of sugar cane (6).

The area of natural forests preserved by companies of the forest sector corresponds to 2.1 million ha, under the form of Permanent Preservation Areas (PPAs), Legal Reserves (LR), and Private Reserves of the National Heritage (PRNHs). In recent decades, with the implementation of natural resources preservation and conservation policies adopted by the Brazilian government, the Conservation Units (CU) went from 58 thousand ha before 1970 to 61.8 million ha currently, where 45.5 percent is under full protection regimen and 54.5 percent is of sustainable use (2).

2.2. PLANTED FORESTS

The data from Table 2 indicate that Brazil has only 7.0 million of planted forests (0.8 percent of its total area), which is significant if compared to the areas of planted forests in China, 45.1 million ha, and of India, 32.6 million ha (2, 7).

According to the SBS- Brazilian Society (2011) for Silvicuture, the Brazilian planted forests are located mainly in the Southeast (44 percent) and South (34 percent) regions. However, there has been alteration in the area of cultivation, with a significant increase in the States located in the new frontier of the sector, such as in the States of Tocantins (37.1 percent) and Mato Grosso do Sul (24.3 percent), and decrease in the States of Minas Gerais (3.8 percent), Bahia (4.4 percent), Espírito Santo (3.6 percent), Mato Grosso (5.2 percent) and Piauí (28.4 percent) (2).

Table 2: Rank in the world of planted forests in 2011 (2, 7, 8).

Rank	Country	Million ha	Rank	Country	Percentage of country área
1st	China	45.1	1st	Japan	28.3
2nd	India	32.6	2nd	Finland	19.4
3rd	Russia	17.3	3rd	Germany	15.1
4th	USA	16.2	4th	Sweeden	8.8
5th	Japan	10.7	5th	China	8.2
6th	Indonesia	9.9	6th	India	3.4
7th	Brazil	7.0	7th	Chile	3.2
8th	Thailand	4.9	8th	USA	2.8
9th	Ukraine	4.4	9th	Indonesia	2.0
10th	Iran	2.3	10th	Brazil	0.8

From the timber originating in planted forests, 13.5 percent comes from fomentation, 28.4 percent comes from third parties, and 58.1 percent of own plantations (2).

The composition of the Brazilian planted forests is shown in Table 3, where a dominance of Eucalyptus spp. is observed. From 2005 to 2010, the growth was 27.9 percent. In 2011, areas of Eucalyptus spp. and Pinus spp. planted totaled 4 873 952 and 1 641 892 ha, respectively. Compared to 2010, the planted area of Eucalyptus spp. grew only 2.5 percent and the one of Pinus spp. decreased 6.5 percent. The main factor that boosted the planting growth of Eucalyptus spp. was the establishment of new plantations to fulfill the future demand of industrial projects in the pulp and paper sectors, since the biggest expansions took place in the States of Tocantins, Mato Grosso do Sul, Paraná, and Maranhão (2).

From the total area of Eucalyptus spp. planted in Brazil, 54.2 percent is located in the Southeast, 16.4 percent in the Northeast, 12.2 percent in the Midwest, 11.8 percent in the South, and 5.5 percent in the North regions (2).

Table 3: Main wood species planted in Brazil in 2011(2).

Common name	Scientific name	Area of forest plantations, ha		
		2010	2011	Percentage
Eucalypt	E. grandis, E. saligna, hybrid E. Urophyla x E. Grandis, E. urophyla, E. viminalis, E. globulos, others	4 754 334	4 873 952	69.6
Pine tree	Pinus taeda, Pinus elliotti outras	1 756 359	1 641 892	23.4
Acacia	Acacia mearnsii Acacia mangium	127 600	146 813	2.10
Rubber tree	Hevea brasiliensis	159 500	165 648	2.36
'Paricá'	Schizolobium amazonicum	85 470	85 473	1.22
Teak	Tectona grandis	65 440	67 693	0.97
'Araucária'	Araucária angustifólia	11 190	11 179	0.16
Alamos	Populus spp.	4 220	4 220	0.06
Others		8 969	8 256	0.12
Total		7 038 524	7 005 125	100.0

Currently, the average productivity of Eucalyptus spp. in Brazil is 40 m3/ha·year (2). In some regions of the country, the productivity of Eucalyptus spp. can reach up to 100 m3/ha·year (3). In 1990, the average productivity of eucalyptus in Brazil was 26 m3/ha·year. It is anticipated that in 2025 the average productivity will reach values of the order of 56 m3/ha·year (8). The average productivity of the species Pinus spp., planted especially in the south of Brazil, is of the order of 37 m3/ha·year (2). This productivity used to be 23 m3/ha·year in 1990 and it should reach 42 m3/ha·year in 2025 (8).

3. WOOD QUALITY PROGRAM IN BRAZIL

In recent decades, scientific and technological advances resulted in significant improvements in productivity, resistance to diseases, uniform degree of forest plantations, and wood quality, etc., especially in Eucalyptus spp., which has excellent adaptability to the country's edaphoclimatic conditions.

Such advances allowed the wood to be segregated for specific purposes, because the technological characteristics of determined products was known. Through the use of classical forestry improvement tools, cloning, and genomics, the production of custom wood to several industrial applications, such as carbonization, pulp and paper, panels, among others, has been possible.

The Eucalyptus spp. genome has already been sequenced and the clone selection using genomic characteristics is in a phase of research that will enable a faster and more efficient selection, unlike the conventional selection, which uses phenotypic characteristics (9).

4. FORESTRY LEGISLATION

The establishment of forest plantations in Brazil is highly regulated by environmental authorities. Currently, the extension of the discussion about the forest code has caused legal uncertainty among investors in the sector.

The Brazilian forest code regulates the way the land should be explored, establishing where the natural vegetation should be kept and where there might be different types of rural production. The code that is currently in effect is from 1965, and it is already greatly amended. Owing to this, in 1999, Bill 1876 was presented in order to replace the one from 1965 to suit the present reality of Brazil. Since then, a discussion about the forest code has been taking place in order to modify the text. On April 25, the text was approved by the Chamber of Deputies and it awaits the approval of the President, who will probably veto it, because it favors the agribusiness sector ('ruralistas') more than the environment.

The main alterations in the old Brazilian forest code are described in Table 4. The 'ruralistas' contend that the new code limits production and that areas already consolidated as productive, even though they are located by rivers, hillsides, or hilltops, should not be preserved. Meanwhile, scientists and environmentalists maintain that keeping these details in the new code will encourage new deforestation.

Table 4: Main changes in the forest code (10).

OLD FOREST CODE	NEW FOREST CODE
Area of legal reserve in the biomes Amazon, 'Cerrado' and the other biomes correspond to 80, 35, and 20 percent of the property, respectively.	The areas of legal reserve are kept as before, except in the states that have 50 percent or more areas preserved; in this case, the requirement of legal reserve is reduced up to half in relation to the old forest code. There is an exemption from the area of legal reserve for small properties.
Areas of permanent preservation, such as river margins, hilltops, hillsides, etc., cannot be deforested.	The new code authorizes the use of areas of permanent preservation for some types of cultivation. It allows agriculture in hillsides with slopes of up to 45° and activities in the river margins that started up to 2008.
The strip of riparian forest for rivers with up to 10 m of width should be 30 m.	The strip of riparian forest for rivers with up to 10m of width should be 15 m.

5. THE BRAZILIAN FOREST-BASED INDUSTRY

The Brazilian forestry industry includes pulp and paper (printing and writing, newsprint, packaging, cardboard and tissue), industrialized wood panels (fibre plates: LDF—low density fibreboard, MDF—medium density fibreboard, HDF—high density fibreboard and hardboard; plyboard: conventional and LVL—laminated veneer lumber; agglomerate: conventional and MDP—medium density particleboard, and OSB—oriented strand board), sawn wood (vigas, boards, wood structural), VAWP—value added wood products (doors, windows, furniture, etc.), treated wood (stakes, light poles, crossarms, pillars, fences, and ties), steel to charcoal (pig iron, iron alloy, and steel) and energy (industrial wood, biomass, and pellets) (2, 11, 12).

The forest-based Brazilian industry consists of 222 pulp and paper companies, 17 fibre plates companies, 20 pellets companies, and around 10 000 sawmills, 300 rolling and plyboard factories, 450 units of wood drying, 48 000 furniture formal companies, and 300 wood preservation companies, in addition to small-scale companies that produce chips, excelsior, briquettes, light poles, poles, and small wooden objects (2, 12, 13). The main industrial poles are concentrated in the south and southeast regions, where the regional and logistic aspects favor the generation of scale economy favoring competitiveness.

The Brazilian forest products industry uses mainly the planted forests, and the pulp and paper industry uses only this type of wood. From the wood coming from planted forests (170.1 million m3), 36.1 percent is used by the pulp and paper industry, 26.3 percent for industrial wood, 10 percent for charcoal production (pig iron), 15.2 percent for sawmills, 7.4 percent for industrialized wood panels, 3.7 percent for plyboard, 0.9 percent for treated wood, and 0.4 percent for other uses (2, 13, 14). From 2010 to 2011, the wood consumption for Eucalyptus spp. in logs increased by 4.1 percent. The consumption of Pinus logs decreased 11.4 percent during this same period (2).

The main consumer of wood from natural forests is the energy sector. In 2011, the production of charcoal was 4 951 207 tons, from which 69.5 percent was produced from planted forest and 30.4 percent from natural forests. The biggest relative participation of woods originating from natural forests is in the production of firewood for industrial use, which uses 43.8 percent of the native forests commercially exploited (4).

5.1. TECHNOLOGICAL LEVEL

In general, the modernity of the technological park, combined with quality and the low cost of raw material, are the main factors that boost the Brazilian sector.

The Brazilian pulp industry is of elevated size and high capital. To guarantee competitiveness in the market, the minimum production of a pulp factory should be superior to 1 200 000 tons per year.

The tendency in the sector has been to increase productive capacity, through mergers and expansion, besides new factories with elevated productive capacity. The pulp factories use mainly continuous digesters, with high-temperature rinsing as well as modified kraft pulping processes, including compact, lo-solids. The bleaching technologies used are ECF—elemental chlorine free, Light-ECF, and TCF—totally chlorine free, including pre-delignification with oxygen, bleaching stages with chloride dioxide, hydrogen peroxide, and ozone. The environmental pollution is strongly controlled by specific legislation, which has led to high investments in environmental control. The pulp and paper industry is a large consumer of steam and electric energy but the new non-integrated pulp factories produce surplus energy of 30 to 40 percent.

Brazil is among the most advanced reconstituted wood panel manufacturers in the world. It has the largest number of state-of-the-art factories (15). With continuous investments in technology and automation, the companies use technologically the existent factories, install new unities, implant continuous production lines, and modernize the finishing process.

In recent years, MDF has lost market share to MDP; for this reason, in Brazil there has been adaptation of agglomerate lines for the production of MDP, which includes continuous press and more silos for fibre separation, among others.

The industrial areas adopt an environmental management system that allows performance monitoring of the effluent treatment and in the correct destination of solid residues, as well as actions aiming to reduce atmospheric emissions and decrease electric energy consumption (15).

The sector of plyboard in Brazil is formed mainly by several small companies with relatively small capital investment of around R$ 350.000 and low technological levels.

There is an elevated number of sawmills in Brazil, about 10 000, and the majority is small, with low levels of technology and environmental control. In the sawmills of bigger size optical scanners or laser for control and classification of logs, as well as determination of the best log position for the log sawing and slash saw or band saw are used. The transport of logs and wooden pieces is mechanized among the several stages (16).

In 2010, the Brazilian pig iron and steel companies used 24.81 percent charcoal and 75.19 percent coal for the reduction of iron ore (17).

Brazil is the world's largest producer of charcoal for reduction of iron ore into pig iron. In 2010, 35 percent of the pig iron produced in Brazil was produced through reduction with charcoal. The advantages of iron ore reduction with charcoal, in relation to coal, is that the former is free of sulfur and phosphorus as well as other undesirable elements, resulting in improved product quality and price. In 2010, the price of coal was 19 percent higher than the price of charcoal. The charcoal had always had its price smaller than the price of coal; however, this trend has been altered by the reduction of the usage of natural forests, wood shortages, and the necessity to have a forest base for the charcoal production (17).

About 10 percent of the total charcoal production in Brazil comes from companies that use high-technology rectangular kilns, and 90 percent from small and medium owners who use traditional kilns.

The rectangular kilns are mechanized, have a combustion chamber for gas burn, the possibility of tar recovery, steam injectors, a heat exchanger to accelerate the cooling process, etc. o To be economically viable, the rectangular kilns should produce at least 5000 m3 of charcoal per month. The cost of installation of each kiln varies from R$0.2 to 0.5 million. There are kilns with the capacity to process up to 500 m3 of wood per cycle of pyrolysis, with a wood conversion yield into charcoal of 30 to 35 percent (18).

The traditional kilns (surface, low-coast, hillsides) are of low yield (27 percent), without carbonization temperature control, and are high polluters of the atmosphere (20).

The Federal University of Viçosa (UFV) has been developing technologies of kilns for charcoal production, aiming at small owners. However, we lack public policies and access to information about the majority of the rural producers.

5.2. FOREST PRODUCTS MARKET

In 2011, The Forest Production Gross Value (FPGV) was R$53.91 billion. The pulp and paper sector contributed 57.1 percent (Table 5), the furniture sector contributed 19.1 percent and industrialized wood panels contributed 10.1 percent of this value (4).

Table 5: Estimative of the FPGV of the main productive chains in 2011 (4).

Segment	Percentage
Pulp and Paper	57.1
Industrialized Wood Panels	10.1
Steel to Charcoal	4.1
Wood Industry	9.6
Furniture	19.1

In 2000, Brazil was the world's 7th largest pulp producer, surpassed only by the United States, Canada, China, Japan, Finland, and Sweden. Currently, the country is the world's fourth largest pulp producer and the first producer and exporter of short fibre pulp in the market. From 2000 to 2011, national pulp production increased 87.9 percent and exports increased 109.4 percent , and they represent 21 percent of the internationally commercialized volume (6, 19). In 2011, pulp production totaled 14 million tons and exports 8.1 million, values a little inferior to the ones from 2010, which were 14.2 million and 8 million tons, respectively. However, the results were considered positive, given the actual national and international scenarios. From the total produced pulp, 85.1 percent is of hardwood (HWD) bleached kraft, 11.8 percent of softwood (SWD) brown kraft, and 3.1 percent of HWD/SWD high-yield pulp. Currently, the industry is facing the expansion of production capacities in their units, with a forecasted increase of 57 percent in present production until 2020. Regarding paper, Brazil is the world's 10th largest producer with 9.8 million tons in 2011. In 2010–2011, the paper industry increased an average of 12 percent per year owing to increased internal demand, which currently consumes 79 percent of national production (13).

In 2000, Brazil was the world's 9th largest producer of sawn wood, and currently ranks 11th. From 2000 to 2011, the national production of sawn wood increased 28 percent and exports decreased 39.4 percent and it represented 1.2 percent of the volume internationally commercialized (2). However, the internal market has been sustaining this increase in production, particularly the civil construction and furniture markets.

In 2000, Brazil was the world's 6th largest producer of agglomerate panels, and now it is the 8th largest producer, being responsible for 6.2 percent of the world export of the product (2).

From 2000 to 2011, the production and consumption of industrialized panels increased 8.3 and 8.7 percent per year, respectively. However, in 2010 and 2011, 6.5 million wooden panels were produced and consumed, owing especially to the non-growth of the furniture sector during this period, which is the main consumer of these panels (2).

The charcoal segment follows the direction of the pig iron market. The large steel industries have their forest sources based on Eucalyptus spp. with which they produce charcoal for the reduction of iron ore; the internal market is the main consumer of charcoal. In 2011, exports of pig iron increased 40 percent in comparison to 2010. However, they have not reached the levels of 2008, the period of the world economy crisis (2).

The Brazilian forest sector has weak participation in the world exports of forest products, with only 2 percent of the total (Table 6). However, this sector is of great importance for the country, being responsible for 3.1 percent of our total exports and 19.1 percent of our commercial balance. Moreover, it is responsible for 0.5 percent of the tributes and 4.7 million of direct and indirect jobs (2).

Table 6: World commerce of forest products in 2011 (2).

Countries	USD, billion	Percentage
USA	54	12
Germany	39	9
Canada	36	8
China	32	7
Finland	18	4
Brazil	6	2

The international market is of great importance for some Brazilian forest products. For example, 60.5 percent of the pulp and 47.1 percent of the plyboard are exported. Some products such as wooden panels, charcoal, and wood attend more the internal market. The main importers of Brazilian forest products are Argentina (paper), Germany (plyboard), China (pulp), and the United States (panels and pulp) (2).

The competitiveness of the forest industrial sector, which historically was elevated in the international market, owing mainly to high forest productivity in Brazil and the low costs of the wood delivered, has been decreasing. The reasons are the disproportionate unexpected increase of internal costs in relation to other international competitors, caused by currency appreciation, increase of salaries and social charges, high cost of electric energy, mainly in the sector of mechanically processed wood, high tax burden, deficient infrastructure with consequent increase in the logistic cost, restrictions to acquisition of land by national companies with majority of foreign capital, as well as extensive discussions regarding the review of the National Forest Code (2).

6. THE GENOLYPTUS AND LIGNODECO PROJECTS

In the last ten years, various projects of P&D have been developed by public and private sectors, aiming at further improving eucalyptus competitiveness as raw material for the forest products industry. Examples of such projects were the Genolyptus and the Lignodeco.

The central purpose of the Genolyptus project, a consortium of 12 forest companies and seven research institutions, was the discovery, sequencing, genetic and physical mapping and determination of gene function of economic importance of species of eucalypt, aiming at the incorporation of genomic technologies and quality of forest and industrial processes. The project aimed molecular genetic breeding and it is based on a multidisciplinary genomic research strategy strongly integrated to an effort of field experimentation and physico-chemical wood evaluation as well as the knowledge and methodologies of classic genetic and quantitative genetic. The backbone of the project is a large and complex experimental network dedicated specifically to forest genomic research and with national coverage of the environmental conditions.

Another project still in progress is the Lignodeco, a consortium of seven Brazilian and European institutions, involving countries such as Brazil, Finland, Denmark, Spain, and France, promoted by the Seventh Framework Programme of the European Union, for a period of 3 years. The main goal of the project is the development of new pre-treatments for an optimized deconstruction of fast-growing biomass into its main

components to produce biofuels, along with pulp production for special paper grades and other bioproducts. The project is promising, and many positive results have been achieved by researchers and have been disseminated to the scientific community through eight papers in scientific journals and 28 presentations in international conferences. The main results obtained so far include: (1) the optimization of analytical tests methods for Eucalyptus spp.; (2) the understanding of lignin composition and structure in young versus adult Eucalyptus spp. plants; (3) xylans management in eucalyptus pulp production; (5) improving eucalypt kraft pulp yield and quality through black liquor xylan deposition; (6) organosolv pre-treatment of lignocellulosics for bioethanol production; (7) oxidative modification of paper pulp lipophilic extractives by laccase-mediator system; and (8) enzymatic hydrolysis of the pulp for bioethanol production. The project now is in its last year, when the study of the new technologies will be finalised aiming the biofuel and pulp production, and also testing in pilot plants will be done.

5. CONCLUSIONS

Brazil has forestry vocation owing to its elevated territorial extension, edaphoclimatic conditions exceptionally adequate for forestry cultures, and the knowledge developed in forestry production technologies. However, this potential is not adequately explored, because only 0.8 percent of its territory is occupied with planted forests.

The great differential of the Brazilian forest industrial sector is the wood, produced at low costs and with elevated quality in the country, especially Eucalyptus spp., which in some areas can reach a productivity of up to 100 m3/ha·year.

Among the sectors of the Brazilian forest industry, the pulp and paper is highlighted, being responsible for 57.1 percent of the FPGV. The country is the world's 4th largest pulp producer and the first producer and exporter of short fiber pulp in the market.

The world competitiveness of the Brazilian forest industrial sector, which historically was elevated, has been decreasing, owing mainly to the overvaluation, high tax burden, high logistics cost, and restrictions to land acquisition by foreigners, as well as the uncertainty regarding the new Brazilian forest code.

Development of specific public policies for the sector are necessary for the country to take comparative advantage in order to strengthen its international competitiveness so that this forestry vocation is fully exploited and contributes in a significant way to the economic and social development of the country.

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SP02

The importance of biomass structure and chemical composition for biorefineries

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Keywords: Structure, chemical composition, fractionation, biomass, biorefineries

ABSTRACT

Biomass is a renewable material with multiple uses: energy, chemicals, and materials. The novelty of present approaches is that processes and raw materials are scrutinised for innovative or better transformations, a large commercial scale is usually thought of, and maximal usage is envisaged in a holistic biorefinery concept. Biomass transformation approaches are grouped according to the types of main processes used in transformation (thermochemical, biotechnological, chemical, or physical) or the targeted products (biofuel, chemicals, or fibre platforms), but it is clear that a mix of processes and products are required for a complete biomass-based refinery.

Biomass, however, is a complex and multiple raw material. It encompasses wood, bark, foliage, grasses, fruits, and seeds, various agro-industrial and forest residues, and organic wastes. It has a lignocellulosic nature but this is only a rough approximation of its chemical complexity. Proportions of the different chemical compounds or families vary hugely, as well as their fine chemical composition. The chemical composition is tissue-specific, which brings in another level of complexity in which the anatomical structure of the material must be considered. The combination of structural and chemical features results into different physical properties that may have a significant role in processing.

Knowledge of the anatomy and chemical structure of the specific biomass is therefore a key issue. This will be exemplified with some biomass cases, and the impact of the specific characteristics on pretreatments (such as fractionation) and processing will be addressed.

1. INTRODUCTION

The word biorefineries started to be used a few decades ago to convey that multiple processing and product families could be obtained from feedstocks of biological origin much like petroleum-based refineries.

With increased awareness of the need for an overall sustainability of resource consumption, renewable feedstocks gained importance, particularly biomass, as a potential provider of energy, chemicals, and materials. Sustainable development and green economy are now unavoidable concepts. In this context, the concept of biorefineries also enlarged its use and visibility, mostly during the last decade, with a broad effort of gathering knowledge on their different processes and areas, leading to the establishment of R&D networks, workshops and conferences, research projects, and scientific publications. The underlying framework for biorefineries is full resource utilization and environmental balance.

Biorefineries are based on biomass as a feedstock. Biomass has a broad definition, encompassing all materials with a biological origin at the beginning of their production chain. It includes therefore three levels of conversion: (a) a first level regards the primary production of agriculture and forestry, algae and animals; (b) a second level refers to byproducts or wastes of their processing, i.e., agro-industrial residues, harvest residues, and forest-based industrial residues; and (c) a third level includes the end-of-life materials after consumption, i.e., wastewood products, waste paper, and organic sewage.

Biomass and biorefineries have a set of advantages that have fostered their present notoriety (Table 1). The environmental footprint of production can be low given that the necessary cautionary measures and good practices are taken, the carbon balance is favourable or neutral, they are renewable, and their sustainability may be ensured. They allow multiple processing routes leading to differing target products (encompassing bioenergy, chemicals, and materials) that may be either combined or privileged upon strategic/opportunity objectives. Biomass has also a broad geographic production potential, which may be a factor of independence from localised sources of feedstocks, leading therefore to its geostrategic importance.

However, biorefineries face challenges and difficulties (Table 1). In contrast to crude-oil-based refineries, which have over a century of advanced research efforts and a mature implementation, the biorefinery concept and the overall logistic of processing and consumption are still in their infancy regarding large-scale industrial approaches. Regarding the nature of their feedstock, biorefineries face two challenges: (i) biomass has a large diversity and complexity at macro, micro, and nano levels; and (ii) biomass is solid. The production location, timing, and characteristics also are relevant aspects that may complicate the whole procurement and processing chain. The economic feasibility of biomass and biorefineries has been a bottleneck for commercial applications; political and financial support often is required (e.g., sugarcane and bioethanol in Brazil). Finally, and much in focus in recent years, is the consideration of potentially devastating competition for land use that may endanger food production and local availability.

Table 1: Competitive advantages and challenges for biorefineries

Competitive advantages	Challenges
Renewable	Solid feedstocks
Ecological impact: C balance, footprint	Diversity (macro, micro, nano levels)
Sustainability potential	Complexity (macro, micro, nano levels)
Geographical spread	Procurement logistics
Versatility/ process-product	Economy
	Land use

2. BIOMASS CELLULAR STRUCTURE AND CHEMICAL COMPOSITION

The biological origin of biomass gives this material a cellular structure. It also gives biomass an enormous diversity at the first level of primary production, in reference to the species as well as within the species to different organs or parts, e.g., the within-species biomass component. This diversity is already observed macroscopically: a tree is quite different from a grass or an algae; the stem wood differs from the bark or from a leaf.

The differences arise from the contrasting structural arrangements of tissues and types of cells, e.g., the anatomical features of the specific biomass material, making the anatomy of plants a fascinating and complex subject. The cells are grouped in types that have different form, dimensions, and cell wall features, such as openings, in relation to their physiological role and evolution. Very simplistically, one can consider elongated cells (such as the fibres and tracheids) that have a length in the range of 1 to a few mm, and cross-sectional widths in the range of 10 to 50 mm, with cell wall thickness of a few mm, vessels and sieve elements with a length and width of hundreds of mm, and thin cell walls of 1 to 3 mm, or parenchyma cells with dimensions under 100 mm and thin walled. Many other types of cells occur with specific characteristics, i.e., sclereids have very thick cell walls, leaving the cells practically without lumen.

These cell types are arranged in tissues that make up the three-dimensional structure of the biomass component. An enormous diversity is found both at the species level as well as in components within the species. Although also present, the diversity between individuals of a species is of a lesser degree.

Wood is comparatively less complex anatomically (and softwoods less than hardwoods) than, for instance, bark, as exemplified in Figures 1 and 2.

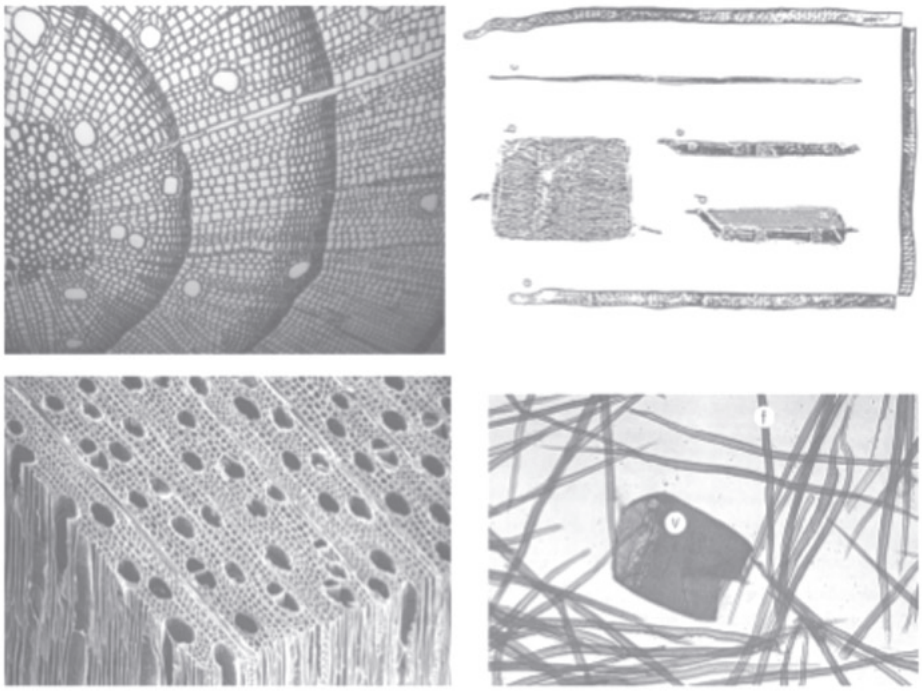

Figure 1: Anatomical structure of a softwood (top left), a hardwood (low left), and types of wood cells (top right) and a microscopic photo of dissociated cells showing fibres and a vessel element.

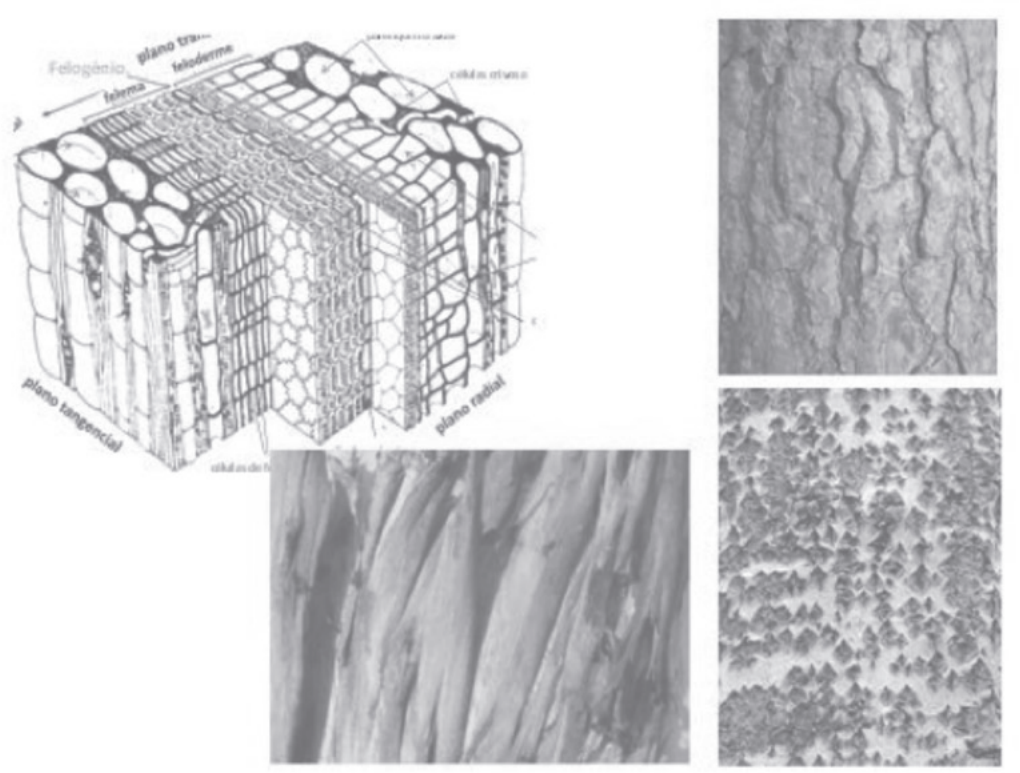

Figure 2: Schematic anatomical structure of bark (left), and three examples of barks showing the diversity of macroscopic aspect.

The diversity of biomass also occurs at the chemical level. The chemical components of biomass may be classified as structural components (macromolecular substances that are largely insoluble without depolymerisation and that define the physical structure of the biomass) and the nonstructural components. The major structural components are the polysaccharides cellulose and hemicelluloses, and lignin, from which the term lignocellulosics is derived and frequently applied to biomass. However, some components, such as the periderm in barks, also have another structural component, suberin. The content of the structural components in one biomass component varies between species (and to a lesser degree between individuals in the species) but mostly between the different biomass components. Even larger variation occurs in the nonstructural components, either the organic compounds that are soluble in solvents, and called extractives, as well as the inorganic components, usually named ashes. Table 2 shows the range of chemical composition that can be found in wood, bark, and leaves.

The chemical heterogeneity, both in content and in composition that is found in biomass is associated with its specific anatomical characteristics.

Table 2: Range of chemical compositional characteristics of wood, bark, and leaves.

	Wood	Barks	Leaves
Ash	>1 %	2-15 %	2-7 %
Extractives	1-10 %	5-30 %	15-50 %
Lignin	20-35 %	20-30 %	10-15 %
Cellulose	40-60 %	20-40 %	15-35 %
Hemicelluloses	15-30 %	20-30 %	10-15 %
Suberin/ Cutin	-	2-45 %	1-4 %

3. BIOMASS FRACTIONATION

The different conversion flows are related to the characteristics of the biomass type but specific preparation is necessary: collection, handling, and fractionation. The biomass preparation for fractionation involves pretreatments, e.g., grinding, screening, separation by density and particle size, washing, etc. The pretreatment may optimise subsequent processing and selection of the multiple options.

The physical and structural characteristics of a specific biomass will influence its behaviour upon mechanical handling, such as grinding, and may allow separation of fractions by differing physical properties (such as particle size or density). This may induce chemical differences between fractions that will make them preferentially suited to a specific conversion route or target component or application.

A few examples are given below from our ongoing experimental research.

One case relates to the study of Quercus cerris bark, which has a substantial amount of cork in its rhytidome. The cork tissue is interspersed with phloem, with very different cellular features (Figure 3) and chemical composition (Table 3). When the bark is fractionated, the fines are removed, and the remaining granules are separated by density and/or water flotation, it is possible to obtain a light fraction that is enriched in the cork tissue. It is this fraction that may be directed to cork-targeted application, either as a material due to the interesting properties of cork materials (i.e., for insulation and sealing) or for chemical fractioning to obtain suberin and/or extractives. The phloem-enriched fraction has a high content of ash material and shows a large amount of arabino-xylans in their hemicelluloses.

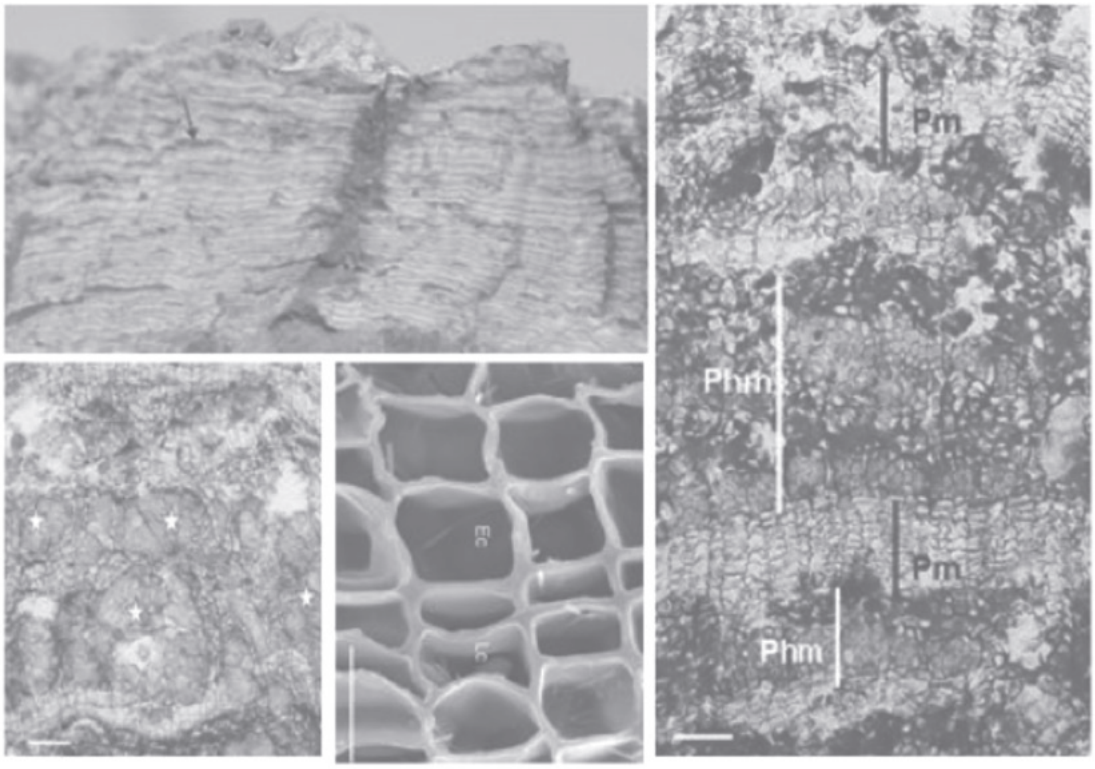

Figure 3: Bark characteristics of Quercus cerris: macroscopic aspect of rhytidome (top left), anatomical structure showing the layers of phellem and phloem (right) and details of sclereids (bottom left) and of the phellem (cork) cellular structure (bottom center).

Table 3: Chemical compositional of the fractions of phloem and of the cork within the bark rhytidome of Quercus cerris.

	Wood	**Barks**
Ash	2.6 %	13.0 %
Extractives	16.7 %	6.5 %
Lignin	28.1 %	35.4 %
Suberin	28.5 %	5.5 %
Monosaccaharides, & of neutral sugars		
Glucose	49.7	47.2
Mannose	2.4	1.3
Galactose	7.3	3.6
Xylose	27.9	40.3
Arabinose	11.5	6.6

The behaviour of the various biomass types upon grinding is material-specific and depends on the specific anatomical structure and cell physical features. Therefore, when considering a novel biomass feedstock for the biorefinery, it is necessary to make its specific characterization. An example is given for the study of four barks that are obtained commercially as side-streams during industrial processing: Eucalyptus globulus, Betula pendula, Picea abies, and Pinus sylvestris.

The grinding yields by particle size differ between the barks (Table 4) with variable amounts of fines (e.g., much higher for eucalypt bark) and coarser material (higher for pine).

Table 4: Mass yields (mass percentage) of fractions of different granulometries after grinding of four barks (Eucalyptus globulus, Betula pendula, Picea abies, and Pinus sylvestris).

(mm)	E. globulus	P. pendula	P. abies	P. sylvestris
<0.180	13.9	3.4	2.4	2.3
0.180-0.250	4.4	1.6	2.7	1.4
0.250-0.425	5.2	3.9	2.9	2.2
0.425-0.850	12.0	10.6	6.7	6.2
0.850-1.00	3.0	3.7	3.0	2.2
1.00-2.00	9.8	21.0	16.4	14.9
>2.00	51.8	55.9	66.0	70.7

The characterization of each granulometric fraction shows that ash content is higher in the fines (Figure 4), a general feature that is common to various biomass types. Industrial byproducts may be enriched in inorganic extraneous material, as it was the case of eucalypt bark, which included high contents of sand from forest and mill handling. The finer fractions are also usually enriched in extractives (data not shown).

Eucalypt bark anatomy is characterized by a high content of fibres and this translates into fractionation with the enrichment in fibres in the coarser fractions. As a result these fractions have higher holocellulose content and less lignin (Figure 5), and are therefore better suited for a fibre-related application, i.e., for pulping.

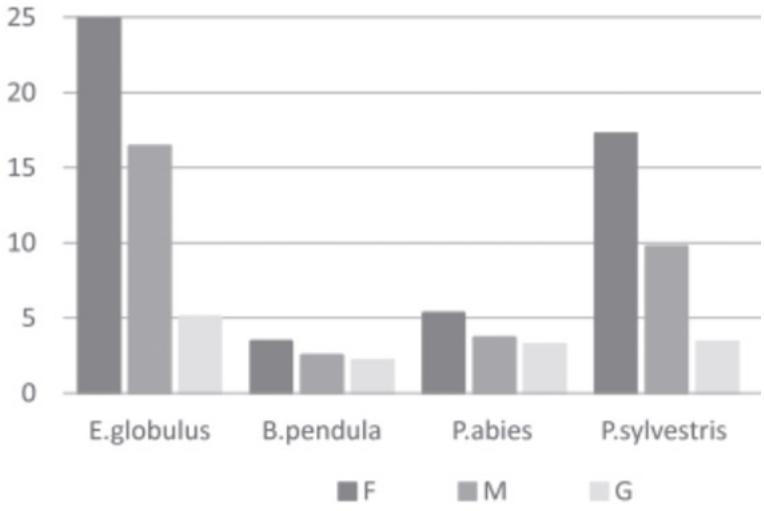

Figure 4: Ash content (mass percentage) of fractions of different granulometries (fine, medium and gross) after grinding of four barks (Eucalyptus globulus, Betula pendula, Picea abies, and Pinus sylvestris).

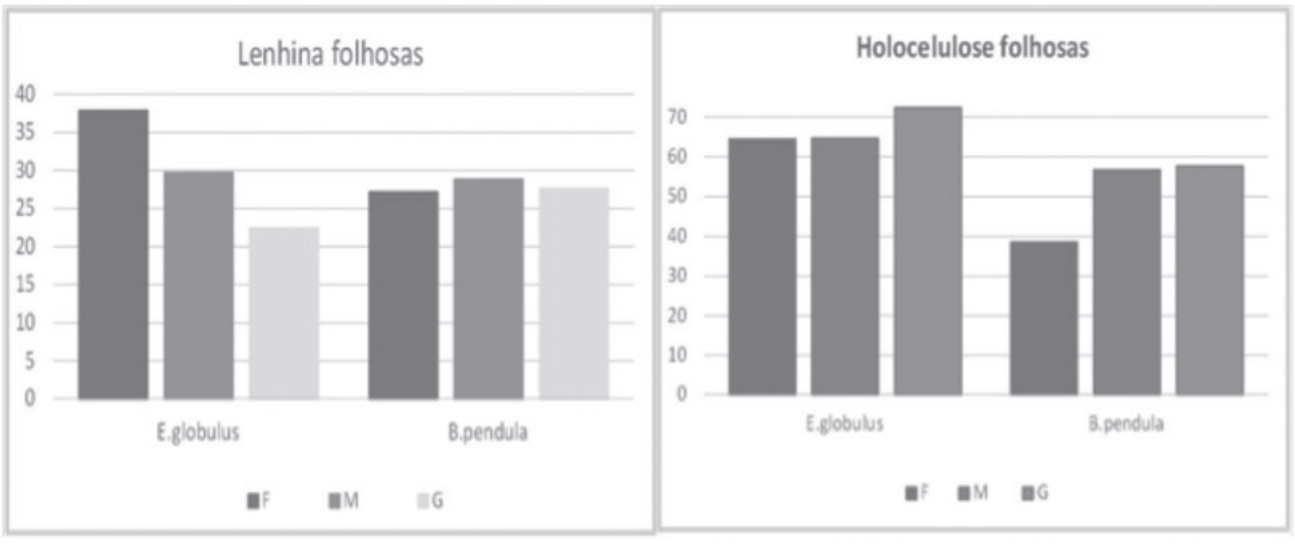

Figure 5: Mass yields (mass percentage) of lignin and holocellulose in fractions of different granulometries (fine, medium and gross) after grinding of the barks of Eucalyptus globulus and Betula pendula.

4. CONCLUSIONS

Biomass and biorefineries are important approaches to production of energy, chemicals, and materials. The full use of the different fractions of the biomass resource is required for biorefineries, whereas the conversion options for biomass may be multiple.

Some challenges are involved in the use of biomass: it is a solid material of cellular nature, and presents a high diversity and complexity at macro, micro and nano levels.

The complexity of the cellular structure involves diversity in the types of cells, of tissues, their arrangements, and the type of biomass components. As regards chemical composition, some general aspects are important: location of the chemical component (cell wall/lumen/ducts/voids), its chemical nature (organic/inorganic) and type (structural / nonstructural).

There is a large diversity in types of biomass and of biomass components between species and also within species/components. A detailed knowledge on the anatomical features of the biomass allows for better planning of pretreatments, fractionation, and conversion lines, in conjunction with the corresponding chemical features.

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ABSTRACTS

ORAL PRESENTATIONS

OP001

Viability of Midwestern Hardwoods: Mechanical Properties of Short Rotation Species

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As the utilization of our forest resource increases, there is a need for analyzing other short rotation tree species for their viability in the marketplace. Illinois has a limited amount of forestland, and most of it contains valuable hardwoods. Some species are not as highly utilized, but these can be used by certain types of industries to produce value-added products. Seven tree species were harvested from the University of Illinois Agricultural Research Station, Dixon Springs, for testing their strength properties. These species included Populus deltoides L. , Platanus occidentalis L., Acer spp. L., Robinia pseudoacacia L., Alnus glutinosa L., Populus spp, and Paulownia tomentosa Thumb., Steudel. These tree species were harvested after 20 years and represented either highland or bottomland sites. American Society for Testing and Materials (ASTM) D-143 (Standard Methods of Testing Small Clear Specimens of Timber) tests were performed on these species and were compared with the values for fully mature wood and from trees harvested from these identical plots ten years ago. Factor analysis was conducted to observe the significance of species, plot location, tree height, and tree variation on these mechanical properties.

The results showed that specific gravity was the most significant factor when trying to predict the mechanical property value of a species. There were no distinct pattern of specific gravity change in the six diffuse-porous woods, and rings per inch were not significant in predicting density. Species and location in the tree (height) were the most significant explanatory factors in all of the tests. These results will help in determining if these species could be used in applications requiring hardwoods or as an alternative in value added materials. This analysis of juvenile wood would help in evaluating the advantages of harvesting on a shorter rotation.

Keywords: Wood Specimen Testing; Short Rotation Hardwoods; Juvenile Wood

OP002

Radial variation in Kraft pulp yield and cellulose content in E. globulus

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NIR prediction of KPY and cellulose content from woodmeal, while relatively quick and cheap compared to laboratory analysis, still requires laborious sample preparation, involving air-drying, sample break-down and subsequent grinding into woodmeal. Recently, a radial-scanning NIR calibration was described that allowed variation in pulp yield and cellulose content to be assessed by surface scanning of intact Eucalyptus nitens wood samples (e.g. increment cores, or disc segments) at sub-annual radial resolution. The successful application of this type of calibration across multiple sites and species requires further development and testing.

We examined radial variation in Kraft pulp yield using NIR spectra collected from the surface of radial wood samples taken at breast height from 11-year-old trees of Eucalyptus globulus grown in Western Australia. Plantations at three sites, a high productivity site with high rainfall, a low productivity site with low rainfall and an intermediate site were studied. The two wetter sites with higher growth rates had significantly higher pulp yield and cellulose content than the drier low productivity site. At these two sites trees from plots with lower stocking had higher pulp yield. Pulp yield and cellulose content increased consistently from pith to bark, with no clear intra-annual cycle of variation. The two more productive sites exhibited significantly steeper pith-to-bark increases in pulp yield. However there was considerable variation in the rate of increase between trees within sites varying from 0.01 to 0.09% KPY per percent of radius.

The application of near infra red (NIR) spectroscopy to the measurement of wood properties from the surface scanning of wood cores will enable detailed study of within-tree variation in pulp yield and cellulose content that has not previously been possible, facilitating its description as a function of site, silviculture and genotype. This will aid the development of a fuller understanding of what drives variation within and between trees.

Keywords: eucalyptus; Kraft pulp yield; radial variation; Near infrared spectroscopy; cellulose content; plantation

OP003

Timber Quality for Wood Product Industries in Cultivated versus Naturally Regenerated Forests in Boreal Conditions - Norway Spruce and Scots Pine according to Finnish National Forest Inventory

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Artificial regeneration of softwood forests started in Finland in 1920's for Norway spruce and in 1950's for Scots pine, but not launched in a large scale before 1960's. The cultivated forests start to provide considerable volumes of logs for wood product industries during 2020's. Cultivated spruce stands are composed of plantations only, whereas pine stands are both directly seeded and planted. According to the existing knowledge, wood and timber properties of these raw material sources differ much from those that the industries are used to process in Nordic countries. Key differences can be traced to the genotype of the cultivation material, growing environment and forest management practices, as well as the adaptation and control of the three items with each other.

In the future, the quantity and quality of wood resources constitute the basis for the wood products and their competitive ability. The customer value depends on the ability to adapt raw materials, processes and products to the expected market segments and customer needs. Hence, it is a strategic issue to build a foresight for the availability and suitability of the woods for the different industrial purposes.

At the Finnish Forest Research Institute, an on-going research project is mapping the areas, volumes and tree dimensions of the cultivated forests vs. naturally regenerated forests by dominant species, geographic region, development class and forest site in Finland based on the data from the 10th National Forest Inventory. For spruce and pine, dimensional measures and factors of the external quality of the sample trees are calculated by dbh class. Of them, the recovery of the most important roundwood assortments and pulpwood, which mirrors the tree quality, is simulated using the measured data and bucking-to-value simulation. The data set consists of 16,651 spruces (8,608 in log size) and 27,297 pines (13,575 in log size). The spruce data includes 1,672 planted trees (744 in log size), the pine data includes 4,662 planted trees (1,528 in log size) and 1,813 directly seeded trees (474 in log size).

Results from the analyses are shown in this paper from the viewpoint of wood product industries. They provide the basis to focus further empirical studies on wood quality and potentials of utilisation in cultivated forests by region, forest site and type of industry. They benefit designing growing for quality schemes in forest management, and setting targets and priorities for further research and development projects on new and improved products and processing technology suitable for this growing raw material source.

Keywords: Wood resources; cultivated forests; timber quality; wood product industries; Pinus sylvestris; Picea abies

OP004

Modelling modulus of elasticity and modulus of rupture of Norway spruce sawn timber with tree and stand characteristics

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Norway spruce (Picea abies (L.) Karst) constitutes approximately three fourths of the annual production of sawn timber in Norway. According to The Norwegian Stress Grading Inspection Scheme, about one third of this is strength-graded. The great variation in mechanical properties and the inconsistent relationship between these properties within and between trees makes precise strength grading difficult. This makes the competition with other building materials that are more precisely described a challenge.

Norway spruce is of great importance for the European building industry, and numerous studies have been done to improve the grading of Norway spruce. Still, little emphasise has been put on sorting early in the conversion chain, for instance before crosscutting the stems. This will most probably enable a more optimal use of the raw material.

Density, MOE and MOR were tested in a pilot study on 373 planks from 45 Norway spruce trees, sampled from 3 stands with different site indices in Østfold county, Norway. This was done prior to a larger study on strength grading, which will include sawn timber from a larger range in site conditions.

Models using different stand- and tree-characteristics to predict MOE and MOR were developed. The MOR models were compared with a model including MOE alone and with models including both MOE and different tree- and stand-characteristics. The pilot study showed that the prediction of MOR can be improved by combining tree- and stand-characteristics with a device that measures MOE. In addition to MOE, relative diameter at breast height reduced the MOR residual variance the most. Relative diameter at breast height also reduced the MOE residual variance significantly, but not to the same extend as for MOR.

Keywords: Strength grading, MOE, MOR, modelling, tree characteristics, stand characteristics

OP005

Effects of commercial thinning and fertilization on selected wood quality attributes of back spruce and Jack pine

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One hundred eighteen trees (59 black spruce and 59 jack pine trees) were harvested from 8 boreal stands located in northern Quebec, Canada, to study the effects of thinning and fertilisation on radial growth and selected wood quality attributes. Three thinning intensities and two fertilisation treatments were examined. X-Ray densitometry was used to assess the variation of ring, earlywood and latewood widths and ring, earlywood and latewood densities. The Fiber quality analyser was used to measure the effects of thinning and fertilisation on earlywood and latewood tracheid lengths and widths. Flexural strength, compression parallel to grain and compression perpendicular to grain were measured on small clear wood samples before and after thinning.

Results indicated that for jack pine, thinning improved radial growth and tracheid width but decreased wood density and tracheid length. No significant effect on the mechanical properties was observed. The fertilisation also improved radial growth and decreased wood density while the impact on tracheid length and width was generally non-significant.

For black spruce, the effects of thinning and fertilization on radial growth were highly significant. However, for density the effect of thinning was significant but varied with tree height and year after treatment. Despite the significant effect of thinning on wood density, this treatment showed no significant effect on the mechanical properties. Fertilization showed a highly significant effect on wood density and this effect varies with tree height and year after treatment. For the anatomical properties, thinning showed non-significant effect on tracheid length and width while fertilization showed significant effects on these properties.

The variation of the selected wood quality attributes of back spruce and jack pine with thinning and fertilisation, although statistically significant in most cases, was much less important than the within tree variations. Taking into account the magnitude of variation of these attributes due to thinning and fertilization, it was concluded that for the studied stands, the negative impact of these treatments has no practical implications on the wood quality of the studied species.

Keywords: Wood quality attributes; commercial thinning; fertilization; wood density; wood morphology; mechanical properties

OP006

Influence of the wood structure on water uptake and swelling and its significance for surface finishing of high quality furniture

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Swelling due to hygroscopic water uptake has a strong impact on the processing of wood for dimensionally stable constructions like furniture and windows. Although swelling ratios in the three principal anatomical directions of most of the commercial timber species are known, few information on the hygroscopic water uptake of wood and related swelling is available on a microscale level. In this study swelling and shrinkage of commercial timber species was analysed on a tissue level by means of high resolution laserscan measurements. Wood samples of different tree species were exposed to different climate conditions and the related swelling and shrinkage of the samples were measured with an accuracy of ±2 µm and a spatial resolution of approximately 50 µm. The anatomical structure of the samples was analysed by light microscopy. The results revealed a different swelling behaviour of wood tissues like vessels with and wihout tyloses, rays, parenchyma with and without heartwood extractives in hardwoods, and earlywood and latewood tracheids in softwoods. The uneven swelling of neighboured tissues is considered to be the initial point for the rupture of lacquered surfaces and in more advanced phases for the formation of drought cracks in furnitures exposed to changing climates. This was confirmed by the analyses of homogenous lacquered surfaces from state-of-the-art carpentries. In contrast, the analyses of surface finishing of high quality historical furniture indicated that famous ebonists and cabinet makers like Abraham and David Röntgen considered the eneven swelling of different tissues within the surface finishing process which significantly contributed to the extraordinary dimensional stability of these master pieces.

Keywords: Wood anatomy, microscale swelling, laserscan measurements, lacquered surfaces, Röntgen cabinets

OP007

Wood Quality and Utilization of Planted Pitch Pine and Yellow Poplar in Korea

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Massive areas of Korean forestland were destroyed by World War II and the Korean War. An afforestation project was launched to create green area in Korea in the 1960s. And in the 1990s, the project was switched to forest care (cultivation) project. By doing an excellent job on the projects, the growing tree stock in Korea increased very fast and dramatically. In 2010, the stock, which was 63.5m^3/ha in 2000 just ten years before, has risen to 125.6m^3/ha similar to the global average.

As the tree stock increases, the ratio of domestic log supply to total log demand in Korea, which was 17% in 2001, increased to 47% in 2010. Pitch pine, which is the second greatest plantation species in Korea, accounts for 25% of the domestic log supply. Because of the bad shape of its stem which was formed by the absence of silviculture and the initial plantation without selecting high quality seed, pitch pine logs have been ground and used as raw materials for manufacturing wood composite board. Processes for manufacturing high-valuable solid-wood products could not be commercialized and it placed pitch pine under pressure of replacement with more economical species. Recently, however, as more of the better logs (IV~V age class tree) are being cut down, the technologies for manufacturing high-valuable solid-wood products are developed and applied to industries. Also, research on biorefinery and bioenergy conversion using the byproducts of the manufacturing process of the solid-wood products is being carried out, as well as research on the manufacture of engineering wood and its use.

Yellow poplar, which is a bee plant, grows straight and rapidly, and has good rooting, has drawn considerable attention as an alternative species to pitch pine. On the yellow poplar, research for acquiring data on the basic properties, like morphological characteristics, physical, mechanical, chemical and biological properties of its species tree (cut from trial plantation forest) is being carried out.

Keywords: Korea, plantation, pitch pine, yellow poplar, engineering wood, bioenergy, biorefinery

OP008

Occurrence of natural slip planes in Eucalyptus wood

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Slip planes can be described as a zone of re-orientated microfibrils caused by a stability failure in the columns of S2 microfibrils, whereby one part of the cell wall slips relative to another. It has been suggested that slip planes can arise naturally due to growth stresses or stresses caused by the flexing of the stem as a result of wind. Slip planes are most usually found in abundance in timber compressed parallel to the grain. It denotes the initial process of failure in a piece

of wood. To have a preliminary notion concerning the possible natural occurrence of slip planes in the fiber wall of Eucalyptus, wood having been subjected to no (artificial) stresses were investigated. In this case, blocks sampled from two radial positions in the log were used, supposed to represent regions exposed to both longitudinal tensile and longitudinal compressive growth stresses. The blocks were sampled from one log collected from each of three Eucalyptus clones planted in Southeast region of Brazil. The small blocks were fully saturated and microtomed to produce tangential longitudinal sections. To eliminate the possibility of inducing slip planes, sections were as thin as 10 µm, cut with a draw angle less than 5° and using a low cutting angle. Tangential longitudinal sections were then examined and slip planes observed using polarized light.

In two of the three clones slip planes were observed in the outer wood of the log and in three clones compression creases, possibly developed from the slip planes, were observed in the central blocks. In the inner wood compression crease lines characterized by high numbers of slip planes can be observed. This indicates an advanced stage of damage, possibly caused by compressive stresses associated with growth stresses. In the outer wood slip planes could be observed in much smaller numbers than in the inner wood, possibly caused by winds or damage to the tree during felling or extraction. It is important to mention that the existence of these deformations is a factor contributing to the reduction of the mechanical strength and stiffness of wood. Brash type failures were concentrated in the inner wood, possibly associated with the presence of compression creases.

Keywords: Slip planes, Eucalyptus; wood.

OP009

Mill variation in bending strength and stiffness of in-grade southern pine No. 2 lumber

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Visually graded lumber has wide variability within each grade. For southern pine (Pinus spp.), variability within grade for 2x4 lumber has increased because it is often harvested from intensively managed plantation forests where trees contain a large percentage of juvenile wood. To investigate resource variability, 744 samples of in-grade, commercially dried and graded No. 2, nominal 2x4 SP lumber from six mills was destructively tested in bending. Average stiffness ranged from 1.32 to 1.87 psi x 106, 3 mills did not meet the stiffness required for the grade (1.6 psi x 106). Bending strength (Fb) ranged from 1,201 to 1,886 psi, again 3 mills did not meet the bending strength required for the grade (1,500 psi). Actual bending strength grade ranged from the Construction grade to No. 1. Analysis of variance of stiffness and bending strength showed significant differences using Tukey's studentized range test at the 0.05 significance level. Stiffness explained a wide range of the variability in strength, with a range of 33% to 51%. This data suggests that destructive testing is critical for better characterization of lumber properties.

Keywords: Lumber; Southern pine; Design Values; Wood

OP010

Effect of thinning and fertilization on Eucalyptus grandis (Hill ex-Maiden) sawn wood quality

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Some species of the genus Eucalyptus can substitute, mainly in short-term rotation, many native wood species for most of uses since being properly managed. The effect of the fertilization and thinning in forest growth yield and quality of the produced wood is one of the questions to be considered in researches related to Eucalyptus grandis.

The study had the objective of studying the influence of forest thinning on some technological properties of sawn wood from a 21 year old grown Eucalyptus grandis stand managed by selective thinning after being fertilized when it was five years old.

The thinning intensities (37, 50 and 75%), presence or absence of past fertilization, two diameter classes, two vertical positions along the stem and three transversal position along the tree radius were taken as the study variables.

The influences of those treatments and their combinations on tree growth stresses were evaluated indirectly through log end splitting, green and dry sawn lumber end splitting, green sawn lumber bow and spring and pith displacement refereed to its normal central position.

Thinning, fertilization, diameter class and log position on the tree height did not bring significant effect on pith displacement which mean pith eccentricity.

Green and dry sawn lumber, log end splitting index, bow and spring were influenced by thinning, fertilization and diameter class in some specific situations.

Green and dry sawn lumber end splitting indexes decrease from pith to bark although green sawn lumber bow increases toward the periphery of the tree. Green lumber spring presents no variation tendency along the log radius.

In general the 75% thinning intensity slightly promoted a better homogeneity of sawn wood quality along the tree radius. It is observed a good positive relationships between dry sawn lumber end splitting and green sawn lumber end splitting.

Keywords: eucalypts; growth stresses; wood defects; sawn wood quality

OP011

Basic density of wood of clones of Eucalyptus related to the productivity of the plantation site

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One question that always disturbs producers and wood researchers is the influence that the environmental conditions for tree growth have on the quality of the wood. In Eucalyptus, rare is the information on this relationship, especially when comparing wood from identical genetic material, planted in different sites. The objective of this study was to compare the wood density of seven clones of the same age, planted at two sites with different productivity conditions. For this, three trees were collected from each of seven clones of Eucalyptus, with seven years of age, planted simultaneously in Paraopeba (site of higher productivity) and Bocaiuva (site of lower productivity), both located in Minas Gerais State, Brazil. Discs were cut at the base, the DBH and 25%, 50%, 75% and 100% of commercial height of each stem. The basic density were determined in each disc, checked their variations along the stem and made comparisons of the average densities of clones according to the site. From the results, it was concluded that all the trees that grew in Paraopeba showed larger than those grown in Bocaiúva. The study also found that clones from Paraopeba, site with the highest productivity, showed higher basic density than the same clones from Bocaiúva.

Keywords: Eucalyptus; wood; basic density; site

OP012

Prospect of Hopea odorata from Problematic Soils for Timber Production

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The increasing demand for wood and pulp has called for the establishment of timber plantations in order to reduce pressure on natural forests. At the same time, the scarcity of land had prompted the use of marginal sites for establishing timber plantations. Hopea odorata stands were established on two sites of different types of problematic soils consisting of tin tailings (ex-tin mine area) and Beach Ridges Interspersed with Swales (BRIS) soil, for greening purpose as well as to improve the economic value of these sites. Selected wood properties of 7-year-old Hopea odorata trees from stands established on BRIS soils in Setiu, Terengganu, and tin tailings in Bidor, Perak, were examined in this study. Freshly sawn samples of 600mm (L) x 100mm (W) x 30mm (T) were obtained. The physical properties studied were moisture content (MC) and density of the wood at 12% MC. The average diameter at breast height (DBH) of both the 7-year-old Hopea odorata stands in Setiu and Bidor were 8cm and 12cm respectively. The density of the wood grown on BRIS soil ranged from 587 to 757kg/m3, with a mean of 650kg/m3.Whereas, the density of the wood grown on tin tailings ranged from 559 to 792 kg/m3, with a mean of 684kg/m3. The density of both 7-year old Hopea odorata grown on two different types of problematic soils is comparable to young trees of different species planted on normal soils. This study provides a better understanding of the wood quality of 7-year-old H. odorata planted on problematic soils, with the possibility of an early selection for timber production using small diameter log.

Keywords: Hopea odorata, BRIS, tin tailings, moisture content, density

OP013

Use of X-ray for Detection of Internal Log Features

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To have knowledge about internal features in saw logs have always been a very important wish among people working in the sawmill industry. The reason for that wish is that with this knowledge it is possible to disintegrate logs in an optimal way.

X-ray linear attenuation depends mainly on density and size of the object that is hit by the X-ray beam. This makes X-ray technology suitable for detection of different features in saw logs as there is a density difference between clear wood and many important internal features such as different kind of knots.

Medical computer tomography (CT) utilise X-ray to detect internal features in human bodies but is also a very good tool for detection of features in saw logs. However, medical CT-scanners are only used for research purposes in the wood sector as they are far to slow for use in the industry.

In order to be able to detect internal log features in industrial speed Log-Scanners with one to four fixed X-ray sources have been developed. With these scanners, that now are used at many sawmills, it is possible to detect and measure features such as: diameter under bark, log type, species, knot parameters, annual ring width, density, heartwood, strength etc. These scanners with fixed sources have a much lower information density than medical CT-scanners but are much faster. The time for scanning a log has been reduced from about two hours to 1.5 seconds. The big draw-back with the scanners with fixed sources is that they give very little information about how defects are located in the rotational direction. However, in order to overcome this drawback, an industrial CT-scanner is now under development. This scanner will operate in industrial speed and will at the same time have an information density that is comparable with a medical CT-scanner.

The aim of this presentation is to summarize the current knowledge on X-ray scanning of wood and to propose some suitable applications and strategies for using a fast CT scanner in the wood industry.

Keywords: X-ray, CT-scanning, sawmill, saw log, wood features

OP014

Optimisation of production planning and process control supported by scanning of internal roundwood properties

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Big problem in conventional sawing operation is that sawn timber output cannot be seen before sawing. Sawn timber pieces are visible first after sawing machines. This is too late. It is not possible to correct mistakes made in sawing operations. There is a strong need to get a scanner, a tool capable to see inside roundwood pieces, stems and logs. Some front edge sawmills are already using rather expensive x-ray scanners. However current scanners can provide only rough estimation about log descriptors, so far. Big steps are estimated to be achieved in measuring accuracy in the future. It is also essential that the scanner prices should reduce in order to realize applications also in SME-companies.

Currently x-ray scanners are typically integrated with shape scanners capable to detect more or less precisely geometrical features of a log, knot volume, distances between whorls, heart wood diameter and content. Measuring accuracy is depending of the number of scanning directions which typically varies from 1 to 4 directions.

X-ray and other internal property scanners can provide useful basic data. However the basic issue is how to convert data to information and how to utilise the information in production planning and process control. Information can be further upgraded into knowledge. Precise scanning and processing of data provides to choose and process wood raw material taking into account the requirements of the final products.

VTT has developed WoodCIM® model system for optimisation sawn timber production based on information provided by x-ray scanning. The model is also a research tool for designing future, flexible wood factories. The paper present results what benefits can be achieved through implementations and integration of internal log property scanners, flexible manufacturing processes and information system.

Future concepts and roadmaps for improvements of information chains within conversion chains and scanners' performance will be presented.

Keywords: sawmill, round wood scanning, x-ray, production planning, process control, value yield, optimisation

OP015

Hardwood Log CT Scanning

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The Hardwood Scanning Center was established by Purdue University and Louisiana State University with funding from the Indiana hardwood industry, grants from state and federal agencies and the Indiana Hardwood Lumbermen's Association. Its mission is to increase the global competitiveness of the United States hardwood industry and to conserve the hardwood resource by development of technologies which will enable hardwood industry to "see inside a tree" and use this information to make better processing decisions.

The Hardwood Scanning Center partnered with others in the development of an industrial grade log CT scanner. The Hardwood Scanning Center also developed visualization and optimization software for the hardwood veneer and sawmill applications. This presentation will provide an overview and update of our activities.

Keywords: Hardwood, log, CT, scanning

OP016

Theoretical and experimental mass attenuation coefficient of the genus eucalyptus wood for a beam of gamma radiation from ^{241}Am

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The quality of wood of reforestation produced in Brazil has been a subject of many discussions in the Forestry Sector. Seeking to produce a rapid growth with wood quality control, the Forestry Sector has found in the Applied Nuclear Physics, a precise method of determining the density of wood known as ad hoc technique of attenuation of gamma-ray.

In this work we report the experimental determination of the mass attenuation coefficient of wood of the genus Eucalyptus for a collimated gamma-ray photon beam from for 241Am radioisotope. We used 324 samples of wood from six different treatments: a seminal of Eucalyptus grandis; two clones of E. grandis; three clones of the hybrid E. grandis x E. urophylla. The same assay was used for the six treatments. It was determined the basic density of the samples by the method of immersion in water and then the basic density was converted into apparent density in the moisture equilibrium and it was determined the attenuation coefficient of mass.

Additionally this work reports on the preliminary results of a Monte Carlo simulation of the experimental apparatus, implemented by using MCNPX code. We used a realistic 241Am gamma beam, with the same collimation system of the source in the experimental set-up. The geometry of the wood targets used in the calculation was identical to the experimental ones, with different values of elementary composition and densities for moist and dry wood. The results showed a high degree of sensitivity of the attenuation coefficient to these parameters. The calculation method is flexible enough to allow for the variation of multiple parameters, including media attenuation properties and the measurement geometry.

Keywords: Mass attenuation coefficient, Monte Carlo simulation, wood density, wood moisture

OP017

Improvement of the CT Reconstruction Technique Using Portable Soft X-ray Apparatus

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Structural members of Korean traditional building were usually made by wood. And the style of that is post-beam architecture which is exposed to exterior environment. So it is very important to detect decay and deterioration of wood because wood play an important role in structural stability. Non-destructive evaluation is an effective method to evaluate internal state of wood. Among the methods, X-ray technique is an effective way to evaluate wood which has a large diameter. Moreover, CT (Computed Tomography) reconstruction technique using X-ray is very useful to display an internal state of wood. But it is not easy to apply at the site. First, X-ray could be harm to users or researchers when they use X-ray at the site. Secondly, medical machines of X-ray CT cannot be used in field. Lastly, medical machines are not economical.

Our studies had been done to develop CT reconstruction technique to show internal state of wooden members by using a lesser number of soft X-ray radiographs. Add to former research results, this study has an object to improve accuracy of the CT image through analysis a single radiograph. X-ray tube was CP 120B (ICM, Belgium). In test, tube voltage and current of which was 45 kVp, 1.5 mA, respectively. Digital detector is NX 06 (RF co., Ltd, Japan) which is CCD (Charge Coupled Device) type. A radiograph was gained while digital detector was exposed to X-ray for one second. The test specimen, which one side badly decayed, was a rafter which had been sought from dissolved historical structure. BP (Back-Projection) method was used to make CT image using 180 radiographs.

To improve accuracy of the CT image, a single radiograph was investigated. It could be confirmed that actual centre of X-ray radiation was different to physical centre between X-ray tube and detector. And the density of specimen was more overestimated as a part of specimen apart from centre of detector. In addition to these, the diameter of specimen or the length of deterioration was also overestimated. These problems could come from using commercial X-ray apparatus which was made for not CT image but X-ray examination and disregarding the shape of X-ray radiation. Therefore, a single radiograph was analysed to find actual centre of X-ray radiation by a contour line of intensity of radiation using MATLAB program. And CT image was restructured after considering shape and intensity of X-ray radiation according to distance of centre of detector. If the intensity of actual centre of X-ray radiation is I, the intensity of X-ray radiation will be (a^2/(a^2+b^2))×I. Where, a is the shortest distance from centre of X-ray radiation to detector and b is a circle radius around point a in detector. It could be found that accuracy of CT image was improved when the pixel of CT image had been analysed.

So, it will be applied to evaluate decay of deterioration of historical wooden structure member or standing tree in the site through development of device after from this study.

Keywords: Non-destructive Evaluation; X-ray; CT Reconstruction; Internal State of Wood

OP018

Validation of a X-Ray densitometry method for the determination of *Eucalyptus grandis* and *Eucalyptus urophylla* radial density profile

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The X-ray densitometry is considered one of the main non-destructive techniques for the analysis of wood due to the high precision and practicality. The method has been applied in determining the density of the wood, and the density variation is a result of the anatomical structure and chemical composition of the same. This technique is still used in the identification of growth rings and determine the pattern of radial variation of density.

This work aimed to ascertain the reliability of the information obtained by the x-ray densitometry technique in determining radial density profile on clones from *Eucalyptus sp.*. To this, it were used two and three clones of Eucalyptus grandis and of *Eucalyptus urophylla*, respectively, with 53 months of age. For radial profile of density determination, withdrew a sample, from each individual, was withdrawn perpendicularly to the axis, passing through the medulla at 1.30 m above the ground. The remainder of the radial sample was sectioned into small specimens with two millimeters of thickness, approximately, for determination of density by hydrostatic method.

Analysis of the data obtained showed that the pattern of radial variation of density obtained by the technique in challenge is very similar to the standard achieved by the determination of density by hydrostatic method, inferring so that the technique is reliable for this kind of analysis.

Keywords: Variation, clones, density.

OP0019

The Usage of Gamma Ray Attenuation Method for *Eucalyptus* Wood Density Evaluation at Past Ages

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The main objectives of the development of clonal eucalyptus forests are rapid growth and productivity. Considering the great diversity of species, the genus Eucalyptus has the potential to attend different segments of wood industry. One of the principal parameters for wood quality evaluation is the basic density, especially when considering industrial and energy purposes. This property has relatively simple determination and is well correlate to several other wood properties.

The objective of this study was to determine basic density of wood on the ages of 2, 4 and 6 years of the physiological development of Eucalyptus spp. 6 years old trees using densitometric radial profiles obtained using the method of gamma ray attenuation and, addi-

tionally, taper functions and DAP measurements to define the regions of the profiles corresponding to each one of the past ages (2 and 4 years). Trees provided by Duraflora S.A. were sampled for each of the ages studied covering two clones (C1 - higher productivity and C2 - lower productivity) and two distinct regions (I – Itapetininga and LP – Lençóis Paulista – both at Sao Paulo State, Brazil), ranked by the company as higher performance and lower one, respectively.

Densitometric profiles (apparent density – 12% MC – and, indirectly, basic density) from discs along the 6 years old trees height were obtained by the gamma ray attenuation method. Subsequently, based on measurements of stem diameter along the height for 2 and 4 years old trees, taper functions were adjusted, allowing establishing the regions of the original densitometric profiles corresponding to each of the past ages. The weighted average basic density of trees in each of the situations and ages studied were calculated, finally, using the formulation of Pronin.

The results indicated that 6 years old trees of clones C1 and C2 of the region of Lençóis Paulista (LP) had weighted average basic density of 465 kg/m3 and 425 kg/m3, while the same clones in Itapetininga (I) region had 417 kg/m3 and 397 kg/m3. For the ages of 2 and 4 years clones C1 and C2 from the region of Lençóis Paulista (LP) also had higher weighted average basic density related to Itapetininga (I) region clones densities. The results indicated that the gamma ray method was an effective tool for determining the local density as well as complete and partial disc densities, allowing estimation of density at past ages. It was detected the increase of the weighted average basic density from 2 to 6 years, with higher percentage increases in the period from 2 to 4 years when related to the period from 4 to 6 years.

Keywords: Density; Eucalyptus spp.; taper functions; wood quality; precocious selection.

OP020

Classifying White Rot and decay resistance of some hardwoods from Sarawak and Peninsular Malaysia and correlations with their Tropical in-ground durability

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White rot wood decay under Malaysian terrestrial conditions pose serious threats to the in-ground service life of timbers besides soft rot and termite threats. A study is made on decay resistance variation for a total combined list of 30 Peninsular Malaysian and Sarawak timber species (plus 6 exotic reference temperate commercial woods) using the laboratory soil-block decay test method of ASTM D 2017, challenged with a representative virulent Malaysian white rot Basidiomycete Pycnoporus sanguineus. Results showed, among the wood species, that Hevea brasiliensis (rubberwood) suffered the most severe wood decay with average percentage mass loss of 43.9%, and regarded as non-durable. On the other scale, there was expectedly negligible decay of the most durable species Eusideroxylon zwageri (belian) heartwood with mean mass loss of only 0.66 %. The remaining species varies between non-durability and moderately high durability, but mainly moderately durable on the American ASTM 2017 and European EN350-1 decay resistance classification scales. Correlation between tropical in-ground durability (from available Peninsular Malaysian, Sarawak and stake test results) of these species and laboratory decay resistance was established demonstrating the extent of influence of fungal decay versus other biotic factors (presumably termites) to in-ground natural durability. Comparative variation of the white rot decay resistance among the timber species will augment the existing pool of information on wood quality classifications of some tropical timbers that are currently sought by the international timber trade, as well as detecting promising relatively decay resistant lesser-utilised species that the forest products industry may also be inclined to utilize in addition to the popular traditional species.

Keywords: Decay resistance, natural durability, decay test, ASTM D 2017, white rot, Pycnoporus sanguineus, Malaysian timbers

OP021

Investigations on the durability of two secondary Pine species (*Pinus halepensis*, *Pinus uncinata*) within the scope of the European natural durability standards revision

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Under the constant pressure to use timber, some wood species, previously considered as secondary and not economically important, are now taken into consideration. Two Pine species, Aleppo Pine (Pinus halepensis) and Mugo Pine (Pinus uncinata) are amongst these secondary timbers. While Aleppo Pine is usually reported as having a low natural durability, Mugo Pine is described as durable despite a lack of clear and/or consistent data on this crucial property for their end-uses.

Aleppo Pine (from Morocco) and Mugo Pine (from France and Spain) were studied for their durability towards both fungi and termites. The tests were performed with or without accelerated ageing (leaching) according to the methods described in the EN 350-1 (Guide to the principles of testing and classification of the natural durability of wood) and normative documents associated to its revision.

The results obtained are discussed within the scope of the European tests standards. Tests methods are compared and a proposal for these timbers classification is given for a future notification in the "Technical guide to natural durability and treatability of selected wood species of importance in Europe", former EN 350-2.

Keywords: Pinus halepensis, Pinus uncinata, Natural durability, Fungi, Termites, Standards and test methods

OP022

Decay factors in termite in-ground baiting systems

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Subterranean termites are serious pests of wood in service in much of the world. One of the most effective techniques for monitoring and controlling termites is the use of in-ground baiting systems which comprise a wood or other cellulosic material bait and/or a termiticide bait held in a open plastic cage so facilitates examination and the termites' access. Wood and other cellulosic substrates are subjected not only to termite attack, but also to fungal decay, which may interfere both with usefulness of the baiting system and with termite attraction.

Decay susceptibility of commercial baits was accessed during one year in the field. Variables evaluated were: mass loss of bait, meteorological data (cumulative rain, average temperature, average relative humidity), moisture content of substrate, termite presence, type of wood/cellulose substrate (cellulose powder, Pinus spp., Populus spp., Pinus pinaster, Hevea brasiliensis, cardboard), baiting model (Advance™, FirstLine™, Terminate™, LNEC) and a wood borate-based treatment.

A multivariate analysis (RDA) was performed, resulting in 78.8% of mass losses variability being explained by the decay factors considered in this analysis. Five factors were considered significant ($P<0.002$): moisture content, cellulose powder and type of bait (namely FirstLine™, Advance™ and LNEC). Advance™ baits were used with different wood/cellulose substrates: cellulose + Populus spp. and H. brasiliensis (treated and no treated). Although cellulose powder had very low mass loss and fungi attack, termites were not attracted to this substrate. H. brasiliensis Advance™ baits were attacked by termites. FirstLine™ baits showed no mass loss in calculation however, these traps were attacked by termites and moulds. LNEC baits, using P. pinaster, had low mass losses although termites' presence was detected periodically. The use of wood borate based treatment was not considered significant for decay resistance in this study; it was noticed that termites did not seem to avoid this fungicide treatments at the levels used.

Baiting design must be done carefully for the achievement of good results in termite monitoring and control in-ground termite baiting systems. The replacement of substrate after wetting and fungal decay may be necessary. Substrate decay resistance should be considered and evaluated in the field, including the search for adequate fungicides. The type of substrate must also be chosen accordingly to termites' preferences.

Keywords: Subterranean termites; fungal decay, bait design; in-ground baiting systems.

OP023

Analysis of decay progress anisotropy by X-ray computer tomography

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Wood has a serious handicap as structural materials that it is vulnerable to decay by fungi. A weather exposed bridge has a possibility of an abrupt fall down, and wooden houses with heavily decayed structural members are easily destroyed by large earthquakes. To avoid such damages, a new predicting method on the decay progress in timber structures, and also its strength losing behavior along with time, is required. We are now preparing a computer simulation method that enables above mentioned prediction, but basic data on wood decay process is lacking.

So, we carried out forced decay tests on small prismatic specimens with three anisotropic directions L, R and T in the length direction to clarify the decay developing velocity in the wood. Spruce was used as specimen, and both white-rot and brown-rot fungi were applied. At each projected term, decay progress was stopped, and the precise three dimensional density distributions in the specimen was measured using X-ray CT equipment.

As a result, the velocity of decay progress in longitudinal direction was the highest by the both used fungi. The variability of decay progress in the specimen was observed on the CT images, especially by white-rot fungi. This variability was seemed to be caused by the moisture contents distribution. In the radial and tangential direction specimens, the apparent weight loss was sporadically occurred by brown-rot fungi, that is in one third of the specimens per each exposure time group. From CT images, many cracks and shrinkage were seen in the vicinity of the cultural media by the dried tested pieces.

Keywords: decay anisotropy, X-ray, computer tomography(CT)

OP024

Evaluation of the effectiveness of *Cromoleana odorata* (L), *Cymbopogon citratus* (Stapf) and *Citrus aurantifolia* (Christm) as preservatives for wood treatment.

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The service life of non-durable or lesser known wood species can be extended with inorganic preservatives, but several are harmful to the environment and non-target organisms. Recently, eco-friendly types from organic sources including plants have been used. The efficacy of Cromoleana odorata, Cymbopogon citratus and Citrus aurantifolia against fungi growth and termite attack was investigated in this study. The wooden blocks measuring 20x20x60 (mm) were prepared from tree species of Pinus caribea (Morelet), Cordia milleni (L.) Mangifera indica (L.) and Terminalia cattapa (L.). The wood samples were impregnated with the extracts prepared from plants of Cromoleana odorata, Cymbopogon citratus and Citrus auran-

tifolia species for 72hrs using dipping method. The samples were divided into two equal halves which are true representatives of all the wooden samples used. One part were incubated at the timber graveyard to expose them to termites attacks while the second part was plated on sterile potato dextrose agar (PDA) and attacked with a wood desroying fungus (Rhizoctonia solani) while the deterioration rate was observe for a period of 1month for fungi growth and six months for termites attacks respectively. Data collected include phytochemical concentration of the plant extracts, retention rate (%), visual durability ratings, and mass and hardness losses of the wood samples due to fungi and termites attacks.

The analysis of variance showed that there was significant difference ($P<0.05$) in the type of extracts used wood species and concentration of the plant extracts. There was significant difference in the visibility test conducted for the wood species attacked by termite. C. odorata was found more effective because it contained more phytochemicals than other extracts used. All the extracts were found to be effective even at low concentration. The weight loss exhibited by tested sample were found to be significantly low.These extracts are potential alternatives for inorganic preservations in that they were found to be effective in suppressing both fungi and termite attacks.

Keywords: Preservatives, extracts, fungi and termites.

OP025

Study of the cure of melamine-urea-formaldehyde resins with very low formaldehyde emissions

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Urea-formaldehyde (UF) resins are the most widely used adhesives for wood-based panels (WBP). Worldwide, these resins represent 80 % of the total production in the aminoresins class. These are thermosetting polymers that, before cure, consist of an aqueous solution/dispersion of unreacted monomers, linear or branched oligomeric and polymeric molecules. They are obtained by condensation of aldehydes with compounds containing amino groups and their commercial success is mostly due to high reactivity, good performance and low cost. However, hydrolytic degradation of covalent bonds in the cured resin causes a significant weakening of mechanical strength and is a source of formaldehyde emissions.

The incorporation of a small percentage of melamine on UF resins improves the moisture/water resistance and therefore decreases formaldehyde emission. This occurs because more stable bonds are formed when a methylene carbon is linked to an amide group from a melamine ring, instead of nitrogen from urea. However, this results in a resin with lower reactivity and, consequently, higher pressing times.

In industry, the methods used for determining resin gel time are not representative of reality and the results are inaccurate and operator-sensitive. Other advanced characterization equipment, such as Differential Scanning Calorimetry (DSC) allows the identification of the onset temperature, cure rate, heat of reaction and kinetic parameters. However, it does not assess the strength of bonds formed within the resin, neither its interaction with wood. While DSC monitors the "chemical cure", ABES (Automatic Bonding Evaluation System), TMA (Thermo Mechanical Analysis) and DMTA (dynamic mechanical thermal analysis) allow for the evaluation of the bonding strength development.

This paper presents the results of curing studies of melamine-urea-formaldehyde (MUF) resins with low formaldehyde emissions performed with ABES technique. This equipment represents an expeditious and quick way to assess the strength of bonds formed during adhesive curing. Simple analytical models allowed for the quantification of resin gel time, cure rate and strength of adhesive joint. A comparison between the results for the resins gel time obtained using ABES and conventional methods is also presented.

Keywords: urea-formaldehyde resin, melamine, Automatic Bonding Evaluation System, gel time, resin cure

OP026

Characterization of Tunisian Aleppo pine Tannin Extract For a Potential Use in Adhesives Formulation

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At present, the production of wood adhesives mainly relies on the petrochemical-based resins, which are non-renewable and therefore ultimately limited in supply. The aim of this work is to get a better knowledge of Mediterranean wood plantations and forests and to valorize them as a potential source of tannins for adhesives formulation; we selected a local Tunisian vegetable material for the study which is Aleppo pine bark.

Tannins are important secondary metabolites and are very diffuse in the whole plant kingdom; they play a principal role in plant defense, for example against herbivores. They are divided in two broad classes, namely condensed tannins and hydrolysable tannins. Vegetable tannins have been used traditionally to tan leather. On the twenty-first century, they found a new application as phenol substitutes in the adhesives formulation.

Tannins can be found in the bark, stem, phloem, seeds, fruits, fruits pods, wood leaves and needles of dicotyledonous plants. The most common commercial tannins are coming from mimosa bark, quebracho wood, pine bark and oak bark.

Aleppo pine (Pinus halepensis Mill) is a conifer tree belongs to Pinaceae family. It is one of the most common pines throughout the Mediterranean on the plains and low mountains. In Tunisia Aleppo pine barks are used traditionally for leather tanning and its local name is "Sellekh".

The intending use of Aleppo pine barks as phenol substitutes in the formulation of adhesives was studied. Thus, total phenols, condensed tannins and hydrolysable tannins were estimated by colorimetric essays, characterized using NMR, DSC and TGA and compared to those of common tannins to evaluate their use as a source

of supply for adhesives formulation. Results show that Aleppo pine has high chemical, thermal and structural properties that lead to consider it as a tannin source for adhesives formulation.

Keywords: Aleppo pine; barks; polyphenols; condensed tannins; hydrolysable tannins; adhesives formulation.

OP027

Investigation the Effect Adhesive Types and High Dovetail Fitting on Stress Carrying Capacity of Miter Frame Corner Joints Constructed of Particleboard and Medium Density Fiberboard (MDF)

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This study was conducted to evaluate the effects of the high dovetail fitting consisting 9 and 14 mm, and adhesive types including polyvinyl acetate (PVAs), cyanoacrylate (CA) and without adhesive (WA) on stress carrying capacity of dovetail joints) under diagonal tension loading. The above combinations were compared in particleboard and medium density fiber board (MDF). L-shape specimens (15×5×1/6) were tested at loading rate of 5 mm/min. The results indicated that dovetail dimension had a significant effect on stress carrying capacity of joints, as stress carrying capacity under diagonal tension has increased, with the increase of high dovetail. The stress carrying capacity joints constructed with CA adhesive higher than joints made PVAc and without adhesive. Furthermore, the stress carrying capacity joints constructed with MDF higher than joints made of particleboard. The lowest ultimate stress carrying capacities (2/61Mpa) were obtained at 9 mm high dovetail of dovetail joints made of particleboard and without adhesive. In addition, the strongest dovetail joints (8/61Mpa) were obtained at 14 mm high dovetail with CA adhesive in medium density fiber.

Keywords: L-shape joints, stress carrying capacity, Dovetail fitting, Cyanoacrylate, polyvinyl acetate

OP028

Measuring roughness – influence of methods and devices

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The surface characterisation of wood and wood materials is an important tool to evaluate the quality of wood processing. There are a number of possibilities to measure surface properties, particularly those of the topographic surfaces (roughness) which differ in the type of device, the method of measuring, and in the accuracy of measurement.

The roughness parameters to be measured of wood and wood materials are standardised [DIN EN 4287, E DIN ISO 25178-2] whereas the methods to obtain them are not. This may lead to incomparable results when different methods are used. Thus it can be shown that the dimension of the measuring area determines the measuring results. Furthermore there is a huge influence of the sample preparation, the climatic conditions, as well as the number of measuring spots on an investigated area.

At IHD, different measuring principles for the determination of the surface roughness have been tested. For this purpose, measuring devices using the profile method were assessed as well as optoelectronic measuring devices, e.g. phase measuring fringe projection equipment. The results demonstrated remarkable differences within the obtained roughness parameters. It revealed that different types of wood require different methods to measure their surface roughness. The choice of the measuring method should therefore be based on the intended application and the type of material.

This paper will show examples of measurements carried out with different types of wood and wood materials to underline the necessity to establish specific methods of roughness measurement in dependence on the material and the specific case of application.

Keywords: Surface characteristics, roughness, measuring conditions, measuring method

OP029

Influence of the physical properties of the wood of antique parquets on the morphological characteristics of their surface

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The scientific objective of this study consisted in researching and analysing the relations between the physical properties of wood and the consequent morphological changes to the surface of parquet tiles after 180 years. This permitted to determine the most important physical and structural properties of wood species that have the greatest impact on the surface durability of the parquets made of them. These properties will be the basis to create a model of an "ideal parquet material".

The study included parquets dating to the 1830s, made of the wood species most commonly applied in parquets in Poland: oak, ash and pine.

The evaluation of the parquets was carried out through macroscopic and microscopic examinations and by testing their roughness, hardness and resistance to abrasion and scratches. The structure of the elements was examined as to their colour and lustre, visible and invisible trails of insects or damages caused by fungi. The results of macroscopic observation showed whether the wood of the parquet was well preserved, with cohesive structure and nice, dark colour with no major discolourations, scratches or indentations. The examinations permitted to check whether any spallings appeared on the front side of the elements in the proximity of joints, due to delaminations formed alongside fibers as a result of stresses caused by usage.

The assessment of surface quality will make it possible to study the factors that influence the durability of wooden parquets, through the analysis of the impact of material, surface finishing and microclimate, determining the importance of each factor.

Keywords: Hardness, resistance to abrasion, resistance to scratches, surface quality, macrostructure and microstructure of wood, antique wooden parquets

OP030

Measure the increase in surface roughness after a wetting-drying cycle to predict adhesion of black spruce wood

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Surfaces of black spruce wood (Picea mariana (Mill.) B.S.P.) were prepared by oblique cutting, peripheral planing, face milling and sanding for gluing and coating purposes. Produced surfaces were evaluated by microscopic analyses, roughness before and after a wetting-drying cycle, as well as glue and coating adhesion before and after accelerated aging treatments. All four surfacing treatments yielded surfaces having different microscopic characteristics and topographies. As opposed to the hypotheses, increase in surface roughness after a wetting-drying cycle was not only related to the level of cellular damage induced by each machining treatment. It resulted from the level of cellular damage combined with second-order sorption effects. Observations revealed that oblique-cut samples, virtually free of damage, as well as sanded ones, characterized by crushed and deformed cells, underwent the most important change in surface roughness during a wetting-drying cycle. The second-order effects dominated in the oblique-cut samples, while the springback of damaged cells was more important for the latter. Results also showed that micro-ruptures acted as discontinuities and reduced permanent swelling of cells for peripheral-planed and face-milled samples. Although the increase in surface roughness was related to the studied machining processes, it was not correlated with adhesion loss of glue or coating. Therefore, the method needs to be further improved in order to account for the relative importance of the different physical effects before it can be used as an index to predict adhesion.

OP031

Stilbenes from the bark of Norway spruce roots

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An increasing desire to replace oil-based and other non-sustainable products has led to the great interest of developing new products to different industries from biomass. The wood-derived material contains many interesting and potential compounds, which could be extracted and utilized as novel biochemicals and agents. Sources of raw material for this kind of utilisation could be from industrial side streams (e.g. debarking) and waste material from harvesting processes (e.g. roots and stumps). Before larger scale utilisation of biomass, there is a real need to gain more knowledge about compounds of interest.

In our earlier studies, we have found that especially the bark of Norway spruce (Picea abies [L.] Karst.) roots close to the stem is rich in stilbene glucosides, astringin and isorhapontin. These stilbenes are polyphenolic extractives, which have been shown to be potent anti-inflammatory, anti-cancer, antioxidant, anti-aging and chemoprotective agents. In addition, some stilbenes have been found to be antimicrobial and also active against termites.

We have developed extraction, concentration and isolation methods for stilbene compounds to study their properties and stability. Our work has included ASE extraction, purification with polymeric resin and enzymatic hydrolysis of stilbene glucosides to their aglycones. Chemical analyses have been done by GC-MS, HPLC-(-MS, -DAD or –NMR). Isolation of stilbenes from bark extracts has been done by semipreparative-HPLC.

According to our stability studies, isolated stilbenes and also bark extracts are stable when stored in -20°C and protected from light. In solution, stilbenes isomerise from trans-form to cis-form except in the case of astringin, when new compound was formed. Our aim is to continue stability studies with UV and pH sensitivity and with identification of formed compounds by e.g. NMR techniques. Also deeper understanding of the stability of bark (fresh and dried) is needed before larger scale utilisation. The suitability of stilbenes as antioxidants or preservatives in cosmetics, food, healthcare and wood protection will be tested.

Keywords: Stilbenes; Norway spruce; Roots; Bark; Extractives; Polyphenols; Bioactive compounds

OP032

Non-wood forest products utilisation in Europe – what are we talking about?

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The paper deals with the issues of terminology and scope of the concept of non-wood forest products (NWFP) and relevant regulations on the access to forests for NWFP utilisation. It also presents an analysis of the importance of individual non-wood forest products and intangible benefits derived from forests in selected European countries using the developed system of criteria and indicators. The key research issues and challenges in the organisation of the NWFP utilisation in the future have also been identified.

The starting point for the analysis were important questions, which in many cases remained unsolved. These are outlined below.

The scope of the term NWFP is very broad, and there is a great variation in the understanding of the term in different geographic regions. According to the definition proposed by the Food and Agriculture Organization in 1999, "non-wood forest products consist of

goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests". However, a variety of different terms and definitions are used in practice, which causes confusion in communication on a global level.

The use of forest resources (NWFP) should be considered in many aspects. Historically, it is an element of tradition resulting from spontaneous human activities in the forest, consisting in the provision of basic needs (harvesting of food products, medicinal plants, construction materials, etc.). At the same time, utilisation of NWFP resources is the sector of forest economy and the field of forest sciences – developing, but not always given proper attention.

NWFP are of economic significance in many countries. This is illustrated by the results of the research conducted in Poland: the annual value of harvested edible mushrooms may reach 15 per cent of the harvested timber. It is, therefore, believed that the promotion, development and organisation of responsible use of non-wood forest products should be considered an element of the regional development of the country.

In many developed countries of Western Europe, where the tradition of gathering products of forest floor resources has disappeared long ago, raw materials and tangible products in the non-wood forest utilisation lose in importance, while more attention is given to the growing importance of forest goods, services and benefits resulting from the non-production functions performed by the forest.

Currently, the real challenge is the elaboration of appropriate rules regulations for NWFP utilisation which are to facilitate the implementation of the criteria for sustainable use of natural resources.

OP033

Influence of the kind of wood (chestnut and Limousin oak) in the extractives and Klason lignin contents of wood fragments used in the ageing of wine brandies

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Traditionally, the ageing of brandy involves the storage in wooden barrels, during which the brandy acquires the desired chemical characteristics and organoleptic properties (colour, aroma and flavour) due to the contact with the wood (Canas et al., 1999; Caldeira et al. 2002, Caldeira et al., 2006, Caldeira et al., 2010), which deliver on increased overall quality of the final drink (Caldeira et al., 2006).

Concerning the botanical species used for the ageing of brandies, the scientific research has been focused on species like Quercus robur L. and Quercus sessiliflora Salisb. from France and Quercus alba L. from the USA, while other species of oak and chestnut have been less studied. Recent works (Canas et al. 1999; Canas et al., 2000; Caldeira et al., 2002) revealed the suitability of chestnut (Castanea sativa Mill.) and Portuguese oak (Quercus pyrenaica Willd.) for this purpose.

Ageing systems of wine brandies have been a target of deep investigation in order to reduce the costs and the ageing period associated with them. In this study it were evaluated the extractives and Klason lignin contents of wood fragments used in the ageing of brandies in stainless steel tanks. It were used two types of fragments (staves and tablets), and two botanical species (Limousin oak and Portuguese chestnut), with the same toasting level. The wood extractive and Klason lignin contents were analysed before and 30 months after the ageing process.

The results showed that chestnut had significantly influenced the extractives and Klason and total lignin contents of the aged brandies. The tablets had a highly significant effect on the extractives and Klason lignin contents, while the staves had more influence on the soluble lignin content.

Keywords: Portuguese chestnut, Limousin oak, wood extractive, lignin contents

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OP034

Potency and Conservation of Songga Tree (*Strychnos lucida* R Brown) as Traditional Medicinal Plant, a Case Study in Sumbawa Island – Indonesia

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Songga tree (Strychnos lucida R Brown), famili Longaniaceae is native in Australia, Thailand, and Indonesia. This tree mostly found in primary forest. Distribution of this species in Indonesia: almost all in the forest area in Dompu District, Nusa Tenggara Barat Province; East Java, Roti Island; Timor Island, and South East Maluku.. This species is one of non timber forest product (NTFP), because the diameter of the tree is not more than 10 cm.

Habitat of this species is in dry, windy, and coastal areas, 0-500 up sea level, and it can grow in stony areas. Local people in Sumbawa Island use this plant as medicine for many kinds of diseases such as aphrodisiac, anti hypertension, anti fertility, anti diabetes, anti malaria, anti cancer, and rheumatism. They got this traditional knowledge from their ancestor.

This study conducted in Sumbawa Island in 2009. The methods were: observation directly to the field, study literature, interview to local people, and key informant in the study area. Besides, It had high and competitive price in international trade, so this species is very worthy for local people.

Unfortunately, the existence of this species in nature in threat because over exploitation, and people around the forest exploit this species in the nature without any effort to cultivate them. As a result, it tends to be rare in nature. According to the description above, this species is threatened in Indonesia's Forest. Because this species can

contribute to local people income, so it is needed to make regulation, conservation, and efforts to make this species sustainable in nature.

Keywords: Potency; conservation; (Strychnos lucida R Brown); traditional; medicinal plant; Indonesia

OP035

Non-Timber Forest Products commercialization in Colombia: Trends, markets and consumption during the last ten years

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Food insecurity, climate change, the greenhouse effects, and the destruction of nature resources are becoming in strong issues today, able to transform our livelihoods and the normal development of structure and composition of tropical ecosystems and tropical forest. Tropical communities and specifically Colombian communities are heavily exposed to the effects of climate change and its impact in reductions of productivity of important crops and the constant loss of forest coverage because of agriculture, increasing in this way food insecurity for poverty communities which are the major part of communities in Colombia. However there are huge opportunities of production, transformation and trading for Non-Timber Forest Products NTFP. From their use, food security could be ensured, and poverty populations can be reduced because of the economic benefits of their commercialization. These products have been highly used for indigenous communities and today some of the Colombian cultures still keep the millenary customs of their ancestors. This paper pretends to collect and evaluate information about the production and commercialization of the most recognized NRFP in Colombia, including products coming from Phytelephas seemanii, Ormosia spp. Juglans neotropica and Heliconia spp. and their influence in the national economy, their trends, and their possibilities in reducing hunger in the country and generates economic benefits for the communities. The main products evaluated are Oils, resins and oleoresins, Gums, Dyes, pigments and natural dyes, Herbs and spices, medicinal plants and phyto-pharmaceutical plants, exotic Flowers and exotic fruits. This revision also contains the prices evolution and the principal markets in which these products have been marketed.

Keywords: Non-Timber Forest Products, commercialization, trading, Colombia, Trends

OP036

Forest for bees

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Mediterranean forest ecosystems possess a unique and diverse flora, characterized by a rich understorey dominated by insect pollinated angiosperms, mainly visited by bees gathering nectar and pollen.

The present worldwide decline in bee populations raises major concerns, mortality being mostly attributed to agricultural intensification, particularly pesticide use. In this context, since Mediterranean forests are mostly kept free from the application of biocides, these ecosystems can play a major ecological role, by providing habitat and food source for bees. The economic value may result both directly from bee products, such as honey, and indirectly by securing effective pollination to agricultural ecosystems either by human-assisted movement of bee colonies or by bees' natural range activity. Hence, forests should be further valuated by its pollination ecosystem service.

By using a study case we present evidence about the relevance of Mediterranean forest ecosystems as a valuable source of nectar and pollen. We further compare honey types produced over the Mediterranean region, regarding their floral sources. Finally we review different management regimes applicable to Mediterranean forests regarding their relevance for nectar and pollen supply. Results demonstrate the need to implement forest management strategies focused on pollination governance, by promoting habitat conservation for bees in a pesticide free space.

Keywords: Bees, forest management, pollination service, bee products

OP037

Effect of commercial quality and provenance on the mechanical behaviour of cork

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Cork properties have given rise to numerous industrial applications, emphasizing on the manufacture of stoppers for wine bottling. This use determines the commercial classification of cork, which is carried out through visual inspection, mainly based on porosity analysis. Currently a high level of automation in this operation has been reached, but even so it remains a subjective process which makes the expression "cork quality" such a nebulous term. Lack of traceability and heterogeneity of commercial grades are some of the main handicaps relative to synthetic alternatives.

In this paper we analyse the mechanical behaviour of cork, with the objective of evaluate the influence of geographical origin and commercial grade on it. Discs from two different origins and four commercial qualities have been submitted to a compression test in the axial direction, radial direction of the tree. Measurements allow a full

characterization of the visco-elastic behaviour in terms of stress for 33 % strain (S33, MPa), Young modulus (E), resilience index (I), density (D, g·l-1) and dimensional recovery at 15 s, 15 min and 1 week (R15s, R15m, R1w, %).

Results show the effect ($p<0,01\%$) of the commercial classification on the stress (S33), resilience (I) and intermediate recovery (R15m). The effect of the origin is appraised specially in the variables that define the initial zone of the stress-strain curve: instantaneous recovery (R15s, $p<0,01\%$) and Young Modulus (E, $p<0,05\%$), being also detected for R15m and R1w. Interaction between both factors has not been detected. Correlations are low excepting that between D and S33 ($R2 = 0.725$). Finally, the analysis of anomalous cases highlights the relationship between mechanical behaviour and the presence of some defects (ligneous inclusions, stains) hardly detectable by image analysis and, therefore, causes of possible classification errors.

It can be concluded that mechanical tests can be of great help in the definition of more objective and homogenous quality grades as well as in the improvement of the final products traceability.

Keywords: Quercus suber; cork properties; cork grading; traceability; quality control

OP038

The surface porosity of natural cork stoppers and quality classes produced from cork boards of different calliper

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The natural cork stoppers are the premium product of the cork industry and the commercial value of cork is determined by its suitability for the production of stoppers. Cork is a biological material with cellular structure, chemical inertia and specific mechanical behaviour that provide an unmatched closure for bottles with worldwide recognition of quality and performance as wine sealant. The aim of this study was to characterize the variability and quantify the surface porosity of wine cork stoppers that were produced from cork boards of different callipers and are of different commercial quality classes.

The porosity of 600 cork stoppers, 300 punched out from cork strips of calliper 27-32 mm and 300 from calliper 45-54 mm was characterized by image analysis on the total lateral surface and tops. Porosity coefficient was 2.5%, 4.0% and 5.8%, respectively for premium, good and standard stoppers from 27-32 mm cork boards, and 2.4%, 4.0% and 5.5% for the premium, good and standard quality class from 45-54 mm. In average, stoppers produced from the thinner cork boards (calliper 27-32 mm) present less pores but with higher average area and maximum pore area than the stoppers produced from 45-54 mm.

The commercial quality classes of cork stoppers can be differentiated by the mean values of the main porosity features of their surface namely dimension and concentration variables, considering either the lateral surface or tops. These features showed an increasing trend from the best to standard quality class independently of the corkboard calliper from which they were produced.

Due to the large sampling and the detailed observation the results may be used for reinforcing quality requirements for the cork stoppers commerce i.e. definition of standards.

Keywords: natural cork stoppers, quality classes, corkboard calliper, porosity, image analysis

OP039

Study of the bonding of cork using ABES technique

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Portugal is the largest worldwide producer of cork and the cork industry plays an important role in Portuguese economy. Cork is a renewable and recyclable raw material and presents unique characteristics as lightness, elasticity, fire resistance, impermeability, and sound and thermal insulation. It is used in several products as stoppers, flooring, footwear components, sound control underlayment, etc. In 2006 the Portuguese cork oak forest represented a carbon sink of around 4.8 million tons.

Cork agglomerate composites use residues from cork stopper production and it is a material of excellence in the field of Sustainable Construction, mostly in flooring and wall applications. Cork agglomerate panels are a cork based sheet material manufactured from cork particles bonded together with a synthetic resin adhesive under a hot-pressing process. This process is quite complex as involves simultaneous and coupled heat and mass transfer, polymerization of the adhesive and forming. Therefore, mechanical, physical and chemical interactions as compression, stress relaxation, softening and distortion of cell wall structure, heat and mass transfer, phase changes of water, as well as adhesive curing and adhesion takes place within a pressing cycle. The dynamics of the strength development influences production speed, energy consumption and product quality. So, a better understanding of the cork particle – adhesive interactions within cork composite mat is important for the optimization and control of this operation.

This paper presents a new application for ABES (Automated Bonding Evaluation System), a technique developed for determining the rate of strength development of adhesives as they cure, in wood lap shear joints. This equipment provides a quantitative means of understanding the dynamics of bond strength development under highly controlled conditions. It allows for accurate control of bonding pressure, platen temperature, and bonding dwell time and good alignment of the lap shear samples. To explore the reactivity of adhesive-cork combination during hot-pressing, a new sample configuration was proposed. Isothermal bond strength development was plotted as a function of time for several platen temperatures and kinetic parameters were computed from these plot families, for each type of adhesive. This technique seems to be appropriate to assess the sensitivity of an adhesive/cork system to different process variables, enabling a quantitative screening of adhesives and operating conditions in industrial context.

Keywords: cork composites, thermosetting resins, Automated Bonding Evaluation System, resin cure

OP040

Getting More Value Out of Granulated Industrial Cork

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Triterpenic compounds, like cerine, betuline, friedeline, betulinic acid, have promising applications as bioactive compounds or precursors to drug ingredients, namely in the prevention and treatment of cancer and HIV infection. Cork, Quercus suber L. outer bark, whose biggest world producer is Portugal, conceals these very high added-value products. The development of a sustainable, clean and efficient process for the extraction and fractionation of these compounds, completely integrated in the industrial cork mill process, without compromising the traditional cork applications, would introduce a valorization step in the cork mill process, broadening the type of markets and clients for the cork sector.

During stoppers production c.a. 60% of cork is rejected, which is milled into different particle sizes for a variety of applications, mainly as agglomerates. Also, 20-30% of the cork entering the mill ends as cork powder that is currently burned.

The objective of this work was to quantify betulinic acid, BA, and betuline, B (the most promising in pharmaceutical applications) in industrial granulated cork and cork powder. Soxhlet extractions were performed for different particle size groups of granulated industrial cork (0.5 to 6 mm) and cork powder, with organic solvents with different polarity (hexane, dichloromethane, acetone).

The best extraction yields were obtained with acetone. The extracts were evaluated qualitatively by GC/MS. Cerine, friedeline, B, BA and -sitosterol were the most abundant of the identified compounds. A quantitative analysis (GC-FID) was performed only for B and BA. Again, acetone extracts presented the highest contents of B and BA: 0.57 g B/kg cork and 3.00 g BA/kg cork (for the smallest particle size group). It is important to highlight that: i) in all extracts, BA content was 3 to 5 times higher than of B; ii) for the 3 solvents, the contents of B and BA with respect to the extract (g of compound/g of extract) are similar for each particle size group.

Results on the influence of the particle size on BA and B yields will also be presented.

Keywords: Cork; Soxhlet extraction; betuline; betulinic acid.

OP041

Green chemicals from cork: suberin monomers as technical lipids

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Cork is harvested from the cork-oak tree (Quercus suber) on a renewable and sustainable basis. Cyclically, every nine years, the cork is removed from the trees, which have a life span of more than one hundred and fifty years. Annually, in Portugal, more than 100,000 tons of cork is extracted. Cork is used in a myriad of products, from the familiar cork-stoppers, to performing composites used as thermal shields in spacecrafts. Cork processing gives rise every year to more than 25,000 tons of a cork powder by-product, which can be used as a source for speciality green chemicals.

Cork has a specific chemical component, suberin, which accounts for more than 40% of its dry weight. Suberin is an heteropolymer based in long-chain, C18 and C22 fatty acids, namely omega-hydroxy fatty acids (LC-OHFA) and alpha,omega-dicarboxylic acids (LC-DCA), that together with glycerol are assembled as a complex polyester. Due to their structural characteristics, such as long hydrocarbon chains, and alpha,omega reactive groups, these families of suberin monomers, have long been seen as lipids of high technical interest. Processes were developed for the extraction of these compounds from the cork powders, followed by its purification, which can be scaled up to industrial production.

A large number of valuable potential uses have been identified for the cork suberin LC-OHFAs and LC-DCAs, including: cosmetic active ingredients, with skin-tensioning and brightening effects; building units of bio-mimetic membranes for ultra-purification processes; synthesis of polyesters and polyamides with elastomeric properties. Another major advantage of these suberin-based compounds is its biological origin, together with its renewability and sustainability, all future's demands for industrial chemicals.

Keywords: Cork; suberin; long-chain omega-hydroxy fatty acids (LC-OHFA); long-chain alpha,omega-dicarboxylic acids (LC-DCA)

OP042

Utilization of Waste Polyethylene Bags in the Manufacture of Particleboard

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Utilization of waste polyethylene bags in the manufacturing of particleboard was investigated, using the same method as that commonly used in the wood-based panel industry. Particleboard (1.9-cm thickness) comprised of mixed wood particle/powered polyethylene (PE) bag waste was fabricated in the laboratory using urea formaldehyde (UF) resin as a binder. Internal bond (IB) strength, bending properties, and dimensional stability were evaluated. The addition of 25% powdered PE bag waste to the mixed particle/PE plastic panels (MWP) did not adversely affect non-aged bonding strength as compared to wood particleboard (WP) but did result in substantial improvement in IB retention after 24-hour water soak and dimensional stability. Average IB retention increased more than 300% and thickness swell and linear expansion decreased 70% and 44%, respectively, for MWP as compared to that of MP. This finding suggests that MWP panels offer great potential for the development of structural panel products with improved moisture resistance, more competitive capabilities, and new markets.

Keywords: Particleboard, polyethylene.

OP043

The optimum condition of moso bamboo for binderless board

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Bamboo consisting of lignin, α-cellulose, hemicellulose, free sugar, and starch is considered to be one of the most abundant and sustainable biomass resources due to rapid growing. We focus on possibility of bamboo as materials for the binderless boards, one of eco-friendly use of lignocellulose materials by self-bonding without synthetic adhesive.

Binderless boards were manufactured from several species of some bamboo, which were moso, hachiku, kinmei and hotei (Phyllostachys spp.).

Boards were prepared by hot-pressing of powder (condition: pressure 5MPa, temperature 200°C, time 10 minutes) and properties of internal bonding (IB), water absorption (WA), thickness swelling (TS) were evaluated according to JIS A 5905-2003 (fiberboard). Moso, having the best values among the four species, was focused on and the optimum preparating condition was investigated: Moso bamboo were harvested every months between June 2010 and May 2011, taken from different heights (bottom: 0–0.9 m, middle: 2.4–3.6 m, 5.4–6.3 m, top: 7.2–8.1 m), at different ages (under 1 year old, 4–6 year old, over 10 year old) were used as sample.

As a result, boards manufactured from moso bamboo, harvested between March and October, collected from bottom and middle part and 4- to 6-year-old bamboo showed higher IB and lower WA and TS than that manufactured other conditions.

In conclusion, moso bamboo was the most suitabe for binderless board than the other species of the bamboos, and specially a moso bamboo of 4- to 6-year-old plant collected from bottom and middle part which harvested between March and October was best.

Keywords: Moso bamboo; binderlss board; self-bonding

OP044

Value-Added Composite Panels from Under-Utilized Wood and Non-Wood Species

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The manufacture of value-added composite panels from under-utilized wood and non-wood species is getting more popular in many countries. Most of the developing countries are rich in agricultural products which create large amount of waste fiber. Rice straw, jute, coconut fiber, oil palm, bagasse are only some of such resources that can be used to produce different types of value-added composite panels including particleboard and medium density fiberboard (MDF). In addition to agricultural waste fibers bamboo is also getting more attention from composite panels manufacturers in Asian countries as an alternative material. Invasive species such as eastern redcedar (Juniperus virginiana) in South Western states in the USA would also be considered as viable raw material to manufacture above products.

The objective of this study was to review both physical and mechanical properties of particleboard and fiberboard panels manufactured from underutilized invasive species and non-wood materials. Eastern redcedar, bamboo, and rice straw were used to manufacture experimental panels. Basic properties of such samples including modulus of elasticity, modulus of rupture, internal bond strength, thickness swelling, water absorption, screw holding strength, density profiles and surface quality were evaluated. Panels made 100% bamboo had the best properties among the other samples. Adding rice straw into the panels reduced both physical and mechanical properties of the samples. However manufacturing sandwich type of panels having fibers on the face layers while particle of the same type of materials in the core improved surface quality in addition to their strength characteristics as compared to those of single layer particle and fiberboards. Based on the findings of this work such underutilized species could have potential to be used as raw material to manufacture value-added panels with accepted properties.

OP045

Development of High Performance Oil Palm Stem Plywood

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One of the problems dealing with oil palm stem (OPS) plywood is the high veneer surface roughness that results in high resin consumption during the plywood manufacturing. The main objective of this study is to develop suitable resin treatment process to improve the properties of plywood made from OPS. The effects of treatment with low molecular weight phenol formaldehyde (LMWPF) resin on the wettability and surface roughness of OPS veneer were examined. OPS veneers were segregated into two categories (outer and inner), prior to soaking in LMWPF resin solution to obtain weight percent gain of 16-20 %. The results show that the effect of LMWPF resin treatment on the surface roughness and density of the veneers is statistically significant. The effects of pretreatment of OPS veneers with LMWPF resin on the bending strength, bond integrity and dimensional stability of OPS plywood were further evaluated. OPS plywood were produced using two types of lay-ups (100% outer and 100% inner) and two UF adhesive spread amounts (200g/m2 and 250g/m2). The effects were more significant on the outer layer veneers of OPS and the treatment was able to improve the MOR by 115%, MOE by 70% , shear strength (dry test) by 134% and shear strength (wet test) by 197%. Whilst the improvement in the inner veneer were 60%, 43%, 90% and 125% on the MOR, MOE, shear strength (dry test) and shear strength (wet test) respectively. Untreated samples signify swelling in range 21.0% to 40.9% and absorbing water between 79.7% until 129.1% after 1 week soaked in cold water. Conversely, the treated samples only swelled in range, 7.9% to 10.9% and absorbed between 38.6% until 64.1% of water. Lastly, the study was carried out to evaluate the effectiveness of phenolic treated OPS plywood against both subterranean termites and white rot fungi. In the termites resistance test, the percentage of weight loss for un-

treated samples were 19.2% (outer veneer) and 23.9% (inner veneer), while for phenolic treated samples were only 10.7% and 15.8%, respectively. The phenolic treatment was able to enhance the resistance towards termites by 38% and towards white rot fungi by 62%.

Keywords: oil palm stem, plywood, resin treatment, strength, dimensional stability

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OP046

Multilayered Cross Laminated Panels from Coconut Palm Timber

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The amount of incidental coconut palms (Cocos nucifera L.) in the plantations of South-Asia and Latin America is enormous. At the beginning of the 90s it was assumed that with a sustainable managing some hundred millions m^3 will be incurred. Since some decades there is attempted meticulous research to enlarge the possibilities of usage for coconut palm.

The research deals with the design and manufacturing of three layered cross-laminated panels (3CLP) of coconut palm timber. Various types concerning the panel thickness (27 and 40 mm), density of the faces (high and medium) and core (medium and low) as well as the resin-types (UF, MUF, PVAc) were tested.

The results of the testing for the main mechanical properties like MoR and MoE cross and parallel to the main panel axes compared to the same panels made from spruce lamellae confirmed high performances for all densities and resin combinations.

Other specific test like strength in shear and adhesion quality after boiling test indicate the best in practice resin for this wooden tissue type. The free formaldehyde and VOC emission of these panels were tested and proved the low values.

For exterior use or in wet condition of this panels it is requested a further research regarding the surface coating.

Keywords: Coconut timber, 3layered cross laminated panels

OP047

Wood structure and Climate Change – a review

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The microscopic structure of angiosperm wood shows diversity patterns from the Cretaceous onwards that indicate that climate change and climate gradients across the planet earth have been and still are main drivers in wood evolution. The resulting climate-related trends in wood structure can be interpreted as adaptations of trees, shrubs, herbs and climbers for optimal functioning in safe and efficient water transport, mechanical support, and biological defence against mechanical damage and the spread of pathogens in the sapwood. Examples will be presented of how features of the growth rings, vessels, fibres and parenchyma can be used as proxies for climate reconstruction. The potential risks of extant woody plants under global warming will also be discussed. One of the great challenges of modern wood research is to model the relationships between climate and wood anatomical diversity patterns of extinct and extant plant communities in such a way that the impact of current and future climate change can be reliably predicted so that appropriate measures can be taken for conservation and sustainable forestry practices.

OP048

Reaction Wood efficiency in leaning stems of four Pinus species.

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A common defect in Pinus sp. is the lack of straightness in its stem. The sinuous trend of the trunk, the eccentricity of the cross section and the compression wood (CW), conditioned the commercial value of this wood, diminishing the yield of both, raw material and finished product quality (Zobel y Van Buijtenen, 1989).

Biomechanical processes that underlie stem straightness had been analyzed in detail in P.pinaster. Genetic differences in the ability for stem straightening between provenances have been detected, mainly analyzing reaction wood efficiency (higher maturation strains). These differences have been identified as a good character for the early selection in this species. Little is known about the differences in strains maturation between species of genus Pinus sp., although it is possible that variability between provenances of the same species is bigger than variability between species. We compare four species (Pinus pinaster, P. halepensis, P. radiata and P. nigra). One-year-old plants were tilted at 45°, fixing the stems to an axe. After two months stems were released. Final positions of individual stems were recorded in photographs just after released. We measured the radial extension of reaction wood in serial stem cross sections. The integral effect of reaction wood on stem leaning and maturation strains was computed with Fournier's model (1994).

Differences in the efficiency of reaction wood among species are discussed.

Keywords: Pinus, compression wood, biomechanics, gravitropism, growth stress, maturation strains, reaction wood.

OP049

The Effects of Stem Inclination Stimulus on Degree of Reaction Wood Development in Five Angiosperm Trees

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There is only a few information concerning the effects of the stem inclination stimulus on reaction wood characteristics in angiosperm trees including growth stress, anatomical features, and chemical components. In this study, to clarify the effects of stem inclination angle from the vertical, sample trees from five angiosperm species (Cercidiphyllum japonicum Sieb. et Zucc., Trochodendron aralioides Sieb. et Zucc., Paulownia tomentosa Steud., Liriodendron tulipfera Linn., and Osmanthus fragrans Lour. var. aurantiacus Makino) were artificially inclined at stem inclination angle of 0 (vertical; normal wood), 30, 50, and 70 degrees from the vertical, and their longitudinal surface-released strain and cell morphology were investigated. Lignin distribution of the S2 layer of wood fiber was examined with visible light microspectrophotometry coupled with phloroglucinol-HCl and M?ule stainings. Lignin content by acetyl bromide method and monosaccharide contents in cellulose and hemicellulose were determined.

The presence of gelatinous (G-) fibers or G-tracheids was confirmed in tension wood of C. japonicum and T. aralioides. The tensile surface-released strain and the area of G-layer varied among three inclination angles of stem. On the other hand, reaction wood of P. tomentosa, L. tulipifera, and O. fragrans had no G-fiber. These three species showed that the increase ratio of tensile growth stress, the decrease ratio of pit aperture angle and lignin distribution of wood fiber in reaction wood were different among three inclination angles of stem. In all five species, tension or reaction wood formed with three inclination angles of stem showed lower lignin content than normal wood. The increase of glucose content and the decrease of xylose content were found in tension or reaction wood. These chemical changes differed among three inclination angles of stem in each species, except for some cases. In conclusion, it is considered that the severity of tension or reaction wood development is different among species and by stem inclination angles.

Keywords: cell morphology; chemical components; growth stress; reaction wood.

OP050

Modelling wood quality under different climatic scenario using a functional-structural tree model

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The purpose of this presentation is to show the variation of wood quality parameters under different and contrasting climatic scenarios, by the use of a functional-structural, three dimensional model developed for Pinus radiata D. Don. at a single tree level. This model simulates growth of trees under different environmental and management conditions and predicts the resulting wood characteristics such as internode length, knots size, ring width and wood density. Traditional dasometric variables are also output of the model and serve to evaluate and compare model results with empirical data. The model adequately simulated total height, diameter of trees and length of growth units and satisfactorily mimicked knots position per unit length of sawn wood. It also satisfactorily mimicked knots size. The estimated monthly increase in ring width compared favourably with the cyclic pattern of growth that is commonly observed in real plantation, as also do wood density. The three dimensional output of the model permits to obtain the logs and after a virtual sawing the corresponding planks, showing growth rings and knots.

The model prove to be an appropriate and reasonable link between environmental and management conditions of the forest and the industrial process, operating as a virtual laboratory.

Research project FONDECYT 11085008 financed by CONICYT, Chile

Keywords: modelling; tree architecture; wood quality; knots; internodes; wood density.

OP051

A Visual Based Wood Microscopic Identification Key

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Microscopic analysis of diagnostic xylem features is currently the only well-established and widely used method for wood identification. The method is time-consuming and requires extensive expertise in specimen preparation, microscopy, and wood anatomical terminology. Identification of wood specimens is typically made using dichotomous keys or computer software with the input of text or coded wood anatomical characters. Use of these types of keys often results in errors because many of the input characters represent subjective definitions and descriptions. To help overcome these problems we substituted micrographs for text-based characters and used direct comparisons of images of unknown wood with reference images from microscope slides. We created a database of Central African and North American species which includes more than 3,000 microstructure images. One of our major objectives was to visually capture the intraspecific variation of microscopic characters. The biological variation of any anatomical character can be documented precisely and comprehensively with photographs rather than with text-based descriptions. For example, the axial parenchyma distribution pattern in many tropical hardwoods is variable within species and the comparison of text-based axial parenchyma characters can cause confusion. By contrast, micrographs provide clarity and additional information that can be useful for species identification. Cell wall sculpturing and pits offer important

diagnostic information; therefore, we collected SEM micrographs in addition to the light-microscopy images. This image-based wood identification key was used in wood identification projects as well as in interactive teaching of wood anatomy.

Keywords: visual key, wood identification, tropical rainforest

OP052

Development Of An Effective Hardwood Pretreatment For The Production Of Ethanol In A Repurposed Kraft Mill

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The North American pulp and paper industry is in decline due to falling demand for paper and board products and in some cases, loss of market pulp share to lower cost countries. As a result, it would be very attractive to repurpose a kraft pulp mills to the production of ethanol. The development of a pretreatment process that can be easily implemented in a repurposed kraft mill with minimum capital is described in this paper. Various pretreatments method was studied for hardwoods that would be compatible in a repurposed mill. These pretreatments method included: water prehydrolysis, sodium carbonate, green liquor (sodium carbonate and sodium sulfide) and prehydrolysis-green liquor. These results show that a pretreatment based on green liquor is the most effective pretreatment for a repurposed mill. The yield of pulps produced by the green liquor pretreatment process is about 80%.with nearly 100% cellulose and 75% xylan retention in mixed southern hardwood. The low pH prevents the random hydrolysis of polysaccharide and secondary peeling reactions from occurring during the pretreatment, resulting in higher retention of the polysaccharides in pulp. About one 35% of the lignin is removed during the green liquor pretreatment process, which is sufficient for efficient enzymatic hydrolysis. The pulps produced by this process can be enzymatically hydrolyzed to monomeric sugars with a high overall sugar recovery. The use of green liquor for pretreatment ensures that the chemicals used during pretreatment can be recovered efficiently using proven technology and can be easily implemented in a repurposed Kraft pulp mill. A patent for the green liquor pretreatment process has been applied for by N. C. State University.

Repurposing an existing kraft mill – closed for economic reasons – can reduce capital investment by 80% compared to a Greenfield Project, and leads to production cash costs of $2.37 - $2.55 per gallon of ethanol. Fiber and enzyme costs represent more than 80% of cash cost. Investment returns (% IRR) of 19 and 26% for the smaller and larger scale Repurposed Kraft Mills are calculated, respectively, based on total ethanol revenues of $2.00 per gallon market price plus $1.01 subsidy. The capital investment for a Greenfield Green Liquor Pretreatment process is currently too high to achieve an economic investment return with any reasonable combination of biomass and enzyme cost, but simplifications are possible that could make Greenfield application of GL Pretreatment attractive.

Keywords: Ethanol; pretreatment; green liquor; enzymatic hydrolysis; economic evaluation

BIOSKETCH-HASAN JAMEEL

Jameel earned his B.S. in Chemical Engineering from Texas A&M University in 1975, and his Ph.D. degree in Chemical Engineering from Princeton University in 1980. In 1979 he joined International Paper, where he stayed until becoming a Professor at NCSU in 1987. He was named the Ellis Signe Olson Professor in 2001. He is presently a member of the Board of Directors for Packaging Corporation of America. He was a visiting Professor at the University of Tokyo in 1987. His professional specialties include pulping and bleaching, process optimization and simulation, and bio-energy and gasification. At N.C. State he teaches Pulp & Paper Unit Processes, Pulping Process Analysis and Biomass to Renewable Energy Processes. Jameel has received numerous honors and awards for his teaching and research, including recognition as NCSU Outstanding Teacher (1990 and 2005), NCSU Alumni Distinguished Professor (1999), and CNR Outstanding Advisor (2006). In 2005 Jameel received the Johan C.F.C. Richter Prize for outstanding contributions to the industry from the TAPPI Pulp Manufacture Division; other honors include the David Wetherhorn Award (1994), TAPPI Outstanding Instructor (1995), the Wayne Carr Best Paper Award (2002) and TAPPI Journal Outstanding Research Paper (2007). Jameel is also a Fellow of TAPPI and the International Academy of Wood Science and a member of AIChE. He holds five patents and has authored two books and more than 100 papers.

OP053

Improvement of Cedar (*Cryptomeria Japonica*) Pulp Using Amphiphilic Lignin Derivatives as a Cellulase Aid-Agent

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Japanese cedar (Cryptomeria japonica) is a main plantation wood that occupies around 60% of softwood plantation. To establish effective use of its improvement and thinning-cut wood, Forestry and Forest Product Research Institute (FFPRI) in Japan built up a test plant in Akita Prefecture for bioethanol production through enzymatic saccharification. The objective of this research is to improve saccharification efficiency of unbleached cedar pulp in the process using amphiphilic lignin derivatives.

Unbleached cedar pulp was kindly supplied from FFPRI. The pulp was subjected to cellulolytic saccharification with Meicelase and Genencor GC 220 at 50^0 C for 48 h in 0.05 M citric acid buffer (pH 4.8). Amphiphilic lignin derivatives (PEGDE-Lig, DAEO-Lig and EPEG-Lig) were prepared by the reaction of lignin with polyethylene glycol diglycidylether (PEGDE), ethoxy (2-hydroxy) propyl polyethylene glycol glycidylether (EPEG), and dodecyloxy-polyethylene glycol glycidylether (DAEO), respectively1), under alkaline conditions. Each derivative was added to the pulp suspension in the amount of 1/10 on the pulp. After sacchrification, the suspension was filtered, and the sacccharification efficiency was estimated from the ratio of precipitate weight to initial pulp weight. The filtrate was subjected to untrafiltration, and the filter paper unit (FPU) activity of the ultrafiltrated supernatant was measured according to the NREL/TP-510-42628 method.

Enzymatic hydrolysis efficiency of unbleached cedar pulp (10 FPU/g of substrate) of Meicelase and GC 220 without additives were 51.8% and 57.9%, respectively. The recovered FPU activities were 15.6% and 18.1%, respectively. PEG 4,000 showed the highest improvement of the saccharification efficiency (69.9% and 73.5%, respectively), and slightly increased the recovered FPU activities to 29.5% and 35.2%, respectively. Interestingly, the recovered FPU activity was dramatically increased by the addition of amphiphilic lignin derivatives, although the increments of sassharification efficiencies were smaller than those with PEG 4,000. In the saccharification with 20 FPU/g of GC220, PEGDE-Lig and EPEG-Lig show the complete recovery of cellulase activity. Thus, the lignin derivatives make repeating use of cellulase possible, leading to the cost reduction of woody biomass saccharification.

1) H. Homma, et al., J. Wood Chem. Technol., 30, 164-174, 2010.

Keywords: amphiphilic lignin derivatives; cellulases; enzymatic saccharification.

OP054

Biomass Quality for Efficient Energy Production – BIQUEEN Project

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Energy production from biomass usually considers raw material energetic efficiency, cost aspects and only as side aspect problems related to biomass origin, fermentation of biomass stocks, solid/volatile pollution, efficiency related to wood part of the plant. However, these aspects are particularly critical in the production of energy through combustion, which is the most current technology used for processing biomass.

Main project objectives are a quality control of biomass, conversion into energy by efficient combustion processes and minimum impact on the area, as follows:

1) verification of the origin of biomass to avoid transfer phenomena of polluted, illegal logged or non-local stocks;
2) control of solid pollutants in biomass came from forest, wood residuals processing and wood industry;
3) monitor of volatile emissions (including greenhouse and toxic gases etc..) resulting from fermentation of wet biomass storage;
4) transformation of biomass in energy, setting up an experimental boiler optimized for optimal combustion for power generation and emissions control.

The goal of the project is to generate real innovations that will be available for local social-economic context.

It was proven that FT-NIR spectroscopy offered an effective tool to separate groups of wooden specimens of different origin. Presence, concentration and kind of pollutants were successfully measured with MIR-ATR. VOCs from biomass combustion and fermentation were measured and defined. Differences were also noticed in CO and NOx concentrations in volatiles derived form combustion of different tree parts. Finally gasification technology and use of "reverse flame" in combustion significantly limited the emission of unburned compounds.

Keywords: biomass, VOC emission, pollution, wood gasification, spectroscopy

OP055

Transgenic modification of hemicellulose properties in wood to increase saccharification efficiency

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Wood recalcitrance to pulping and saccharification is highly influenced by the degree of lignin content, and is further affected by hemicellulosic branching and modification. Acetylation of glucuronoxylan in hardwoods, or galactoglucomannans in softwood, limits hemicellulose solubility. Uronic acids and arabinose linked to hemicelluloses can further crosslink either neighbouring hemicelluloses or hemicelluloses and lignin, thus further contributing to the recalcitrance of the cell wall matrix.

Any alteration in hemicellulose content impacts pulp yield, refining energy, fibre crosslinking, strength and smoothness, which makes it an important factor for both papermaking and saccharification. For example, a lower content of hemicellulose is required in preparation of tissues, hand sheets and diapers, where it must be removed by various methods, leading to a significant decrease in pulp yield.

Enhanced cell wall solubility and degradation can be obtained not only by a decrease in hemicellulose content, but also by the de-esterification of the ester bond between lignin and methyl glucuronic acid residues on the glucuronoxylan backbone. Moreover, reduction of hemicellulose acetylation by a transgenic approach may decrease the chemical demand for hemicellulose hydrolysis and removal, influence water absorption and increase pulp and saccharification yields.

We have successfully transformed plants with enzymes that reduces the ester bonds between uronic acids of the xylan and lignin as well as additional enzymes that remove the xylan acetyl groups. Cell walls of these plants have a lower degree of acetylation and improved saccharification efficiency without negatively affecting the biomass accumulation and mechanical properties. This concept provides new directions for more economical processing of wood.

Keywords: Genetically engineered wood; hemicelluloses; acetylation; saccharification; pulp; bioethanol

OP056

POPping pretreatment for enzymatic hydrolysis of Pine and Oak wood

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The objective of this study was to produce bioethanol from wood as feedstock. This feedstock requires some form of pretreatment that can enable enzymes to gain greater access to cellulosic and hemicellulosic components of cell walls. Bioconversion begins with a pretreatment stage to physically increase surface area along wood fibres.

We have investigated pretreatment of Pine (Pinus densiflora) and Oak (Quercus acutissima) using milling refinery combined with popping method, which was performed in a laboratory-scale cast iron cylindrical reactor. When the temperature and pressure inside the reactor reached 220 °C and 21 kg f cm-1 respectively, the sample was rapidly exposed to one atmospheric pressure through a hatch attached to the reactor. This method can save energy for pretreatment and enzyme loading for enzymatic hydrolysis. The effects of the popping pretreatment were studied in terms of structural and compositional changes in the substrates and their susceptibility to enzymatic hydrolysis. After popping pretreatment, the amounts of holocellulose in Pine and Oak were 52.13 % and 60.41 %, respectively, compared to 65.50 % and 73.82 % in un-pretreated substrates. Electron microscope revealed cracks and holes in pretreated fibers. After enzymatic hydrolysis, the glucose yield of pretreated Pine and Oak was 92.8 % and 72.4 % respectively, and compared to <5 % for un-pretreated substrates.

Keywords: popping pretreatment, bioethanol, enzyme hydrolysis, wood

OP057

Knot shape assessment on various species through X-ray CT scanning

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X-ray computer tomography (CT) is the most promising method for non-destructively analysing knottiness in wood logs or beams. Two methods for measuring knot size and location from stacks of CT-images were developed and applied to a wide range of wood samples.

The first method aims to provide exhaustive and accurate measurements by manually pointing and tracking the knots within the image stack in view to reconstruct 3D knot shape and arrangement. The method was applied on a set of 125 logs of 17 European species (mainly hardwoods) with the objective to identify species-specific markers based on knot morphology.

The second method, which is more oriented toward industrial uses, is based upon an automated algorithm to individualise the knots and output their size and location without any human intervention. Still in development, this method is yet applicable to simple branch architecture patterns, like for softwoods, assuming that moisture content is relatively homogeneous between sapwood and heartwood.

Both methods were applied to a set of air-dried beams of Norway spruce and silver fir. The comparison showed that, depending on the beam, 71 to 100 % of the manually measured knots were detected by the automatic method. The R2 values between manual and automated measurements were greater than 0.90 for knot maximal diameter, volume and inclination, and equal to 0.65 for knot length.

Keywords: wood, knottiness, computer tomography, image analysis.

OP058

Reconstruction of Knots from Simulated Discrete X-ray Images of *Pinus Sylvestris* Logs

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For many years it has been of interest to be able to predict the properties of sawn wood products from tree features. X-ray technology has made it possible to measure internal as well as external features of saw logs, and to use these features for predicting log quality. However, data available for simulation of the sawing process and prediction of sawn timber quality has, until now, been limited to logs scanned using computed tomography.

The objective of this study is to develop a method for reconstruction of parametrically described whorls and knots from industrial scanning of Scots pine (Pinus sylvestris L.) logs, using discrete X-ray images. The method is designed using the logs in the Swedish pine stem bank (SPSB) as data basis, and is based on a few predictor features extracted from these logs, namely whorl volume, distance between whorls, and distance between pith and surface. These features are measured in simulated discrete X-ray images of the logs in the SPSB, and virtual models of the whorls and knots are created, using a feature- and knowledge based model. Virtual logs are then composed using the reconstructed knots within the original shape of the logs. Simulated test sawing of the virtual logs shows that the reconstruction method results in a representative model of the knot structure in the log, when considering the grade distribution of the sawn timber produced by the simulation program.

The results of this study can for instance be used for improved online quality predictions at sawmills. One step in this direction is to use industrial X-ray data to enlarge the amount of log data available for sawing simulation research. Future work should focus on developing practical applications of the results presented here.

Keywords: Knot models, quality prediction, sawing simulation, sawlogs, wood quality, X-ray scanning

OP059

Modeling knots shape in black spruce (*picea mariana*) and jack pine (*pinus banksiana*)

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Wood quality models that describe the link between tree growth and knottiness have generally been calibrated using external branch measurements, which are often imprecise and costly to acquire. Using X-ray computed tomography (CT) it is now possible to describe the entire internal shape of knots with precision, and to relate it to external branch parameters.

We used a method based on pointing and tracking the knots on successive CT images taken along the stem to identify and reconstruct knots in 3D. All knots from the merchantable sections of 32 black spruce (Picea mariana (Mill.) B.S.P.) and 16 jack pine (Pinus banksiana Lamb.) trees were scanned for this study. These species were chosen both for their commercial importance in eastern Canada and for the fact that, in the sawn timber, knot size is an important cause of visual downgrade. Trees were sampled along a sequence of ages in stands that had never been subjected to any silvicultural treatments. In total, we reconstructed the shape of more than 3,500 knots in jack pine and approximately 18,000 in black spruce.

Using a nonlinear approach, we fitted a model of knot geometry based on a Weibull function. Separate equations were used to describe 1) the curvature (pith position) of the knot and 2) the evolution of the knot diameter along its pith. The combination of these two equations allowed an accurate representation of knot shape using only seven parameters. We extracted these parameters for each knot and modeled them as functions of the external branch and tree characteristics. For black spruce, the model residuals from the curvature equation were less than 4 mm for 75% of the observations, whilst the residuals from the diameter equation were less than 1.7 mm for 75% of the observations. In jack pine, the corresponding statistics increased to 5.8 mm and 3.6 mm, respectively.

To facilitate the integration of the developed knot model into a tree growth model, we expressed knot shape as a function of external branch and tree characteristics. For example, the parameter which describes the slope of the knot curvature close to the bark is positively related to the branch insertion angle in the stem, but negatively influenced by the diameter of the branch and the stem diameter, and therefore by the overall vigour of the tree. The resulting model explained approximately 75% of the variance in this parameter. Overall, the use of knot parameters which can be predicted from external tree-level variables facilitated the integration of our model into a tree growth model.

Keywords: knots, nonlinear modeling, computer tomography, image analysis

OP060

Crack detection in softwood using x-ray computer-tomography

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Cracks, splits and checks are considered as severe internal defects in round wood logs in the sawmilling industry due: Their presence reduces the yield of premium quality sawn products due to low aesthetical appreciation and a decline in mechanical strength. As the inner location and the distribution of cracks and splits cannot be predicted from the two cross sections and the circumferential surface of a log it is not possible to optimise the position of sawing patterns of such logs in order to minimise their impact on the quality features of the sawn product.

X-ray computed tomography is a non-destructive technology which allows to visualise, detect and measure internal structures of an object. The physical basis is a divergent absorption characteristic of material of different density. For wood this allows detection of internal knot features, rot or splits and cracks due to the density contrasts between the areas of interest. As cracks are empty, air filled space surrounded by solid wood, they appear in CT images with generally strong contrast. An automated detection algorithm thus would allow to reconstruct the location and the size of internal cracks and splits of a log and could be used either for industrial applications in the wood industry or for scientific applications for investigations on round wood quality and wood technology.

An algorithm for automated detection of splits and cracks in CT images was developed and validated against ground truth manual measurements on stem discs. The algorithm was validated against the number of cracks detected correctly, the correct azimuth position, and the correct size.

For this study, 20 tree discs from 5 spruce (Picea abies (L.) Karst.) and 5 silver fir (Abies alba Mill.) logs were sampled both form butt and the top end. The 10 logs had a mid-diameter of 47…52…58 cm (without bark) and a length of 5 m. The sample was selected so that all typical shapes of heart checks (I-, Y- and X-shaped cracks) and also ring shakes were included. The material was scanned in fresh condition using a Microtec CT.log. The X-ray source was set to 180 kV and 14 mA. Reconstruction of the images was performed to 768x768 pixels, allowing a spatial resolution of 1.1x1.1mm.

The success of correct detection rate and quantification of width and length of cracks improves with the quality of the CT images. In CT images of fir with wet heartwood the detection of cracks was difficult due to the low contrasts affected by the high moisture content of the wood.

The algorithm successfully detected radially orientated crack, but was unable to detect ring shakes. This is due to the similarity of contrasts of circular structures as they can also be found in annual ring boundaries between latewood and earlywood. Detection accuracy in terms of the ratio of correctly detected and missed cracks was 83%, accuracy with regards to the ratio of correctly detected cracks to false positively registered objects was 55% due to a high number of irregular shaped objects in the cross section. An additional filter on size and elongation of these objects would improve this detection rate. On average the cracks were measured 13.7mm or 13% of the crack's length too short.

Keywords: roundwood, internal defects, cracks, X-ray, computed tomography, Norway spruce, Silver fir

OP061

Automatic Detection of Fungal Wood Decay in high-speed Computed Tomography Images

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Fungal decay affects wood quality significantly, both in strength grading and in visual assessment of sawn timber. Decay is typically caused by fungi which decompose the wood cell walls. Depending on the type of fungi, lignin, cellulose or a combination of the two is decomposed. In its initial stages, decay causes a discolouring of the wood, rendering it undesirable for visual appearance. As the fungi further decompose the wood fibre, the resulting loss of strength reduces the wood's suitability for structural uses.

Precise knowledge of the internal extents of the decay could increase accuracy in log grading, as well as in sawing optimization, when maximizing the value of sawn timber. Therefore automatic detection of decayed areas could potentially prove beneficial to industrial wood processors.

X-ray Computed Tomography provides a non-destructive method to detect and measure the extent of decay internally within a saw log, by providing a high resolution 3D density measurement of the log. In the initial stages, decayed areas contain relatively high moisture content. Since water is of higher density (1000 kg/m3) than green heartwood (~450 kg/m3), the decayed areas are visible as relatively high density areas. As the process continues, and the wood fibre becomes consumed or decayed beyond a certain extent, it loses structural integrity and also begins to dry. At this point, both the moisture and the majority of the wood fibre no longer exist, and the decayed areas are of lower density than sound wood. These unusual density variations are visible with relatively high contrast in the CT data and as such are detectable by automatic algorithms.

In previous studies, decay detection algorithms have been developed using medical or research CT scanners, which are too slow for industrial sawmill applications. Recently, a high speed CT Scanner capable of speeds to 120m/min has been developed specifically for the sawmill industry by MiCROTEC, an Italian machinery company. In this study, simulation software was used to generate high speed scanner data from research CT images. An automatic decay detection algorithm was developed using 20 Norway Spruce Logs and 6 Silver Fir Logs from the Black Forest region in Southern Germany. The algorithm produces a 3D description of the extents and degree of the decay and is capable of running at industrial speeds. Results from this algorithm were compared to reference measurements taken on both boards and log cross sections.

Keywords: CT scanning, decay, rot, Norway Spruce, Silver Fir, X-ray scanning

OP062

Validation of beech (*Fagus sylvatica L.*) branch scar quotient to determine internal knottiness using CT technology

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Occluded knots appear on the bark of smooth-barked species, especially beech, as so called "branch scars/seals". With the growth in girth the branch scar alters the dimension only in horizontal direction. Therefore the quotient of width and height of the scar allows to deduce the size of occlusion of the branch.

This criterion, known as the "branch scar quotient" respectively "branch seal quotient", is based on a rule published by KNIGGE/SCHULZ in 1966. It describes the possibility to determine the radius of occluded knots on beech by measuring the relation of their branch seal width to branch seal height.

From that it is possible in certain precision to determine directly the branch containing core of underlying stem diameters.

In this context it is of particular importance that in the revision of European Norm for hardwood round timber (EN 1316-1) as well as of new grading rules in Germany (RVR) the implementation of thresholds are stipulated.

Altogether 46 seals with subjacent knots were removed as sample materials. Logs of beech with stem diameters between 30 and 55cm were used, found in the stands in the southwest of Baden-Württemberg. A wide range of branch seal quotients from 1:1 to 1:6 could be investigated in that extensive approach.

A computed tomography (CT) analysis was preposed. This approach was helpful in two ways: to support in destructive radial cutting through the knot. In the real (radial) view measurement was possible to determine the ratio between knotty and clear wood very precisely. Secondly by manual measurements a "ground truth" reference system is established which allows to develop a branch model for internal knot structure based on CT images for fresh wood.

The results of the statistical analysis are ranked as highly satisfying.

To explore the relation between calculated percentages of the knot containing stem core from the branch seal quotient vs. the manually measured knot containing core, a statistical analysis was set up. To determine the direct relation between these variables, a correlation was calculated. With the resulting correlation coefficient of r = 0,91 a tight positive linear relationship could be identified.

The regression analysis also expressed a very tight linear relationship through a straight line showing a gradient of y = 1,0005x – 0,0047 and a coefficient of determination of R2 = 0,83. From the gradient, it can also be derived that there is actually no over- or underestimation of the knotty core by trend, calculated from the branch seal quotient. With the gradient of 1,0005x the regression straight line also nearly perfectly represents the bisecting line between abscissa and ordinate.

The work on the internal knot model for Beech is in progress.

Keywords: knots in beech; branch scar, clear wood, knotty core, branch scar quotient, grading rules in Europe and Germany, CT-scanning

OP063

Trunk structure, CT scanning and tree architecture

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The future of log grading and sawing optimization is moving further towards the detection of most external and internal features. The recent results gained with a medical X-ray CT scanner and a manual procedure of image interpretation (Colin et al., 20101) let expect new ways for improving industrial CT scanning.

The objective of this report is to depict how can be taken maximal advantage of the computer tomography to recover as many as possible architectural features.

Logs of spruce, fir, oak and other broadleaved species were scanned, recovered from individuals either with good or bad external quality. Primary growth, phyllotaxis, bud arrangement, knot arrangement and shapes were quantified. Detailed studies on sessile oak provided encouraging results on epicormic knot detection. It turned out that species-specific architectural features strongly constrain wood defects.

Our results give access to procedures of species recognition, log grading and sawing optimization accounting for the species-specific architectural patterns.

Keywords: X-ray CT, tree architecture, wood defects

1 Colin F, Mothe F, Freyburger C, Morisset JB, Leban JM, Fontaine F. 2010. Tracking rameal traces in sessile oak trunks with X-ray computer tomography: biological bases, preliminary results and perspectives. Trees-Structure and Function, 24: 953-967.

OP064

Correlation between Structure of Native Hardwood Lignin and Extent of Kraft and Soda-AQ Delignification

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Two eucalyptus hybrids (EGC 39, EGC 241), resulting from crosses between Eucalyptus grandis and Eucalyptus camaldulensis, were investigated to see if they could produce kraft papermaking fibers with low lignin and adequate physical properties. The two hybrids were harvested at an age of 8 years along with 6-8 year old Eucalyptus camaldulensis (Rostrata). All three eucalypti were grown in the area of Gharb in the North-West of Morocco. The lignin in the EGC 39 chips was more reactive in kraft and soda-AQ (SAQ) pulping as compared to the other two eucalypti. Methoxyl analyses and nitrobenzene oxidation (NBO) of the in-situ lignin (wood meals) were performed, and it was concluded that the syringyl content of the EGC 39 lignin was less than or equal to those in the other two eucalypti.

Ethylguaiacol (EG) is quite efficient at trapping coniferyl alcohol (CA) generated from the cleavage of uncondensed β-O-4 dimers during SAQ delignification of hardwoods (Kanungo et al. J. Wood Chem. Technol. 31, 267, 2011). Some of the CA is transformed to vinylguaiacol (VG) and isoeugenol (IE), and the α-carbon atom in all three monomers condenses to the C-5 position of EG. The EG trapping method showed that the lignin in the EGC 39 hybrid contained the highest concentration of β-O-4 structures where the ring that rearranges to the quinone methide (the A-ring) was an uncondensed guaiacyl unit (uncondensed G-β-O-4). Preliminary results (including those from sugar maple) will also be presented to show that this method coupled with syringyl content analysis of the lignin may be able to predict the reactivity of a hardwood in kraft and SAQ cooking.

OP065

Implementation of a hemicelluloses extraction stage in a kraft pulp mill for production of papermaking chemicals: energy balance, economics and life cycle assessment

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Pulp producers need to increase value in their mills in a fierce economic environment, while papermakers are looking for cheap bio-sourced additives. Extraction of hemicelluloses prior to kraft cooking emerges as a promising bio-refinery opportunity to fulfil both of these objectives.

We propose a retrofit in a softwood kraft pulp mill where wood chips are extracted in mild acidic conditions prior to white liquor impregnation and cooking. Then the extracted fraction is purified by ultra-filtration. The rejected fraction is mixed with weak black liquor to be sent to evaporation and recovery cycle, while the purified hemicelluloses fraction is sold to papermakers for functional applications.

A mass balance modelling of the kraft pulp mill is performed by following separately cellulose, hemicelluloses and lignin fraction, together with associated energy requirements. The separation coefficients for each fraction used in the modelling are identified from laboratory chemical analysis of extracted and purified fractions.

The mass balance shows that it is possible to maintain pulp production while pre-extracting the hemicelluloses, provided that wood chips supply is increased. This only slightly increases the organic load on the recovery boiler. However, additional energy is required to evaporate the rejected fraction from the ultra-filtration stage. This slightly reduces the generated electricity sold to the power grid. Besides, hemicelluloses extraction reduces energy needs for the cooking stage, thanks to accelerated kinetics. Also, bleaching chemicals needs are reduced, for same final brightness.

All in all, the proposed retrofit makes it possible to maintain pulp production and produce market hemicelluloses at the same time in an economically viable way. The life cycle assessment shows that the hemicelluloses extraction scenario increases the consumption of renewable resources compared to the original kraft process (because of increased wood consumption), but enables to limit non-renewable resources consumption and impacts on climate change and air acidification.

Keywords: bio-refinery, kraft process, hemicelluloses, extraction, papermaking, life cycle assessment

OP066

Evolving Elite Plants with Low Lignin and High Cellulose Reed Bamboos (*Ochlandra* spp.) from the Western Ghats of India for Pulp and Paper Industry

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The reed bamboos (Ochlandra spp.) of commercial importance are known to occur in the wild throughout the semi-evergreen and moist deciduous forests of the Western Ghat region in India. Reed bamboos are of particular interest to the pulp and paper industry owing to their fast growth and long-fibred raw material. In view of economical and environmental concerns of the delignification process in pulping, there is growing interest in the industry to evolve pulpwood species of reduced lignin content. A total of 373 clumps representing 4 species were collected from 20 geographic locations covering 87 populations from the wild for the present study. The search for low lignin and high cellulose plants among the accessions, based on chemical analysis with wet laboratory methods and using FT-NIR spectroscopy enabled high throughput assessment and quantification of the phenotypic variation, leading to identification of elite populations and individual plants (clumps) of low lignin and high cellulose content.

A reduction of 6% lignin from the average with inversely higher cellulose content and modest wood density with desirable fiber properties was observed in Ochlandra travancorica. The estimated phenotypic coefficients of variation in lignin and cellulose were relatively low (< 10%) as compared to extractive and ash contents which displayed 13 and 23% respectively. However, individual clumps of certain low lignin populations of O. travancorica displayed elite reed bamboo with as low as 14% lignin offering scope for selection and mass clonal multiplication of plants for desired low lignin/high cellulose pulping raw material. The allied variety/species included in the study were O. travancorica var. hirsuta, O. scriptoria and O. setigera which did not show marked species-to-species differences in lignin, cellulose, extractive and ash contents and in their phenotypic variation. The major conclusions of the study are: Low lignin and high cellulose plants of O. travancorica do occur in their natural habitats offering scope for selection in evolving desired bamboo resources of pulp and paper industry with at least 5% reduction in lignin content. FT-NIR reflectance spectroscopy appears to be suitable for non-destructive rapid prediction of lignin, holocellulose, extractive and ash contents of large number of samples in breeding programmes of reed bamboos. The breakthrough of our study on a successful search for low lignin and high cellulose plants from the wild promises to give a boost to bamboo improvement programmes for pulp and paper industry, even without the intervention of genetic modification technology.

Keywords: Lignin, cellulose, extractives, ash content, FT-NIR spectroscopy, reed bamboo, Ochlandra

OP067

Characterization of the *Eucalyptus globulus* Wood Extraction in Modified Auto-Hydrolysis Conditions

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When applying the Biorefinary concept to the Pulp and Paper Industry there's the possibility of producing bio-ethanol from the fermentation of extracted hemicelluloses from E. globulus wood, previous to the kraft process. This paper's goal is to evaluate two different chemical methods for the hemicelluloses extraction before kraft pulping, without affecting the wood and subsequently the pulp properties. These two methods involve: sequential auto-hydrolysis and auto-hydrolysis using green liquor. The experimental methodology for both methods is similar; it was studied the pre-treatment impact on the global extraction yield, the hemicelluloses extraction yield and the kraft pulping yield. After the extraction, the obtained extract was analysed chemically and the wood was submitted to kraft pulping.

In the sequential auto-hydrolysis, six sequential extraction levels, with low severity conditions, were used. In each level, "fresh" wood was treated with the extract obtained in the previous level. In the first level, ultra – pure water was used. All extractions were executed in 200g rotational reactors, at 150ºC for 80 minutes, starting from 40ºC with a temperature increment of 1,5ºC/minute and a liquid wood ratio of 4 L/kg. After 6 levels of extraction, the global equivalent extraction yield obtained was about 6,9%w/wwoodbasis. Concerning the kraft pulping, these extraction conditions don't present major differences in the pulping yield when compared with reference wood. The extract chemical analysis made for each level showed that there's a preferential extraction/formation of others compounds instead of hemicelluloses. After 6 levels of extraction, only 1,9%w/w are hemicelluloses. The other compounds are mainly furfural, lignin and formic acid. This fact limits the viability of this process for the co-production of ethanol.

For the auto-hydrolysis using green liquor, several extractions with different conditions were tested, being the green liquor charge (%TTA) the most important parameter. The green liquor charges varied between 0,25 and 3%TTA, for different extraction conditions (time and temperature). The results obtained show that the optimal TTA charge, which results in a better balance between the kraft pulping results and the hemicelluloses extraction yield, is 1%TTA. For this charge, two different extraction conditions where studied, with the same temperature (150ºC) but different time of extraction (240 and 320 minutes). These conditions led to extraction yields of about 5,7 and 7,6 %w/wwoodbasis, respectively. However, and despite the good kraft cooking results, the hemicelluloses extraction yield (1,2 and 1,4%w/wwoodbasis) at a low-end, limit the process viability for ethanol co-production. Still, under these conditions, it was possible to preserve the initial wood kraft cooking yield using lower alkaline charges.

Keywords: auto-hydrolysis with green liquor; kraft pulping; hemicelluloses extraction; sequential auto-hydrolysis.

OP068

Influence of pulp viscosity on paper production

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Cellulose is a polysaccharide with linear structure make up of units of β-D-glucose connected by links type (1-4). Its length turns cellulose insoluble in organic solvents, water, acids and bases at room temperature.

In the cellulosic pulp, it is possible to measure the cellulose chains by viscosity with values being directly proportional. This work aimed to evaluate the influence of pulp viscosity on paper properties.

Except light dispersal coefficient, all tests were made according to TAPPI "Technical Association of the Pulp and Paper Industry"; viscosity according to T 230 om-94; Opacity according to T 519 om-96; tear resistance according to T 414 om-98; tensile index according to T 494 om-96 and resistance to the passage of air according to T 536 om-96; burst index according TAPPI T 807 om-99; light dispersal coefficient according to ISO 9416: 2009.

The results showed a correlation of r= 0.658 for traction index, r= 0.343 for tear index, r= -0.447 for opacity, r= -0.907 for the light dispersal coefficient, r= 0.733 for resistance to passage of air and r= 0.711 for burst index. Traction index; light dispersal coefficient; resistance to passage of air and burst index showed significant correlation. The increase in viscosity indicates that cellulose pulp has a higher degree of polymerization, thereby the microfibrils will connect stronger, generating a paper with better properties. The pulp viscosity influences paper properties.

Keywords: cellulose; opacity; viscosity.

OP069

Pre-Drying Treatment of Oil Palm Veneers

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The oil palm stem has been viewed as a suitable alternative material to traditional woods in the manufacture of veneer and its derivatives. However, the high moisture content in the oil palm wood (up to 500%) is a major hindrance in its processing, causing a significantly higher amount of energy and time in drying them compared to traditional wood veneers. The response surface methodology was used in this study to optimize the efficiency of a pre-drying process on oil palm veneers in reducing its moisture content. Oil palm veneers used in this study were divided into outer and inner veneers. The green veneers were then fed along the grain into a specially designed and built veneer roller press machine to squeeze out its moisture with varying passes, pressure and roller press speed. The results showed that for the outer oil palm veneers, pre-drying should be carried out with 2 passes at 82 kgf/cm2 pressure and fed at a rate of 38.55 Hz. The optimum pre-drying conditions for the inner oil palm veneers would be 2 passes, 73 kgf/cm2 pressure and a feed rate of 41.49 Hz. Under these conditions, the MC reduction for the outer and inner veneers were 16.2% and 20.14% respectively. The thickness of the veneers after the pressing process was >90% of its original thickness which shows that the volume reduction was not significant.

Keywords: Oil palm stem, roller pressing, veneers, moisture content

OP070

Dimensional stability of heat treated *Pinus roxburghii* Sarg. And *Mangifera indica* L. woods

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Heating of wood at lower temperatures (below 100°C) results only loss of free water from the wood resulting in seasoning of wood. Heating at higher temperatures (usually between 150 to 260°C) causes chemical, physical, mechanical and micro-structural changes in wood resulting in production of new modified material. Effect of heating temperatures and time duration on the dimensional stability of softwood (Pinus roxburghii Sarg.) and hardwood (Mangifera indica L.) was investigated. Wooden specimens of specific size were heated at 160, 190 and 210°C temperatures for 4, 8 and 12 hours in a heat treatment plant. Volumetric shrinkage and swelling, equilibrium moisture content (E.M.C.) at different relative humidities and water absorption was studied. Results revealed that heat treatment at 210°C for 12h caused reduction in volumetric swelling (34.7%) and shrinkage (28.53%) as compared to control. Thermal treatment at 190°C for 4h resulted maximum reduction in E.M.C. in Pinus roxburghii Sarg. while higher temperature was required by Mangifera indica L. specimens. The ratio of E.M.C. between unmodified and modified wood decreased with increasing humidity. Decrease in water absorption was observed with treated Mangifera indica L. wood specimens.

Keywords: Pinus roxburghii Sarg.; Mangifera indica L.; equilibrium moisture content (E.M.C.); volumetric shrinkage and swelling; water absorption.

OP071

Experimental solar kiln drying of refractory timbers from Mozambique

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In Mozambique, the majority of woodworking industry lack conventional kiln drying facilities. This is partially attributed to both financial reasons, shortage of suitable drying schedules and the use of fairly less prone to drying degrade timbers species of chanfuta (Afzelia quanzensis) , umbila (Pterocarpus angolensis DC) and jambirre (Milletia stulhmannii). Several other native timber species remain overlooked as they are relatively very prone to develop drying defects if

not carefully kiln dried. As an alternative to financial reasons along with the country being a sunbelt, the present study was aimed at constructing solar kiln and thereafter drying refractory hardwoods up to 10% moisture content (MC) target. Under separate charges/loads, the experiment consisted of refractory lesser used timbers of 38 years old plantation grown Eucalyptus cloeziana and planks from undated mature trees of 2 native hardwood species (Cordyla africana and Brachystegia spiciformis). Eucalyptus timbers are generally known for tendency to develop checks and in Mozambique the trees are mainly used for transmission poles. Brachystegia spiciformis is nearly the country most abundant growing wood stock and its use has been restricted to railway sleepers/ties. Of the three tested species, Cordyla africana timber is relatively unknown in the sector, though sparse uses in furniture are reported. The performance of solar kiln drying was assessed in terms of drying rate and quality of dried boards. Preliminary results show that 25 mm thick boards of the three species with an average initial/green MC of 45% needed at least 30 sunny days with mid-day temperatures above 30oC to reach 10 % MC. Analysis on deformations such as bow, crook, twist and cup were in acceptable range and prong tests revealed low residual stress of the dried boards. Based on this outcome, solar kin dryers may constitute an alternative cheap and reliable option to dry satisfactorily refractory timbers in Mozambique.

Keywords: Brachystegia spiciformis; Cordyla Africana; Eucalyptus cloeziana; refractory hardwoods; solar kiln

OP072

Drying Behaviour of Rubberwood at High Temperature

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A renew interest on drying wood at high temperature in the last few decades is principally attributed to the advantage of accelerated drying which directly resulted in reduction in drying time and energy consumption, and improvement in some drying-associated problems such as reduction in warping. High temperature (HT) drying of softwoods such as plantation grown radiata pine and other southern pines has long been practised in countries like Australia, New Zealand and in the United States. Commercial high-temperature drying methods of light hardwood such as rubberwood and/or other tropical hardwoods are a nonentity. The study on the effect of high temperature treatment on rubberwood was conducted at a dry bulb temperature (DBT) range of 100°C to 150°C using a laboratory drying chamber. The control temperature was set at 60°C. Each treatment consisting of 40 samples of furniture dimension stocks measuring 30mm (T) x 100mm (W) x 600 mm (L) were used in the study. The respective initial DBT settings were maintained throughout each experiment. During the drying process, wet bulb temperatures were gradually reduced to induce drying at different moisture content stages. All test pieces were dried from the green condition (with initial moisture content at an average of 68%) until the average moisture content for each drying run was reduced down to approximately 6-8% based on estimated oven-dried weight. Results showed that the drying times of rubberwood decreased exponentially with the increment of drying temperature (R2= 0.9912). Typically, flatsawn samples dried faster than quartersawn samples during drying at 60°C and 100°C respectively. However, both the flatsawn and quartersawn samples showed similar drying time when drying were carried out at more than 100°C, i.e. 120-150°C employed in this study. This shows that drying rubberwood of mixed-sawn type can be better controlled during high temperature drying to achieve uniformity drying and subsequently quality fast throughput.

Keywords: flatsawn, quartersawn, moisture content, density

OP073

Influence of Wood Steam Drying Process on Fracture Toughness and Shear Yield Strength Determination

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Results of fracture toughness (specific work of fracture) and shear yield strength of steam kiln–dried wood simultaneously determined on the basis of cutting power measurement are presented. Wood species, namely oak (Quercus robur L.) and pine (Pinus sylvestris L.) from the northern part of Pomerania region in Poland, were subject of steam kiln–drying process in a laboratory kiln, specially designed and manufactured for the Gdansk University of Technology. While the colour changes have been observed directly after process, changes in mechanical properties have to be measured. The samples, after drying, were subject of examination during cutting tests on the modern narrow-kerf frame sawing machine PRW15M. Measurements of cutting power for steam dried and air dried samples, as a reference, allowed to reveal the effect of wood steam drying on mechanical properties of wood. It has been recognized that steam wood drying causes a decrease of the mechanical properties of the wood such as: fracture toughness and shear yield strength. Those mechanical properties were determined on the basis of the modern fracture mechanics.

Keywords: wood properties, wood drying methods

OP074

New opportunities for a traditional wood product: Chestnut square edge logs with wane and its mechanical properties in green state

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The square edge logs with wane are full logs edged on four sides maintaining boxed heart and an approximately central pith according to specific grading rules. This product is a traditional structural component, called in Italian "Uso Fiume". Such elements are produced using principally Silver fir (Abies alba, Mill.), Spruce (Picea abies, Karst.) and Chestnut (Castanea sativa, Mill.), and they have been widely used in Italian buildings over the time, in substitution to structural sawn timber, principally for roofing.

The square edged logs with wane production and use offer several benefits: energy saving during production, easy and cheap manufacturing process (theoretically possible by hand tools), easy installation due to the not-rounded cross section and possibility to use traditional mechanical connections, less rough material required to obtain structural elements with the same nominal section of traditional sawn timber and similar mechanical properties in comparison to it. Nowadays in Europe only the use of Spruce and Silver Fir square edged logs with wane is accepted, because no ETAG (European Technical Approval Guideline) nor CUAP (Common Understanding of Assessment Procedure) are available for Chestnut. In December 2011 a CUAP, containing the requirements for the strength grading, physical and mechanical properties determination for Chestnut, has been drafted and it is waiting for the final endorsement, opening new opportunities in the chestnut products employment. One of the major drawbacks, that raise this product production price, is that for the large cross section materials the seasoning time is long, due to the very low permeability of the heartwood, also in the south Europe climatic conditions (up to 2-3 years for the larger cross section). One of the most important consequence is that those products are often installed in green state.

In order to assess the green chestnut square edged logs with wane fitness for use, 49 logs were collected in Liguria Region. The nominal cross section, that is the cross section defined by the rectangle circumscribing the piece of timber at mid-length, varies from 120x120 mm2 to 230x240 mm2. The whole length and the central third of the logs were graded separately, the average and characteristic physical and mechanical properties were determined according to the CUAP draft specifications and standard requirements (EN 408, EN 384, ISO 3131): density, local modulus of elasticity (MOE) and modulus of rupture (MOR). The high average moisture content (around 48) affected only the MOE value reducing it at the average one of 9600 MPa. The registered MOR characteristic value of 28 MPa is the same one reported by the Standard UNI 11035:2010-2 (Visual strength grading rules and characteristics values for structural timber population) for the Italian Chestnut structural timber of equivalent nominal cross section determined at the 12% of moisture content. Additionally the possible use of the dynamic longitudinal MOE for the static MOE and MOR prediction was investigated.

Acknowledgements: the research has been performed under the grants of Department of Agriculture, Tourism and Culture - Mountain Policies and Wildlife Service, Liguria Region – Italy.

Keywords: Structural timber, Chestnut, Square edged logs with wane.

OP075

What do we know about the effects of silviculture and genetics on branches/knots?: Douglas-fir as a case study

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The number, diameter, and inclination of tree branches, which become knots in logs and products are important determinants of quality and value along the market chain. In the forest, branch characteristics can either be ignored until the grading system and markets determine quality and value, or they can be silviculturally manipulated or subject to genetic selection to improve quality and value.

Branching traits are under weak to moderate genetic control. At the low end of heritability is branch size, so that it is more effective to control this trait with initial spacing and stand density management thanby genotype. Frequency of ramicorn branches has the strongest control and is related to the propensity of second flushing. Incidence of forking is less heritable than ramicorns but the economic impact is stronger; both forking and ramicorn branching are actively scored and selected against in tree improvement programs since they cause quality degrade. Marked variation is observed in young progeny tests in the number of branches (and thereby number of knots) but this trait is not currently scored.

To promote stem growth, silviculturists often either plant at wide spacing or use early thinning and fertilization but these practices slow crown recession, promote faster branch growth, and increase branch lifeleading to large branch diameter and low value. Alternatively, they can either employ pruning or density management to accelerate branch death through crown recession to reduce branch diameter but with a sacrifice of stem growth . Trade-offs are inevitable and silviculturists need to be well informed to find the most economically attractive approach for a stand.

Models are presented for describing and predicting the effect of initial spacing, thinning, and fertilization on branch size and distribution in coastal Douglas-fir growing in the Pacific Northwest of North America; the potential exists to do the same for forking and ramicorn branching breeding values. Product recovery equations and simulated milling can be applied to assess the economic performance of alternative silvicultural regimes. Many of these components have been incorporated into growth and yield models or into software for post-processing output from growth models. These tools can be used to manage and assess the tree-to-product chain value.

There are economic factors that typically limit the manipulation of branch traits to less than the biological maxima. The relatively high cost of operational Douglas-fir planting stock and of precommercial thinning dictate that initial planting density is generally kept within a fairly narrow range (720 to 1100 stems/hectare). The time and intensity of thinning are also often dictated by cost and market forces (demand for small sawlogs). Intense selection against ramicorn branching will result in some reduction of potential growth gain.

OP076

Regulation of seasonal changes in cambial activity in trees

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Wood has been used for thousands of years as a raw material for timber, furniture, pulp and paper, chemicals, medicines and fuels. In addition, since wood is a major carbon sink, it is expected to play an important role in removing the excess of atmospheric CO2 that is

generated by the burning of fossil fuels. Therefore, there is great demand for wood as a renewable bio-material and source of bio-energy.

Wood is produced by the division of vascular cambium (cambium) of stems of trees. Cambial cells differentiate into secondary xylem cells through a process of cell expansion or elongation, cell wall thickening (secondary wall deposition), cell wall sculpturing (formation of modified structure such as pits and perforations), lignification, and cell death. Although wood is of great economical importance, the precise process of its formation is not yet fully understood. Therefore, in order to create "new woods" with more desirable qualities, detailed information is needed on the cellular and molecular aspects of cambial activity.

In temperate and cool zones, the cambium of trees undergoes seasonal cycles of activity and dormancy. This periodicity plays a critical role in the control of both the quantity and the quality of wood. In addition, seasonal variations in cambial activity play an important role in the determination of the environmental adaptivity of trees. However, the physiological regulation of cambial periodicity is still not fully understood. In this paper, we will introduce recent information concerning the mechanism of changes in cambial activity. In particular, we will show our recent data concerning the process of the start of first cell divisions of the cambium from late winter to early spring using the model system of localized-heating induced cambial reactivation. Moreover, we will show the cold stability of microtubules, which play important roles in the division and differentiation of plant cells, in cambial cells and their derivatives in active and dormant seasons of cambium. The changes in cold stability of microtubules might be closely related to seasonal changes in the cold tolerance of trees.

Keywords: Cambium; cell division; cold tolerance; microtubules; xylem differentiation; wood formation

OP077

Initiation of cell death in parenchyma cells related with heartwood formation in the pith region of branches in *Robinia pseudoacacia* L. var. *inermis*

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The formation of heartwood is a unique phenomenon in long-lived woody plants. According to IAWA, heartwood is defined as "the inner layers of wood, which, in the growing tree, have ceased to contain living cells, and in which the reserve materials (e.g., starch) have been removed or converted into heartwood substances". Some species form colored heartwood because xylem parenchyma cells synthesize heartwood substances such as polyphenols that contribute to increases in the decay resistance of tree trunk, prior to their death. A full understanding of the mechanism of heartwood formation should provide information that is useful in efforts to control the chemical properties of wood.

Heartwood formation in temperate zone trees results from the death of xylem parenchyma cells that is associated with the annual life cycle of the tree. The death of xylem parenchyma cells progresses from the inner toward the outer region of the stem. Therefore, the death of parenchyma cells might be expected to begin in the tissues at the center of branches and stems, namely pith regions. If this hypothesis is correct, the parenchyma cells in the pith might be involved in the initiation of heartwood formation. However, the site of initiation of heartwood formation remains to be identified.

We will show the timing and role of cell death during heartwood formation of four types of parenchyma cells around pith regions of branches of Robinia pseudoacacia L. var. inermis. Our results indicate that the initiation of heartwood formation occurs in pith regions of branches in Robinia pseudoacacia L. var. inermis. Moreover, it appears that not only xylem ray parenchyma cells but also small parenchyma cells in the perimedullary zone in the outer part of the pith might be involved in the synthesis of heartwood substances.

Keywords: cell death, heartwood formation, pith, Robinia pseudoacacia, xylem parenchyma cell

OP078

Wood quality of planted loblolly pine in the southern United States: Synthesis of decade long research

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Loblolly pine (Pinus taeda L.) is a key commercial tree species grown in the southern United States of America (USA); and occupies more than half the standing pine volume. Over the years, management strategies used to grow loblolly pine in plantations have changed significantly, with a shift towards more intensive regimes from operational regimes, primarily aimed at producing more fiber on a shorter rotation. However, the quality of wood/fiber produced from such short rotation, intensively managed stands were questionable compared to that produced from natural stands or operationally managed stands. The Wood Quality Consortium (WQC), is collaborative research group between scientists at the University of Georgia and the United States Department of Agriculture – Forest Service through support from industries in the southern USA, established in 1999 with the objective of quantifying the variability in wood properties of plantation grown loblolly pine across southeastern USA. The primary objectives of WQC are to 1) Identify the variability in wood properties of loblolly pine at different levels, within tree from stump-to-tip and from pith-to-bark and spatially across the loblolly pine growing range in the southern USA; 2) Model the patterns of variability in several wood properties of loblolly pine; 3) Model the effect of different silvicultural management practices on the wood properties of loblolly pine; and 4) Develop a decision support system that has the capability to estimate the quality of wood produced from a stand along with the growth and yield information. In this paper, our objective is to have a synthesis of various research achievements made by the WQC over a decade long research. Primarily, the models developed to predict wood properties of loblolly pine and its real time application in a growth and yield simulator will be presented.

Keywords: loblolly pine; wood quality; intensive silviculture; wood property

OP079

Scheduling of Wood drying chambers

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In this paper we present a rather new and efficient planning approach for scheduling softwood drying chambers. A heuristic approach, which generates near optimal kiln allocation plans according to existing production specifications, is proposed. The heuristic takes stacking and placement restrictions into account, and calculates the position, time, and kiln for each lumber package where a large variety of dimensions are processed. Our approach complements the prevailing technological procedures for wood drying kilns and adds important time and customer aspects to the short term loading decisions.

In our conceptual model we assume that multiple, identical drying kilns exist in a large softwood processing sawmill. The overall solution is divided into two steps: First, a job shop scheduling problem is solved and secondly a solution for a packing problem with capacity and stacking restrictions must be provided.

We provide a mathematical model formulation for the specific planning problem. The goal is to minimize the total tardiness of all sawn timber packages while taking technological and capacity restrictions into account. The heuristic approach is tested according to real production data. The developed heuristic starts by grouping timber packages according to board thickness. Each group is characterized by a range of thickness. Following this, the packages in each group are pooled in order of their release time into potential batches for drying. Prior defined length patterns that correspond to a specific, kiln-dependent package length combination influence the batch creation process. In the next step, the best potential batch is selected and assigned to the corresponding kiln. After all packages have been scheduled, an improvement iteration by using the tabu-search algorithm is applied.

Even under the currently prevailing production conditions, a considerable improvement could be achieved both in the total tardiness and the utilization of available kiln space compared to the current situation. Further optimization could be gained by coordinating the planning of independent production units, or implementing new measures, such as drying different assortments of timber in one batch, outsourcing the drying of special assortments, or invest in supplementing kiln units for the drying of smaller volumes in more flexible time slots.

Keywords: softwood drying chambers, loading problems, optimization, tabu search

OP080

LCA Supported Sustainable Product Development for Furniture Industry

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LCA is an internationally accepted tool for assessing the environmental impacts associated with a product, process or service throughout its life cycle, i.e. from the growing of the raw material, harvesting or extraction through to processing, transport, use, maintenance, reuse, recycling or disposal. LCA could also be a powerful tool for designers (product developers), manufacturers, and consumers to compare the environmental credentials of similar products and services. Question remains; are we ready to apply this tool effectively in furniture design process? Leading furniture producers using LCA tools were evaluated and challenges of applying LCA were summarized. Case study of LCA conducted on a simple wooden furniture product with different design options is presented.

It is believed that LCA will continue to bridge the design, engineering and marketing communities leading to products that inspire customers while reducing environmental impacts. This tool should be included into teaching concepts. Methodology to teach furniture design based on aesthetic, strength, manufacturing and environmental concepts was developed to teach this subject effectively.

- observations on the relative importance of material selection
- highlights the differences between the product systems by showing the results per kg of finished product mass

OP081

Log Positioning Optimisation during Primary Breakdown Sawing

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In many softwood sawmills logs are positioned in front of the primary breakdown saw according to predetermined rules such as centering the log and/or positioning the plane of maximum curvature vertically. However, if one wants to optimise this positioning process in terms of value recovery there can be tens of thousands different log positions to consider depending on the positioning range and number of increments specified. In modern sawmills three-dimensional laser scanners can provide exact shape and dimensional information for this process. Recently, full log CT scanners have also been developed that can provide information on the internal characteristics of a log.

The problem with optimisation of the positioning of a log optimally is the short time available in the production process to evaluate the thousands of available options. This study considered two scenarios: one where only log shape information was available (as from 3D laser scanning) and one where internal knot characteristics were available (as from CT scanning). In the first scenario the sawing of 60 real pine log images considering only external shape were simulated. The sawing of each log was simulated in 10 062 different posi-

tions. In the second scenario the sawing of 10 real logs for which internal knot characteristics and external shape were available, were simulated in even more different positions. In both scenarios the optimal value recovery was identified for each log. A number of meta-heuristic search algorithms including simulated annealing, particle swarm optimisation, a genetic algorithm and a self-developed algorithm were evaluated to see whether one can reach a close-to-optimal sawing position in much less iterations than the exhaustive simulation of all positioning possibilities.

In this presentation the various search strategies to optimally position a log in front of the primary breakdown saw will be discussed. The potential improvement in value recovery possible when either shape scanning or CT scanning is available will also be discussed.

Keywords: Log positioning optimisation; sawmill processing; meta-heuristic search algorithms

OP082

Side-by-Side Determination of Workers' Exposure to Wood Dust with IOM and Open Face Sampler

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Different measuring devices have been used throughout the world for the evaluation of woodworkers' exposure to airborne particles. Differences between measuring devices are in the design of filter holders, which defines the efficiency of collecting the particular fractions of airborne particles. European standards (EN 13205:2001 and CEN/TR 15230:2005) have tried to harmonize measurement methods and ensure comparability of exposures assessed by different filter holders with a single occupational exposure limit (OEL) for inhalable hardwood dust. Due to a significant number of already existing data on exposure, in recent ten years the aim of researches in European countries has been to find the conversion factor for mass concentrations determined with different samplers. European Directive 2004/37/EC, which recommends OEL of 5 mg/m3 for inhalable fraction of hardwood dust, has been fully accepted in Croatia in 2007. Before that, the limit values for concentrations of harmful substances in working environment have been prescribed for exposure to respirable fraction and total inhalable wood dust. According to the accepted standards and regulations, we replaced 25 mm Open Faced (OF) filter holder with IOM head for the determination of workers' exposure to inhalable dust. The aim of research presented in this paper was to determine IOM/OF sampler ratio in the industrial environment. Side-by-side sampling was conducted using the personal sampling heads – 25 mm Open Faced (Casella) and IOM sampler (SKC) during 8 working hours. The mean values of mass concentration of oak wood dust estimated by IOM and OF samplers were 3.78 mg/m3 and 3.17 mg/m3, respectively. The difference of mean values is not statistically significant (u-test, p=0.59). The IOM/OF ratios had a range of 0.7-2.3. The mean IOM/OF ratio value was 1.114 and geometric mean IOM/OF ratio value was 1.08. The side-by-side determination should also be carried out in the environment with low wood dust mass concentration.

Keywords: side-by-side determination, carcinogenic substances, exposure to wood dust, total inhalable fraction, European Directive 2004/37/EC

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OP083

Buying into Sustainable Innovation Management (SIM): Why should wood products pay more attention to SIM?

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The use of wood as a raw material has a great sustainability impact. Wood is sustainable because is a renewable natural resource and has low environmental impact. For every ton of lumber that is processed about 350 kg of CO2 are sequestrated whereas other construction materials such as concrete and aluminum release up to 4 tons of CO2 for every ton that is produced. In terms of performance, wood is a strong and long lasting material when is combined with the proper engineering techniques. And there is much to say about its appearance, one of the most important characteristics sought by wood products consumers.

Even though wood as a raw material has great and intrinsic sustainability, performance and esthetic properties, wood products industries around the World still continue to struggle to design, implement and control sustainable manufacturing processes. Reduction of process waste and manufacturing lead times can be fought by using contemporary and accepted continuous improvement methodologies such as lean thinking or quick response manufacturing (QRM). However the root of the problem can be relied to the product design stage where over 80% of process waste, lead time, and cost are determined. Only by creating sustainable products that require less packaging, can be reused and recycled, and are manufactured using streamed line operations is how we can assure our business is in alignment with SIM. The discussion will focus on explaining each of the three SIM core concepts.

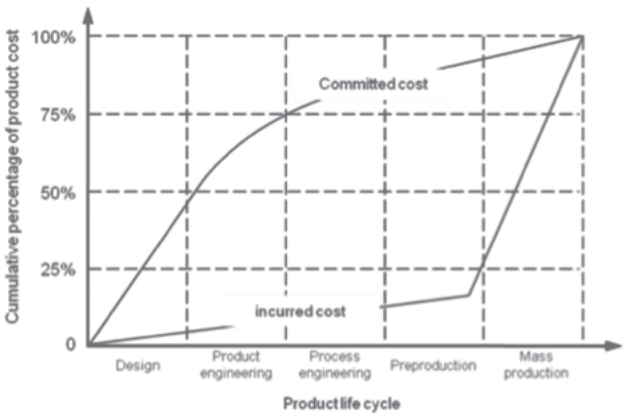

Figure 1. Product cost by production stage

SUSTAINABLE PACKAGING

As indicated earlier, critical for wood products firms to achieve SIM is to engineer products that require minimum packaging and can be reused and recycled. Product engineering is an important stage in the product life-cycle because it determines the manufacturability of products and their production costs. Product design consumes only 8% of the total production cost, but 80% of total cost of the product is determined in this stage (See Figure 1) and an important part of the decision process in product engineering is packaging design. A good packaging design needs to last for a long time, protects the product from transportation and climate damage, avoid tampering and harming for the consumer, and should provide good marketing opportunities. It has been estimated that for every $11 spent in the product, $1 is spent in packaging so the challenge for today wood products industry is how to design and create packaging that has all the functionality elements described before but at the same time is optimized, and can be reused or recycled.

SUSTAINABLE PRODUCT DESIGN

Similar challenges to the packaging design function are found in designing wood products that can be reused and recycled. US office furniture manufactures have found that their products last between 9 to 12 years and a total of 2.6 million units need to be replaced each year. In order to extent these products life spam, many office furniture producers now offering an alternative to refurbish the old furniture instead of just dispose them. This trend has also created great opportunities to create a market for second hand products (reusability). Other furniture industry subsector such as the Amish solid furniture sector market their products as "build to last" and offer very long warranty periods where the piece of furniture can be replaced or repaired basically at any time. Another example of a recycled wood product is the wood pallet industry where according to pallet manufacturers their profit share is bigger from recycling operations than from their brand new pallet operations.

SUSTAINABLE MANUFACTURING PROCESSES

A streamed line process requires to focus on value creation and flow. Once the product has been determined, the attention should be turned into an in-deep analysis of all the processes required to produce the good. The first activity requires the formation of a continuous improvement (CI) team that meets on a regular base to analyze and discuss how to eliminate waste from the production process. This team must have strong support from the administration, be multidisciplinary, and have strong/clear goals. The main goal of the CI team is to identify and eliminate waste in order to increase value and flow. Waste in a manufacturing process can have many faces and it is usually found in the form of excess inventory, reprocessing, low material yields, excessive movement and transportation, waiting, little empowerment, among others. The CI group could use a visual tool such a value stream map (VSM) to achieve the CI team's goal. Recently we have applied VSM to manufacturing and product design processes in wood products industries. In the manufacturing case, we found that valued-added time in sawmills range from 8.8 to 12.3 percent of total production time. Also, we applied VSM to the furniture engineering process of a large solid wood furniture manufacturer and we found that it takes more than 133 days to process an order in the engineering department. Thanks to the application of VSM analysis we were able to identify waste and to recommend solutions to help these firms to stream line their respective processes.

Stream-lining a process is not just about eliminating waste in the form of materials, waiting times, or assets usage. It is also about energy consumption. Lately we have also seen a lot of interest in the manufacturing sector in looking for meaningful ways to decrease energy usage with the goal to reduce cost and carbon footprint metrics. The focus has been mostly in finding solutions to decrease energy consumption that require less than 1 year payback. At the top of the solution lists is lighting modifications. For instance, installing new efficient lamps and motion sensors is saving an average of $110,000 a year to wood products companies. Also, the elimination of air compressed leaks is saving around $33,000 per year with less than 0.11 year payback. Other high-impact energy management solutions in wood products firms are total productive maintenance programs (TPM), automatic sensors to stop equipment when it is not needed, and the replacement of oversized motors and fans. Any of these last tree solutions can save wood products industries from $5,000 to $35,000 per year with less than 1 year payback. We have also found that wood products companies are interested in monitoring energy consumption by using energy data management systems. Currently, we are assisting industries in Virginia to install energy monitoring technology that will allow these industries to understand how energy is consumed. Further analysis on energy data will allow these industries to uncover trends and to relate energy consumption with internal and external events.

Important in SIM is also logistics and supply chain management. In the last 20 years we have seen an unprecedented increase in Global Commerce, however; global transportation generates about 2.7% of the world CO2 emissions. Wood products companies have become big contributors to this negative environmental impact where it is especially significant the exports from USA to Europe and Asia of low value-added products such as round timber logs. But also internal transportation in the forest products industry has a huge impact to the environment where it has been estimated that 0.3725 pounds of CO2 are released per ton per mile. These two facts lead us to believe that the proper management of forest products logistics is critical to create a truly sustainable wood products supply chain. The complexity of logistics can be found in woody biomass energy facilities. For instance, an 80 mega-watt facility requires around 3000 tons of wood chips per day. This translates into approximately 150 daily trucks or in about 110,000 pounds of released CO2 per day only in transportation (from a 100 mile radius).

I would like to end this discussion saying that SIM is not only about environmental impact. The SIM initiative should be able to support the bottom line of the company, the cash flow. As it was described, the SIM initiative should be a holistic approach that help synchronizes the firm's business processes to increase the competitiveness while decreasing the firm's carbon footprint. Any attempt to align the company into the SIM principles will require a strategic approach to also pursue an increase of the business wealth. Therefore, other secondary processes such as marketing and information technologies may play a significant role to penetrate new niche markets that are interested in buying product from SIM aligned companies. There are a few examples out there of wood products firms that have aligned along SIM with great results and it is expected that this trend will continue to growth.

If you would like more information about SIM, please contact Dr. Henry Quesada at quesada@vt.edu

OP084

Innovative Processing and utilization of Bamboo Resources in Ghana in a Climatic Threatened Environment: The Technical Issues

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The sustainable use of bamboo resources is an important part of forest management because bamboo is believed to be an essential tool to balance technological advancement with environmental sustainability in most tropical countries like Ghana. In this present study, the technical issues involved in the enhanced processing and the development of a viable bamboo based industry in Ghana were addressed. The technological properties of native bamboo species in southern Ghana- thermogravimetric, phytochemical and selected physical and mechanical properties of Bamboo species from different sites in Ghana- were examined.

Preliminary phytochemical screening revealed the absence of alkaloids (an important decay resistance indicator) and the presence of anthraquinone glycosides. The results of the thermogravimetric analysis indicate a rapid weight loss between temperature of 200 °C and 400 °C in all samples. There was no marked trend in the shrinkage for outer diameter and culm wall thickness of bamboo samples and were not statistically significant at 5%. The information on the technical properties of bamboo in Ghana will be relevant for innovative processing and utilization of our bamboo resources.

The study concluded with recommendations for capital investments supported by research to establish some bamboo- based industries in southern Ghana. This step is relevant towards developing location-specific adaptation tools to the impact of climate change in Ghana.

Keywords: Bamboo, technical properties, processing, innovation

OP085

The role of Wood in Ghanaian Economy: Past and Present Performance

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Wood and wood products play important roles in many developing economy; first as a source of domestic energy (fuelwood), and as foreign exchange earner and employment. In southern Ghana, where over 680 timber species abound, the processing and trade in lumber and other wood products has provide thousands of Ghanaians with employment. Though export values and volumes from Ghanaian sawmills keep fluctuating over 4% of Ghana Gross Domestic Products is still attributed to timber trade. In 2010, in term of export values of wood products from Ghanaian sawmills to consumers countries about 136 million Euros was realized.

In this study, the socio-economic role of wood in some communities with sawmills in Ghana was reviewed over last decade and field observation of the existing trend in processing and export of some wood products was conducted.

A fall in the volume export of wood products especially tertiary products like furniture was obtained. There is a gradual decrease the number of locals employed by some sawmills mainly due to low production levels in existing wood processing facilities. Investment in modern equipment for wood processing that utilize smaller round logs as well as better utilization of wood residues may improve the socio-economic benefits of wood in diverse forms in Ghana and many developing countries where trade in wood product is an integral part of export product mix.

Keywords: Wood, processing, export values and tertiary wood products.

OP086

The Opportunity of REDD+ Scheme to Conserve Peat Swamp Forest in Tripa Ecosystems, Aceh -Indonesia

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Indonesia is well known as a mega biodiversity country. Sumatran orangutan (Pongo abelii) is one of the animals diversity that occurs naturally in peat swamp and lowland tropical forests. Orangutan Sumatra has got big attention due to high rate of deforestation in Sumatra. Forest cover changed to estate plantation (particularly oil palm), agriculture land and settlement. The land use change does not only diminish orangutan's habitat, but also increases emission of carbon dioxide (CO2) to the air. Nevertheless, Indonesia has committed to reduce emission about 26% from the business of usual by 2020.

We conducted a study on the analysis of opportunity cost, which is defined as foregone economic benefits that would have been associated with a 'business as usual' pattern of land-use change, in a habitat of Sumatran orangutan of Tripa peat swamp forest, Aceh, using REDD Abacus tool. Opportunity cost is one component of investment costs of reduce emission from deforestation and forest degradation (REDD). Total carbon stocks in the landscape were measured, land cover change from 1990 to 2009 was calculated and profitability of main commodities was analyzed. Our study showed that total carbon stocks in different land use types ranged from 25.65 tC/ha in agroforest to 388.42 tC/ha in undisturbed peat swamp forest. Dipterocarpaceae and Lauraceae were the most dominant tree families in undisturbed peat swamp forest. Land cover change in Tripa peat swamp forest was mostly driven by oil palm plantation. Forest cover reduced significantly from 58% in 1990 to only 18% of total area (60 316 ha) in 2009, while oil palm plantation increased dramatically from 4% in 1990 to 39% in 2009. Total aboveground emission ranging from 9.0 tCO2e/ha/yr , in the period of 2001–2005, to 21.5 tCO2e/ha/yr in the period 1990–1995. Undoubtedly, oil palm was the most profit commodity compare with other tree-crops, such as cacao and home garden products. The opportunity cost of conversion of natural forest and natural swamp forest conversion to oil palm plantations ranged from USD 10.5/tCO2e to USD 17/tCO2e. Using the threshold of 5 USD/tCO2e, the emissions from land-use conversion that could have been avoided range between 6 tCO2e to 14.6 tCO2e in the periods of studied. The highest proportion of emissions that could have been avoided occurred in the 1990–1995 period (67.7%, totalling 14.6 tCO2e),

while the lowest was during 1995–2001 (40%, totalling 6.1 tCO2e). Conservation of Tripa peat swamp forest as habitat of Sumatran orangutan is a challenge for co-benefit through REDD+ scheme.

Keywords: abatement cost; carbon stock; CO2 emission; provitability analysis; REDD Abacus; REDD+

OP087

Environmental impact assessment of wood pulp from fast-growing eucalyptus plantation in South China:Based on case study results by using Life Cycle Analysis

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The development of China's wood pulp industry over the past two decades has been remarkable, particularly in southern China where the largest wood pulp capacity expansion is currently being established. The greatest challenge facing the Chinese wood pulp industry is to ensure sufficient wood raw material supply due to virgin wood fibre shortage from domestic forests. Eucalyptus, which suits the growing conditions in southern China, is becoming the dominant wood supply for the wood pulp industry. A total area of 1.9 million hectares of fast-growing eucalyptus plantations has been planned, in southern China, integrating with newly-built large-scale wood pulp mills. There are increasing concerns in the public and from different stakeholders, either concerning the potential impacts to the environmental by managing large-scale eucalyptus plantations, or focusing on the environmental burden due to large-scale pulp mill establishment.

This study aims to identify and quantify the environmental impacts associated to Bleached Eucalyptus Kraft Pulp (BEKP), which is one of the common commercial grades in the global market, produced from fast-growing eucalyptus plantations in south China, by using the Life Cycle Analysis (LCA) as an analytical tool. The system boundary has been defined by using a cradle-to-gate perspective, from seedling production in the nursery, through silvicultural operations in the plantation, to the market pulp products ready at the mill gate. The case study has been divided into two sub-systems for data collection: forest sub-system based on the data from a company in Guangxi province as leading operators of eucalyptus plantations, and pulp mill sub-system based on the data from a pulp mill in Hunan province as a representative of "state-of-art" pulp producers in China. The key processes have been designed and site-specific data collection has been carried out in Nov.2009, and April-July 2010, regarding the mass materials and energy flow, and the emission released to the atmosphere, soil and water as a consequence of plantation operations and manufacture processes.

Umberto 5.5 software was used to conduct the life cycle inventory which compiles all the inputs and outputs of the research system. The impact categories associated with the research boundary, namely global warming, acidification, eutrophication, non-renewable resources depletion and human toxicity were analysed, and several processes were identified as hot spots.

Keywords: Life Cycle Analysis (LCA), wood pulp, fast-growing eucalyptus plantation

OP088

Bio-based solutions for Eco-efficient construction

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The construction industry consumes massive quantities of materials with a share of 40% of the current worldwide resource consumption of nature resources. In order to decrease the impact of this industrial chain in the global greenhouse gas (GHG) emissions, novel construction solutions are needed including also recyclable and reusable products. Bio-based products and new fibre concepts have potential to substitute fossil-based products and bring new eco-efficient solutions to the built environment.

This paper explores the potential of new wooden fibre and nanocellulose products targeting new construction solutions. These include wood-based composites as well as composites of wood with other natural fibres. Particular focus is given to recyclable and reusable products from wood and construction industry sidestreams. Current applications and new solutions at different stages of research and development, in Finland, are presented and case-studies described.

The combination of wood and other natural fibres with selected polymers and plastics processing technologies offers exciting new opportunities for developing bio-composite and wood plastic composite products. The recycling of wood and plastic material decreases natural raw material consumptions.. In different process nano-fibres can be used to modify material properties and thus create products that better correspond to future market needs.

These processes create new materials for the construction industry with improved properties supporting better thermal insulation, acoustics and a healthy indoor environment. The application of nanotechnologies, on the other hand, allows for the development of functional products with an active role in the built environment.

Keywords: biomaterials, eco-efficient construction, new fibres, functional materials.

OP089

The Role of Harvested Wood Products in Carbon Storage: Comparison of Estimation Methods

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Harvested wood products (HWP) in use accumulate carbon for periods that range from a few days to several decades. In addition, discarded HWP may be disposed of in landfills where they may persist for long periods. Over the last few years, some methodological frameworks have been proposed to allow the estimation of carbon storage in HWP in the national greenhouse gas emission inventories performed under the United Nations Framework Convention on Climate Change.

This study compares two methods for estimating carbon accumulation in HWP: tier 1 method proposed by the Intergovernmental

Panel on Climate Change (IPCC) in the 2006 Guidelines (GL tier 1 method) and tier 2 method proposed by the IPCC in the Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG tier 2 method). These methods were applied to Portugal for three alternative approaches: stock-change, production and atmospheric-flow. Another objective was to perform a sensitivity analysis in order to identify the calculation procedures and the input data that have the largest impact on the HWP accumulation estimates and, therefore, should be carefully selected in the development of higher tier methods. An uncertainty analysis was also carried out with Monte Carlo simulation.

The estimates of carbon accumulation obtained with the two methods are similar, except for the production approach, as the GL tier 1 method underestimates carbon accumulation in landfills with this approach. The results also suggest that the atmospheric-flow approach generates the highest estimates of carbon accumulation in HWP for countries like Portugal that are net exporters of HWP. The most influential calculation procedures and input data were the algorithm used to calculate the change in carbon stocks for the pools that follow a first order decay, the procedure to estimate the input of carbon to the pool of HWP in landfills, the procedure to determine the change in carbon stocks of HWP in landfills for the production approach, the type of carbon stocks considered in landfills and the conversion factor for wood-based panels.

Keywords: Carbon; harvested wood products; Portugal; uncertainty

OP090

Resources for the future: How forests and forest products will meet future society needs

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The world and society in general in 2011 are characterised by a number of main drivers: scarcity of resources, urbanisation, demands for personal flexibility, need for affordable living space and ecological awareness of the consumer.

Wood and wood-based materials provide an answer to these societal needs and will continue to do so even more strongly in future. Wood-based construction, lighter and faster than traditional systems, gives an adequate response to urbanisation and the demand for affordable living. As a naturally renewable raw material with growing stock at least in Europe, wood matches policy demands over resource efficiency and at the same time provides a truly ecological alternative.

All in all, they provide a comprehensive response to human needs, provided they are produced in an economic way and provide advantages over competing products as regards the use of resources, their price-performance ratio and versatility and can be supplied "locally" avoiding too long logistical chains.

Wood products, in particular the construction with wood and wood-based solutions, will be a cornerstone of the EU initiative to bring down GHG emissions by 80% towards 2050, the so-called Roadmap 2050.

Keywords: Society needs, urbanisation, renewable resources, resource efficiency, GHG emission reduction.

OP091

Moisture content determination by microwave radar

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Moisture content of wood and wood based product is an important indicator in wood processing and utilization. Microwave radar technology offers a non-contact quick moisture determination technique. The experiences of an industrial application are discussed in the paper. In the industrial trial we used a Novelda, - a Norwegian company - made development kit. It is wide band (1-5 MHz) impulse radar. The applied power level is in the nW range. We applied standard back scattering setup. We found good correlation between the radar signal amplitude and the moisture content of the sample. The microwave has high penetration in dry wood, so testing construction size wood material or glue-lam beam is possible.

Keywords: Moisture content, wood, wood composite, microwave, industrial trial

OP092

Stability of Hydrogen Bondings of Aged Woods after Steam Modification: Detection by Infrared Spectroscopy

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Aging can affect the lifetime and quality of wood-based products by altering the self-binding of the components. This self-binding ability has been thought to be related to the binding performance of lignin, hemicelluloses, or polyuronide. Hydrogen bonding must also play an important role here, similar to their role in case of the binding of fibers that comprise paper. This study focused on the stability of hydrogen bonding with respect to aged wood. Wood samples were treated with D2O steam to distinguish the accessible hydroxyl groups by infrared (IR) spectroscopy.

The samples were archeological Pinus densiflora timber from baulks installed in the main hall of the Fukushoji Temple in Japan as a cultural property in four different years of A. C. 1500, 1662, 1836, and present day. Their quality, grade, and use environment were similar. They were sliced into 20-mm thick film-like samples; treated with D2O steam at 140°C and 200°C for 2 h; and exposed to saturated H2O vapor at room temperature for 16 h. The changes upon hydroxyl group (OH) and the substituted OD were detected by IR spectroscopy.

Immediately after the D2O steam treatment, the rate of OD substitution of the aged wood was higher than that of the present day wood. However, by subsequent exposure to H2O vapor at room

temperature, the aged wood lost a larger amount of OD by substitution of OH in comparison with the present day wood. These results indicate that the hydroxyl groups of the aged wood were more susceptible to both heat steam and ambient moisture than those of the present day wood.

Precise OD analysis after steam treatment revealed that the wood samples display at least four different types of bands. This is partially because of the different types of hydrogen bonding. By exposure to H2O moisture at room temperature, two of the OD bands that appear in the higher wavenumber region of the aged wood drastically changed with position; however, those of the present day wood changed only marginally. The other experiments using IR spectroscopy under stretching implied that these four bands possibly had different load-bearing abilities for tensile stress. Thus, the stability of hydrogen bonding produced by steam treatment was evaluated via the OD groups produced by D2O steam treatment, and the less stable portions of the aged woods were demonstrated.

Keywords: Aged wood; hydroxyl group; hydrogen bonding; infrared (IR) spectroscopy

OP093

Physical-mechanical properties and state of art in the investigation of European Hardwoods

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Switzerland, but also other European countries, still use the bulk of harvested hardwood directly for energetic purposes instead of adding value on it by other applications since it is the most convenient and profitable solution for unused assortments at the moment. The two most important ways for stem hardwood are the use as solid wood (e.g. roof structures, stairs, furniture, flooring) and wood composites (e.g. solid wood panels, plywood). Scientific analyses reveal that hardwoods nowadays even enter softwood domains such as wood based materials and structural timber (glued laminated timber, Duo and Trio beams). Investigations help to understand the properties of hardwood and to simplify the processing. Especially for glued wooden elements information of material parameters such as elasto-mechanical properties, sorption, liquid water adsorption, swelling, shrinking as well as creep in the 3 main directions are necessary to make a FE-calculation. Currently, these parameters are only evaluable for spruce (PhD thesis Neuhaus, Germany 1981), for hardwood only little information is available.

In this study the effect of wood moisture content on the elastic properties of beech wood (Fagus sylvatica L.) and maple (Acer Pseudoplatanus L.) were examined. The investigations comprise the determination of the elastic moduli (Young`s moduli EL, ER, ET; shear moduli GLR, GLT, GRT) and Poisson`s ratios (μlr, μrl, μrt, μtr, μlt, μtl) as well as different mechanical (tensile and compression strength, bending strength tested) and physical properties (sorption, thermal conductivity) at different wood moisture content steps with respect to the three axes of anisotropy (longitudinal, radial, tangential).

The results demonstrate the significant influence of wood moisture content. All measured elastic moduli decrease with increasing wood moisture content, whereby moduli are affected by the moisture content to different degrees.

Conversely, only a slight correlation between the Poisson`s ratios and the moisture content exist. Except for μlr and μlt, where an increase and a slight decrease is observed with increasing wood moisture content, respectively, the measured Poisson`s ratios are insensitive to changes in wood moisture content.

Keywords: Hardwood, mechanical properties, elastic constants, orthotropic behaviour, sorption, swelling

OP094

Radial Profiling of Wood Quality and Chemical Composition via NIR Spectroscopy

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The use of near infrared (NIR) spectroscopy for the prediction of wood properties is now commonplace with applications in both the pulp and solid wood products sectors. These applications generally use woodmeal that is prepared from grinding discs or cores and as such provide an average value of the property over the region sampled. Wood however is a highly complex, heterogeneous matrix, which inherently requires spatially resolved measurement of wood properties to provide information regards the overall uniformity.

With the exception of standing tree acoustic velocity, the most common approach to non-destructive evaluation of standing trees is to remove increment cores using a borer (usually 5-mm (¼") or 10-mm/12-mm (½") in diameter). The cores are generally taken bark-to-bark, through (or close to) the pith or they are taken pith-to-bark. Once obtained the cores can be assessed for a number of wood properties, typically; density, stiffness, shrinkage, microfibril angle (MFA), ratio of heartwood to sapwood. Generally these assessments are done in isolation with some measurements requiring considerable experience in their measurement (e.g. MFA by microscopy). The SilviScan suite of technologies offers the ability to measure a number of these properties on the same sample at high spatial resolution (tens of microns), following suitable preparation, but does not allow chemical composition or pulp yield to be determined.

A custom-built, fully-automated linear translation stage has been coupled to a Bruker MPA FT-NIR via a custom fibre-optic probe. Samples are loaded into cassettes either as whole cores (oriented with the radial-tangential plane towards the aperture) or as SilviScan strips (2 mm thick tangentially, 12 mm deep longitudinally) of varying length. Software control of the linear transport and spectral acquisition enables NIR spectra to be obtained at locations every 1 mm along the length of the core or radial strip. Using established calibrations a number of properties can then be predicted for every radial increment to establish radial profiles similar to SilviScan, but which now include properties such as cellulose, lignin, hemicellulose, Kraft pulp yield as well as MFA, density and stiffness.

Keywords: NIR, radial profile, Kraft pulp yield, MFA, chemical composition, density, stiffness

OP095

Non-destructive detection of ring shake in standing sweet chestnut trees with tomography

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The importance of Sweet chestnut in commercial forestry in Germany has been increasing, because as a Mediterranean species it might be well adapted to the changing climate. However, timber value is severely reduced by ring shake, a defect undetectable visually in standing trees. We tested whether ring shake can be detected by stress wave (ST) and electrical resistivity tomography (ERT). Altogether 55 trees in six stands varying in age and silvicultural treatment (crown thinning, low thinning, future tree selection) were measured in the field, and stem cross-sections were brought to the laboratory for further analysis. 16 of the sample trees were affected by ring shake. Their proportion in the old stand with future tree selection was significantly higher than in the other treatments. In this stand, 9 out of 10 measured trees had ring shake. The variation of mean moisture content and the spatial variation of moisture content were not associated with the occurrence of ring shake.

The combination of stress wave and electrical resistivity tomography was well suited to detect the occurrence of ring shake. The low number of electrodes used in this trial limited the spatial resolution of electrical resistivity tomography and should be increased in further experiments. The time required to measure one tree, in this study up to one hour, could be drastically reduced by thorough training and a purpose-made set-up of the equipment. With these improvements, this technique could be used successfully to assess the frequency and distribution of ring shake in Sweet chestnut stand and to analyse the effects of silvicultural treatments.

Keywords: Non-destructive testing; silviculture; ring shake; Sweet chestnut (Castanea sativa Mill.)

OP096

Heartwood Detection of Scotch pine (*Pinus sylvestris*) Using the Fluorescence of Stilbene Pinosylvin

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The amount of the heartwood is an important quality factor in the final wood products. If the amount of heartwood could be determined, high decay resistant timber could be separated more easily from the less durable ones. Heartwood is used e.g. in window frame industry to achieve more weatherproof products. This study proposes a fluorescence imaging method for the accurate determination of the heartwood content of Scotch pine boards. The method is based on the fluorescence of stilbenes pinosylvin and pinosylvin monomethyl ether, which are specific compounds in the heartwood of Scotch pine.

The formation of pinosylvin and its monomethyl ether occurs during the transformation process from sapwood to heartwood. Previous studies have shown that these compounds protect wood against different rotting fungi and thus the amount of pinosylvin and its monomethyl ether correlates highly with the decay resistance of wood. Since the compounds are highly fluorescent, the information given by the fluorescence can be used for detecting the heartwood part of the Scotch pine. To achieve this, an accurate determination of excitation and emission wavelength regions is studied.

This study shows accurate fluorescence measurements from the heartwood and the sapwood of Scotch pine boards. Fluorescence measurements were done with a bispectrometer where excitation wavelengths were scanned by using a monochromator and a xenon arc light. Emission spectra for each excitation wavelength were measured with an optical spectrometer. From the measurements, optimal wavelength regions for the illumination (300 – 350 nm) and for the detection (410 – 430 nm) were determined. This study also presents an on-line measuring prototype for real manufacturing speeds.

The proposed method can benefit in optimizing the drying process. The heartwood contains less water than the sapwood. Thus, a board with a high amount of heartwood does not require so long drying time as boards with high amount of sapwood. Moreover, the information of the position and the amount of the heartwood in the logs could be used for determining optimal sawing parameters for producing high quality heartwood products.

Keywords: fluorescence; heartwood; pinosylvin; Pinus sylvestris, stilbene

OP097

The principle of Voluntary Approach and the Voluntary Programs of Forest Certification in Chile: why do the firms certify?

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In recent years the need for designing efficient environmental policies has led regulators to explore the principle of "voluntary approach" as a complementary tool to existing policies. As a general goal, our project analyses how forest certification voluntary programs are currently being developed in Chile and what are the factors that influence participation by firms. Moreover, this study has two specific goals. The first specific goal is to characterize the firms that are voluntarily certified by Chilean System for Sustainable Forest Management Certification (CERTFOR) and Forest Stewardship Council (FSC-Chile), and the second specific goal is to empirically analyze the determinants that encourage firms' participation into certifying programs.

The current study assumes that firms will certify only if expected benefits of certification are greater than costs. Then this study identifies the importance of economic factors, such as production, local demand, location, and others and how these factors facilitate the adoption of forest certification. Through econometric analysis and variables such as proxy of benefits and costs of forest certification, we

apply a Probit model of decision. It explains the firm´s participation in sustainable forest management and chain of custody, respectively.

The results show that firms owned by a holding company, with a high-volume production and sales in the international market, are more likely to participate in forestry certification. Nevertheless, we could perceive that presence of the local market has a negative and significant impact in the processes of the certification on small firms. Finally, we recommend two relevant aspects that policymakers should have into consideration: first, we suggest the designing of a support mechanism that includes the medium and smallholders firms. Secondly, we are convinced that the government plays an important role encouraging environmental awareness programs for final consumers. This action contributes to create initiatives of disposition to pay for the certified wood.

Keywords: Voluntary approach; forest certification; Probit model; CERTFOR; FSC; Sustainable forest management; Chain of custody; holdings.

OP098

Value Creation in International Business Relationships: Perspectives of Finnish Wood Products Suppliers

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A growing number of marketing researchers and practitioners are considering value as an essential constituent of marketing strategy development and implementation. Delivering superior value to customers is a key to creating and sustaining long-term business relationships. In order to differentiate themselves through improved customer interactions, wood products companies need to understand how they can create value in international business-to-business relationships. The purpose of this study was to examine how wood products companies create value in international business relationships. As a highly competitive player worldwide, this study focused on the perspective of Finnish wood products suppliers.

Based on the literature review, a conceptual framework of supplier's value creations in international business relationships was developed. The independent variable is value that suppliers intend to deliver to the customers, whereas the dependent variable is value that suppliers receive from the customers. Further, the framework includes the effects of customer commitment/trust and psychic distance on supplier's value creation. A nationwide survey with a structured questionnaire was conducted from September to December 2004 to closely examine prevailing experiences and perceptions in both primary and value-added wood products companies in Finland. Data of 86 relationships with the Japanese and European customer were collected through the interviews.

Results indicate that Finnish suppliers consider delivering high quality wood products as the most important part of value proposition. They were reluctant to accept low price and trade discounts for the products. The emphasis of low price in value proposition may result in diminishing profits accrued to the supplier. Suppliers incorporating delivery-related services into their offering of high quality products may gain more profit from the customers. The supplier's willingness of providing information may affect positively the customer's willingness of providing information, helping contact to new customers, and assisting the supplier's innovation in return. Higher customer commitment and trust may result in gaining higher profit and stable demand with friendliness and honesty from the customer.

Keywords: Finland; international business relationships; value Creation; wood products suppliers

OP099

'Smaller is Better': Case Studies of Small and Medium Forest Enterprises from the Western Region of The Gambia

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All over the world, small- and medium-sized enterprises are being upheld as an effective and sustainable mechanism for creating employment opportunities, generating wealth, and improving community wellbeing. This logic is now being applied to the forested regions of developing economies where the prevailing thinking is shifting from 'bigger is better' to 'smaller is better'. Small and medium forest enterprises (SMFEs) are increasingly being thought of as instruments of change, promoting the sustainable use of forested ecosystems, while also contributing to the livelihoods of oftentimes impoverished forest-dependent people.

The Western Region of the Gambia provides an interesting context for a study of the opportunities and barriers encountered by SMFEs. In recent years, policy reform has led to improved conditions for community forestry initiatives and a climate that is conducive to small business training and capacity building. Yet, issues still remain and SMFEs in this region face several challenges that threaten their ability to develop and grow. The aim of this study is to better understand and articulate some of these constraints, many of which revolve around access to financial services. In total, 16 SMFEs from the Western Region of The Gambia were interviewed for this multiple case study. Interviews with 14 financial institutions were also undertaken to supplement the findings.

Results indicate that the government of The Gambia has exerted a positive impact on SMFEs by devolving forest tenures to local communities, providing capacity building and support programs, and simplifying regulations. Nevertheless, weak enforcement, corruption, and illegal activities all remain major barriers to the success of SMFEs. In addition, and despite government efforts, all of the studied enterprises revealed the need for the continued provision of business development services. Finally, a key result indicates that, while SMFEs have easy access to savings and deposits accounts, they have very limited access to much needed credit, especially from banks. In some ways, cooperative credit unions have been filling this void by providing loans. However, most credit-only and microcredit schemes are currently being delivered by non-government organizations, business associations, and government projects.

OP100

What makes wood so attractive?

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Wood products are the result of several stages from primary conversion and secondary processing to different kinds of design and surface treatment. Within this production chain each stage is affected by demands of different types of industrial customers in a consecutive chain of purchases and sales. Furthermore consumers` preferences have backward effects on the production. Criteria that wood processing companies, traders and consumers use may differ. Thus, there is a complex set of parameters influencing the quality requirements on products from primary conversion to the end-user. Visible wood products have features that affect consumers` buying decision. When asking people, if visible features are seen as negative defects or as parts of an aesthetical composition this question is determined by individual visual perception, preferences and experience.

Companies in a wood processing chain are confronted with the challenge to measure the quality of their products aiming at their costumers` needs. They use manual grading technics and scanning technologies to handle the product quality spectra. This quality determination is the basic information source for each product to achieve the expected product value meeting specific consumer requirements.

For end-users the relevance of objectively measurable wood features is probably unconsciously and emotionally affecting their choice. The composition of features e.g. knots, tree ring patterns and colour influence the aesthetic impression to people. The connection between consumers` preferences and objectively measureable features within the production chain is not well established yet. When trying to connect consumers preferences it is a challenge to link emotional terms like "warm" or "natural" or "calming" to measurable parameters as mentioned above. Therefore there is a need for finding criteria which reflect end-users requirements.

The aim of this study is to find criteria which are important for people`s assessment of wooden floorings. 109 persons and 15 wood experts were interviewed in 2011. Both qualitative and quantitative approaches were used. The results show the most important criteria for people`s aesthetical assessment of wood floorings.

This work is a base study for further investigations in the project called "What makes wood so attractive? Transforming consumers` emotions into material characteristics" which is supported contract research 'Forschungsprogramm' of the 'Baden-Württemberg Stiftung'.

Keywords: Floor boards; consumers` preferences; consumers` emotions, consumers` perception, wood quality; board classification; wood surface; feature detection

OP101

From a Production Orientation to a Stakeholder Orientation: The Evolution of Marketing Sophistication in Private, Multi-site U.S. Sawmills

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Marketing can be thought of as a means of satisfying stakeholder needs in a social context. The role of marketing within a firm and the way it is conducted serve as indications of the sophistication of a firm. When marketing is purely a selling function, the company is likely production oriented. Conversely, marketing as an integrator or relationship-builder implies a more sophisticated market-orientation. The evolution of marketing can be explained by contingency and institutional theories. Contingency theory suggests that organizations continually adapt to a changing external environment while institutional theory suggests that practices and business models can become institutionalized and remain intact even when they are no longer ideal. Based on previous research, it is clear that marketing is changing over time. There are clear indications that some historical events such as the world war and Great Depression have influenced the shifting orientation of marketing.

This study focuses on the "real" marketing sophistication and practice present in the US sawmilling sector. Here, marketing sophistication is used to mean the "degree of market orientation." It also explores the evolution of marketing sophistication in the sawmilling sector during the past years and the direction towards which marketing will develop. Finally, it investigates the interface between marketing and sales departments which can have essential impacts on marketing sophistication.

OP102

Emerging trends in wood protection research and industrial application

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Wood has been used in construction and other uses to satisfy human needs and also to store carbon. However, one of the limiting factors of its use is its durability. Throughout the human history, several strategies have been proposed and used to improve its durability against biological, physical chemical and mechanicals de-

teriorations. Uses of natural decay species and dimensional stable species such as teak and cedars, design and construction methods to keep wood immune to deterioration agents , uses of biocides and non-biocidal method are well documented . Environmental issues mainly shape developments in wood protection particularly in regions with well-developed economies, to satisfy requirements for "green" (environmentally preferred) wood products. This paper is a review of the emerging trends in wood protection. It will cover the carbon based biocides (organic) with minimum negative impact on humans and environment alone or in combination with copper or other inorganic chemicals to control bacteria , non biocidal methods such as chemical and physical modifications used to improve the biological and dimensional stability of wood products. Developments in tropical wood protection are also highlighted.

Keywords: Wood protection, New technology, Environmental protection

OP103

Development of new wood protection formulations by incorporation of synergic bio molecules

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The European project Bimosyn attempts to investigate the degree of synergy between antioxidant bioactive substances and conventional biocides in order to develop more environmentally-friendly wood protection formulations. The aim is to use natural extracts from plant sources with the potential to be used as biocide adjuvants for the chemical sector.

The study focuses on the inclusion of adjuvants of an antioxidant nature of synthetic and natural origin in commercially-available formulations of domestic insecticidal and/or fungicidal products, and industrial pesticide products. Natural adjuvants are those deriving from plant, fruit and vegetable residues such as pine bark and grape seeds and from medicinal plant extracts. The inclusion of these adjuvants will enable the percentage of customarily-used biocide to be reduced in formulations so as to thus obtain decay and insect-control substances of a more environmentally-friendly nature. The two areas of application in wood preservation against xylophagous insects and fungi are considered.

The main objective of this project involves studying the synergism between antioxidant bioactive molecules and some organic biocides included within the new European Biocide Directive 98/8/CE (BPD), for the development of new formulation products whose performance features may clearly help to distinguish them from other products available on the market.

Organic wood protection fungicides, e.g. propi-, tebuconazole, N,N-Didecyl-N,N-dimethylammonium chloride (DDAC) and 3-iodo-2-propynyl-butylcarbamate (IPBC) were combined with 6 antioxidants of plant origin and one chelator. Combinations of organic insecticides, e.g. thiacloprid, cypermethrin and bifenthrin with antioxidant and medicinal plant extracts were also prepared. Screening and standard basidiomycetes decay tests and test with termites were carried out to determine the effective levels of ingredients. The effect of leaching was studied as well. The obtained results are promising, indicating synergic effects, and some strategies for further immobilisation of the formulation ingredients are discussed.

Keywords: decay fungi, antioxidants, impregnation, laboratory tests, organic preservatives for wood, termites

OP104

Triazole- based ionic liquids to protect of lignocellulosic materials against fungi

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Ionic liquids (ILs) represent a new group of compounds consisting of a cation and an anion with tend to be non-volatile substances in room temperature. Structure modification of ILs makes it possible to obtain compounds of new physico-chemical properties, deep of penetration into wood and higher effectiveness of action against microorganisms.

Wood Technology Institute together with the Chemical Technology Department at the Poznań University of Technology has developed new ionic liquids based biocides. These include so far not described originally protic ILs - 1,2,4-triazole derivatives. These compounds have many attractive properties possess a unique structure, even more excellent antifungal activity.

In presented paper we examined on biotic properties of novel structure of tebuconazole derivatieves: tebuconazole hydrochloride, allyltebuconazole chloride, methyltebuconazole iodide, tebuconazole dihydrocitrate. Our investigation against wood-degrading fungi were contained also the didecyldimethylammonium 3-aminotriazolate as well as didecyldime-thylammonium nitrate(V) with 15% tebuconazole or with (7.5% tebuconazole +7.5% propiconazole). In order to confirm the structure of the new ionic liquids analyses using thin layer chromatography and proton and carbon spectra of nuclear magnetic resonance were carried out, as well as elementary analyses CHNO.

The most active compound against brown and white rot fungi were protic ionic liquids- tebuconazole hydrochloride . The fungistatic dose (ED50) for Coniophora puteana reached 0.1 ppm, the fungitoxic dose (ED100) - 5 ppm and lethal dose (LD) - 5 ppm. The fungicidal value of didecyldimethylammonium nitrate(V) with 15% tebuconazole for Coniophora puteana were < 0.73kg/m3 , for Trametes versicolor ranged from 0.81 kg/m3 to 1.76 kg/m3 The investigation of protic triazole-based ionic liquids demonstrated the strongest action against blue stain and mould fungi. The growth of mycelium on the surface of wood samples was inhibited in the amount of application 15 g/m2.

The aim of this study was to determine of penetration capabilities of novel ionic liquids in wood. The penetration depth into Scots pine wood Pinus sylvestris L. of didecydimethyl-ammonium nitrate(V) with 15 % tebuconazole was reached 6.2 mm.

The results of research on the use of ionic liquids- tebuconazole derivatives in protecting technologies for wood-based panels allowed to develop novel particleboard obtained from debarked Scots pine chips. We studied the influence of the type, amounts and the method of application of ionic liquids on standard parameters of panel. The

panels including the amount of 3.0 kg per m3 of hydrochloride tebuconazole (added to the glue) or 4.5 kg/m3 of didecyldimethylammonium nitrate(V) with 15% tebuconazole obtain the resistance to wood decaying fungi and to the growth on surface by moulds.

Keywords: Ionic liquids, triazole, fungal activity, wood, particleboard, protection

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OP105

Protective Nanoparticle Coating Reducing Water Absorption of Wood Species

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The protection of wood against environmental factors of humidity, moisture and water is a primary requirement to enhance application and durability of different species. Common chemical treatments often mask the natural image of wood and more sustainable alternatives should be developed. One technique to reduce water absorption is inspired by the Lotus-leaf effect, where hydrophobic moieties are combined with micro- to nanoscale surface structures. In this research, we explore the possibilities to protect different tropical wood species with a (at least partially bio-based) nanoparticle coating and evaluate the coating performances by means of morphology and time-dependent water contact angle measurements.

An aqueous dispersion of imidized styrene maleic-anhydride (i-SMA) nanoparticles was synthesized under pure conditions or in presence of 70 wt.-% palm oil (i-SMA/oil) with solid contents of 35 wt.-% (pure i-SMA) and 65 wt.-% (i-SMA/oil) respectively. The nanoparticle dispersions were applied as such or mixed with a traditional styrene-butadiene binder, in contact with air-dry wood of six species, namely, Banco (Unidentified sp.), Pseudobombax maximum, Schizolobium parahybum, Machaerium sp., Acacia sp. and Senna sp. with densities between 0.3 and 0.9 g/cm3. The coatings were dried for 2 min at 120°C in a hot-air oven and further stabilized overnight under room conditions.

The initial static water contact angles on non-coated woods varied between 78 and 112° and sharply decreased as a function of the contact time. Evidently, the contact angle cannot be purely related to the wood components (% cellulose, % lignin), as it depends both on surface composition and roughness. In particular, species with highest hydrophobic lignin contents do not present necessarily highest contact angles, as they have highest densities and smoothest surfaces. The pure i-SMA nanoparticles do not form a protective layer, as their porous structure allows for water penetration. On the other hand, the i-SMA/oil coating forms a continuous layer that protects against water absorption and shows a contact angle of 120° remaining constant over time. A thicker coating does not necessarily provide higher contact angles but a thin coating where the original wood structure remains visible, often yields better results. The same stabilization in water absorption was observed with a binder, due to the formation of a closed coating structure. However, the presence of vegetable oil seems to act as a natural binder and is favourable in providing highest contact angle and low contact angle hysteresis. After previous experiences of such coatings onto porous paper substrates, we now also project good potentials to apply these materials to various wood types with good homogeneity, adhesion and protection. The local interactions with cellulose and lignin moieties are presently further investigated with spectroscopy.

Keywords: Wood surface, Protection, Hydrophobicity, Water absorption, Nanocoating.

OP106

Antifungal activity and chemical compositions of cinnamon oil treated rubberwood particleboards

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Application of cinnamon oil as an environmentally-friendly antifungal agent to protect against mold growth (Aspergillus sp., Penicillium sp., Trichoderma sp. and Trichothecium sp.) on rubberwood particleboards was investigated. A solution of cinnamon oil in ethanol was sprayed onto rubberwood particles during the adhesive-particle blending process to achieve various oil loading contents ranging from 0% to 3.5 % (by weight of cinnamon oil to dried wood particles). After forming and pre-pressing, the mats were hot-pressed at 160°C for 10 minutes into 10mm thick panels with target density of 750kg/m3. Mold resistance of the particleboards manufactured was then examined. GC-MS analysis was also performed to identify chemical components of cinnamon oil left within the particleboards. It was found that the minimal cinnamon oil loading content of 2.1% was capable of providing a complete protection against mold growth on rubberwood particleboard for up to 12 weeks under storage condition at 25°C and 100% RH. The antifungal activity of the cinnamon oil treated particleboard was proposed to arise mainly from cinnamaldehyde and eugenol, major components of cinnamon oil, which were largely retained within the panels after the hostile hot pressing.

Keywords: Antifungal activity; cinnamon oil; rubberwood; particleboard

OP107

Small (and quick) is beautiful: understanding and exploiting genetic variation of wood quality in corewood

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Trees are large and long-lived organisms, with pronounced changes of within-stem physical, chemical and mechanical properties, which make their characterization difficult. Tree selection and breeding require the estimation of the degree of genetic control (heritability)

and of the association between traits (genetic correlations), both of which need the use of large sample sizes. Therefore, the main barrier for understanding and exploiting variability is our ability to screen in a cost-effective manner, and as early as possible, the wood quality of large numbers (even thousands) of trees.

In the case of fast-grown species—and from a solid-wood utilization point of view—the poor wood quality (particularly low stiffness and dimensional stability) of the first few rings, affects the profitability and rotation length of plantations. At the University of Canterbury we have redefined the quality problem as improving corewood (arbitrarily defined as the first ten growth rings), which permit us ignore age-age correlations with harvest age and focus on very early (age < 2 years) performance. In addition, we have avoided dealing with unpredictable quantity and distribution of reaction wood by leaning the trees and separately analyzing the properties of 'normal' and reaction wood.

In this paper we discuss the development of tools and technique for early assessments, comparisons with later performance, estimates of genetic parameters from several progeny and clonal tests and the financial effects of corewood improvement. Finally we discuss the results that we have obtained so far when screening the deployment population for Pinus radiata in New Zealand.

Keywords: wood quality, breeding, acoustics, economic evaluation

OP108

Altering wood quality: What can physiology tell us about the limitations?

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Under the pressure of the growing demand for wood products, strategies have been developed to use wood more efficiently. In conifer species where growth is inversely related to wood density, rapid growth rate is the principal criterion for tree breeding and high density only second. Another strategy is to grow wood with more uniform properties along the stem. Wood fulfills many of the functions required for tree survival, such as water, carbon and nutrient transport, mechanical support and storage of water and photosynthates. The evolutionary process has optimized tree structure to maximize survival of the species, but not necessarily the quality properties needed for lumber. Wood structure within and between trees differs due to changing demands on hydraulic efficiency, safety and mechanical performance. The optimum structures for achievement of these essential functions will most likely differ, leading to conflicting demands on wood structure for physiological fitness. Superior wood quality such as high uniformity is not always paralleled by high hydraulic safety and mechanical performance.

Whole ring density is a quite good indirect measure for hydraulic vulnerability in mature conifer wood but not in very young trees. In juvenile conifer wood, other structural traits such as high latewood percentage and thick earlywood cell walls are associated with high drought resistance. Knowledge about these relationships enables early selection of individuals for higher drought resistance.

Breeding for wood quality or growth without understanding the relationships between wood structure and tree survival may result in trees which meet the demands of industry but also in trees that might have poor survival prospects in a changing environment. Global change is expected to increase the frequency of heat waves and drought periods. As a consequence, reduced water availability will directly affect tree survival in many areas. An indirect affect which has to be taken into account is a lower resistance of drought stressed trees against insect pests. Knowledge about the hydraulic performance of trees under drought stress is therefore of utmost importance. This knowledge can be applied to prognosticate survival prospects of tree species or to screen for less drought sensitive clones or provenances. Breeding for high wood quality should be done only if it meets as well the requirements of hydraulic and mechanical safety within a tree stem.

Keywords: conduit wall reinforcement; drought resistance; structure-function relationships; tree breeding, wood density

OP109

Comparing *Pinus radiata* selection for favorable wood properties on clonal two year old nursery trees with analogous 12 year old field trials

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Being able to select amongst clonal genotypes for desirable structural timber product properties at a very early stage has a potential to rapidly accelerate advances in future planting stock quality. In the first part of this study (Apiolaza et al.) we have presented a ranking assessment of 20 different two year old clonal entities, grown in a nursery, based on the wood properties of modulus of elasticity and dimensional stability. In this presentation we will describe our complimentary and more traditional assessment of 12 year old clones of the same genetic entities growing at two typical plantation sites in New Zealand. The first site was steeply sloping ground at an altitude of ~400m. Here five biological replicates of 15 of the 20 clonal entities present were selected for wood quality assessment. The second site was on flat land close to sea level; here five biological replicates of 19 of the 20 clonal entities were selected for assessment. At both sites inventory measurements of diameter were made and time of flight acoustic velocities were recorded for each of the trees. Finally, a 12 mm bark to bark increment core was taken from each of the individual trees, taking great care to obtain the pith in each core. Cores were then sent to SilviScan for measurements of density, microfibril angle and estimation of modulus of elasticity. Standing tree measurements of time of flight acoustic velocity, and the resulting rankings, will be compared to those made on the younger clones. Rankings based on the Silviscan data corresponding to two years old will be presented and compared between the two sites and to the nursery material of our previous study. A further assessment will be made on the Silviscan data corresponding to ten years old, producing an assessment more typical of that used by tree breeders at reproductive maturity. The successfulness of early selection compared to selection at the age of reproductive maturity, plus the effect of environment will be discussed.

Keywords: Radiata pine, clones, breeding, wood quality

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OP110

Variation in the wood properties of Sitka spruce: implications for wood processing and forest management

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Radial and longitudinal variation in wood properties has a major impact on wood utilisation, particularly wood from conifer forests grown on relatively short rotations. Trees grown in these forests are generally characterised by their high juvenile wood (corewood) content. Compared with mature wood, juvenile wood has high microfibril angle (MFA), low density, low modulus of elasticity (MOE), high longitudinal shrinkage, and higher compression wood content. Solid timber cut from the juvenile core has poorer strength properties and higher propensity to distort.

In this paper we will present the current state of knowledge on the inter- and intra-tree variation in selected wood properties of Sitka spruce (Picea sitchensis) grown in the United Kingdom and Ireland. Sitka spruce is the predominant commercial species in these two countries and is normally grown on 35-45 year rotations. On more wind-exposed sites forests are often managed on a no-thin basis resulting in a high proportion of juvenile wood. Until recently, the major focus of wood quality research was wood density, but more recent research has investigated the radial variation, and to a lesser extent longitudinal variation in MFA, MOE, bending strength and distortion. These studies have sampled trees from a range of sites of different ages and silvicultural regimes. Analysis of the data from these studies using mixed effects models has enabled the intra-tree and inter-tree variation to be quantified.

In these studies structural timber has also been produced, strength graded and mechanically tested. Because the grade that Sitka spruce structural timber can achieve is limited by its MOE, management practices that result in even small decreases in this property could have a significant effect on the yield of structural timber produced by a sawmill and hence its profitability. While segregation in the forest and the sawmill, for example using portable acoustic tools, and alterations to sawmill cutting patterns can reduce the amount of timber rejected during the strength grading process, it is important that forest managers have an understanding of how their actions affect end-product quality and implement practices that will improve it.

Keywords: Sitka spruce/Inter tree variability/Processing/Solid wood

OP111

The process of vessel formation in relation to leaf phenology and water conduction in deciduous hardwood species

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For trees growth, the supply of water is essential. In hardwood species, vessel plays an important role in the water conduction. Morphology of vessel elements such as the number or lumen area is closely related to water availability of trees. It is important to form vessel network, which is constructed by continuously vessel element connection for axial direction, for transporting water from roots to leaves. In order to understand the mechanism of tree growth and adaptation to environment of trees growth, we need to reveal the process of vessel network formation.

In deciduous ring-porous species, it is reported that the current earlywood vessels mainly conduct water. To understand the process of earlywood vessel network formation, it is important to reveal the relationship between the process of vessel formation and leaf phenology in the first stage of growth season because it is related to the start of water conduction by earlywood vessels.

In this study, we compared the process of first earlywood vessel formation with leaf phenology and seasonal change in the water conduction pathway in three ring-porous species (Quercus serrata, Robinia pseudoacacia and Castanea crenata). The study trees were felled down 3-14 days intervals and samples for the observation of vessel formation were taken from various height of the stem. In the same intervals, leaf phenology was recorded and dye injection experiment was conducted to observe the water conduction pathway. In three species, differentiation of earlywood vessel started at entire the trunk before bud break. In this period, dye was distributed at the previous latewood zone. Water conduction by current earlywood vessels started when the leaf flush and the start of shoot elongation were observed and then foliation was promoted. Water conduction by first current earlywood vessels might not contribute to first shoot activity, such as bud swelling and bud break, but it might contribute to leaf expanding and maturing.

Keywords: deciduous hardwood species; earlywood vessel formation; leaf phenology; water conduction

OP112

Particle boards from hot-water extracted softwoods and hardwoods

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Facing a growing demand for energy and chemical resources, independent from crude oil, biomass will play a key role in developing new supply concepts. One way might be a value added chain for forest products, and their use in forest-based biorefineries. The objective of this work was to produce quality particle boards from raw materials that have been hot-water pre-extracted. The purpose behind was to recover mainly hemicelluloses from the wood particles to obtain by-products for e.g. bioethanol or other value-added chemicals.

Wood particles from four different species were hydrothermally treated before single-layered particles boards were made. Extracts were chemically characterized. Physical and mechanical property tests were carried out according to standards. Results show that it is feasible to produce high quality particle boards from hot water extracted wood particles. Boards produced from material with over 16 % weight loss after extraction showed significantly lower thickness swelling, while internal bonding has dropped. There was also a strong species-specific effect, meaning hardwoods responded different compared to softwoods. Bending strength was slightly lowered, while stiffness and formaldehyde content both increased.

The lower mechanical performance still met the required industry standards. Based on the obtained results an integrated biorefinery for an existing particle board plant seems feasible. Further aspects such as energy efficiency, up-scaling issues and an economic assessment need to be considered in future research.

Keywords:wood-based composites, multiple-used, biorefinery, thickness swelling, strength properties, extractive

OP113

Evaluation of gluing process in strand particles

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The adhesion process basically depends on the interaction between adhesive and wood. The adhesive is the most expensive component on panel production. Therefore, the optimization of its use is greatly important. Clarify the behavior of adhesive distribution on wood material is one the factors that may help on the characterization of the gluing process.This work aimed to evaluate the gluing quality of strand particles and the influence of such process on the final gluing quality of OSB panels.

Six hundred and fifty eight particles had their dimensions measured and mass determined before and after gluing process. The variables glue amount (g/m^2) and effective amount of adhesive applied (%) were evaluated. Phenol-formaldehyde adhesive was applied at 6, 9 and 12% in Pinus oocarpa and Eucalyptus grandis particles. The perpendicular tension test was conducted in the panels produced.

The gluing process of strand particles in laboratory is heterogeneous, which makes the analysis of the influence of the processing variables on the effective amount of adhesive applied and glue amount difficult. It was verified that OSB panels made from Pinus oocarpa species presented lower glue amount per particle in relation to Eucalyptus grandis species. Increases in glue amount of particles are related to increases of perpendicular tension strength.

Keywords: glue amount; perpendicular tension; adhesive; gluing.

OP114

Effect of Waste Melamine Impregnated Paper on Properties of Oriented Strandboard

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The objective of this study was to evaluate some of the properties of oriented strandboard (OSB) panels manufactured using waste melamine impregnated paper (WMIP) as filler. Poplar (Populous euro x Americana) strands and shredded WMIP, which was used up to 50% with increment of 10% based on oven-dry wood weight in the core layer, were mixed using urea formaldehyde as binder. A total of six three –layer experimental panels with dimensions of 40 cm by 40 cm by 1.0 cm with an average target density of 0.55 g/cm3 were manufactured. Mechanical and physical properties including modulus of elasticity, modulus of rupture, internal bond strength, thickness swelling, and water absorption of the samples were determined according to EN 310, EN 319 and EN 317, respectively. Based on the results of this work, the bending properties and internal bond strength values of the samples increased with increasing WMIP amount in the panels. In addition, thickness swelling and water absorption characteristics of the samples having WMIP content were lower than those of control panels. It appears that WMIP may have potential to be utilized in OSB without having any adverse influence on their strength properties.

Keywords: Waste melamine impregnated paper; oriented strand board; urea formaldehyde; strength properties; physical properties

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OP115

Performance of wood-CFRP composite in variable temperature and moisture content conditions

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Building industry in case of new constructions or refurbished or repaired ones utilizes wood as a base material. New materials, such as graded wood, LVL or other composite boards or beams provide sufficient reliability for the load capacity and predicted lifetime of the constructions. When comes to ancient ones, the problem may not be that easy to solve, because of conservational restrictions or simple problems in disassembly of complex structures. Rapid development of materials engineering provides many possibilities for designers, constructors and builders. Lately, material eagerly applied by both building contractors and conservators is FRP (fiber reinforced plastic) composites. Gross of market share belongs to carbon fiber composites, especially CFRP tapes. This is caused by relatively high CFRP strength parameters and low specific gravity, advantageous especially with ancient structures, because of low additional load applied. In concrete structures, CFRP tapes are commonly used, problem of application of these tapes to wood constructions is relatively new and not well described.

Because of CFRP designation for building and structures, it was decided to test influence of variable moister content and temperature on the strength of the composite based on pine wood, epoxy resin and CFRP tape. Variable conditions of moisture content and temperature are selected to simulate real-life conditions of rafter framing. Research will be performed within the moisture content span of usual rafter working conditions, and temperatures characteristic to central European climate conditions. Strength testing will contain influence of mentioned factors on modulus of elasticity and bending strength of pine-epoxy resin-CFRP composite.

Keywords: composite, bending strength, modulus of elasticity, variable temperature conditions, variable moisture conditions

OP116

Properties of Medium Density Fibreboard (MDF) from kenaf (*Hibiscus cannabinus* L.) core as affected by different refining conditions

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The objective of this investigation was to evaluate the properties of fibers and medium density fibreboard (MDF) from kenaf core (Hibiscus cannabinus L.). Kenaf core was refined at various refining pressures (3, 5 and 7 bar) with different refining times (3 and 5 minutes). The effect of refining pressure and time on the properties of the fibres and properties of MDF were evaluated. The resulting fibres were blended with 12% of Urea-Formaldehyde (UF) resin and consolidated into 700 kg/m^3 density board. The water absorption (WA), thickness swelling (TS), modulus of rupture (MOR), modulus of elasticity (MOE) and internal bonding (IB) were determined based on MS Standards 1787: 2005. This study showed that refining pressure had a significant effect on the fibre properties, however refining time only effect the length of the fibre, but has no apparent effect on the fibre width, aspect ratio and MDF properties. Low refining pressure produced long fibre and with high WA, TS, MOR and MOE but low in IB value, while high refining pressure produced short fibre with low WA and TS, but high MOR, MOE and IB value. The optimum refining condition was at 7 bar and 5 minutes with the fibre length of 0.81mm, aspect ratio of 23.4 and the MDF recorded MOR of 30.3 MPa, MOE of 3619 MPa, IB of 0.66 MPa, WA of 14.6% and TS of 63.2%.

Keywords: Refining Pressure, Refining Time, Physical Properties, Mechanical Properties.

OP117

Tri-terpenoids detected from fruiting body of *Antrodia cinnamomea* and leaves and stem of *Cinnamomum kanehirae* Hay

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Antrodia cinnamomea, a well-known folk medicinal fungus found in Taiwan only, has drawn much concerns and attentions in recent medical researches due to its large amount of tri-terpenoid production along with its legendary therapy. It is one of brown rot fungi and specifically parasites on the inner wall of decayed hollow trunk of Cinnamomum kanehirae Hay.

The fruiting body of A. cinnamomea is precious and expensive since it grows relatively slowly and is less available. It may be of great interest to investigate whether A. cinnamomea and C. kanehirae have the extractives in common. The fruiting body of A. cinnamomea and leaves and stem of C. kanehirae were extracted and analyzed.

The results indicated that some tri-terpenoids, sulfurenic acid, eburicoic acid and dehydro-eburicoic acid from the fruiting body of A. cinnamomea and one tri-terpenoid, cerevisterol, from the leaves and stem of C. kanehirae are identified. A. cinnamomea has more extracted constituents than leaves and stem of C. kanehirae and all the samples have common constituents respectively detected in each specific retention time between 10~15 min based on high performance liquid chromatograph.

Keywords: Antrodia cinnamomea ; Cinnamomum kanehirae Hay; tri-terpenoids, fruiting body

OP118

Green deserts: novel afforestation technologies in semiarid environments

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The LIFE project "Green Deserts" aims to demonstrate the technical and economic feasibility of the application of an innovative technology to sowing and tree planting in semiarid areas of the Iberian Peninsula and in areas degraded by fire or mining.

The "waterbox" is a smart polypropylene container with a lid, on whose surface there is a series of diagonal grooves which collect water from rain and moisture from air by condensation. Its 15-litre deposit provides water to the plant during its first year by means of a wick, with no additional source of irrigation. The wick penetrates the soil under the box, slowly dripping water to the plant root system. As the plant grows, its roots go deeper and deeper into the soil, eventually finding its own water source. Once this happens, the box can be removed. The vessel design also prevents water evaporation from its top, creating a microclimate in its interior that protects the plant from sunlight, wind, frost and pests.

The results of experimental tests conducted in 5 Spanish provinces (namely Valladolid, Leon, Zamora, Zaragoza and Barcelona), have yielded mean survival rates above 90% in those seedlings equipped with waterbox, without significant differences amongst the species under test, while 78% of the control group planted without any specific device had died after one year. This allows an environmental and economic improvement by avoiding the need for plant replacement.

These results allow the application of this innovative technology in very diverse fields such as agriculture, reforestation and restoration of ecosystems, and could offer an interesting solution for seeding or planting in places where irrigation is difficult and expensive to conduct.

Keywords: waterbox, green deserts, forestry, arid, irrigation control, survival.

OP119

New Wood Derived Materials – Potentials

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There is a high interest of replacing oil based materials with renewable, bio-degradable ones. Here the utilisation of the major wood components; cellulose, lignin and the hemicelluloses, glucomannan and xylan comes into special focus. Minor wood components from bark or extractives can certainly be attractive for speciality products but can not serve as replacements for the majority of oil based polymer materials.

Cellulose has traditionally been used (apart from pulp) in producing regenerated materials as well as chemical derivates thereof. Improvement of the dissolution and reactivity of the cellulose is here a key issue in making way for more environmentally friendly processes. Nanofibrillated cellulose has acquired exciting interests and energy efficient ways in its production seems feasible in the near future. As a material the nanofibrils possesses high interest as barrier materials or as aerogels in filters etc. The material production in larger scale is though a major development issue due to the high water holding capacity.

Hemicelluloses are of interest as oxygen barrier films, showing excellent properties. One drawback is the relatively low molecular weight of the wood xylan and glucomannan mainly reflected in a too high brittleness. Utilising these hemicelluloses in combination with cellulosic reinforcements or employing cross-linking strategies for increasing ductility of the films may be one way. Another possibility is to modify the xylan by grafting, for example with PLA, into a material with thermoplastic behaviour.

Lignin derived from wood materials generally represents a rather heterogeneous substance. The LignoBoost process has here made it possible to produce larger quantities of lignin more cost efficiently and with less impurities. High interest has arisen in lignin utilisation for carbon fibres. Other promising potential uses of kraft lignin are as activated carbon and for replacement of phenol formaldehyde resins.

Large challenges still exist in the development of competitive materials derived from wood. The progress is however promising.

Keywords: Barrier films; cellulose; hemicelluloses; lignin; nanofibres

OP120

Increasing sub/tropical eucalypt timber plantation profitability by value adding to thinnings

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New processing options and end-uses are being developed to create larger, more stable and higher-value markets for plantation-sourced wood. To justify continued expansion of Australia's current hardwood plantation estate it is becoming necessary to develop higher value end-uses for, both pulpwood and smaller 'sawlog' resources. To improve its profitability and win new markets, the industry needs to use stems currently culled during thinnings as they have little or no economic value.

This paper describes current Australian R&D into value adding to improve economic returns from small diameter (12 - 25 cm), 8–15 year old sub/tropical hardwood plantation thinnings. The product focus is raised far above the pulpwood commodity baseline to maximise the value of the fibre harvested. Small spindleless veneer lathe technology has been used to optimize the processing of this resource. Results are clearly indicating that the early age hardwood plantation resource, previously thought to be unusable, can be processed to yield valuable structural grade veneer. Plywood and Laminated Veneer Lumber (LVL) products have been manufactured and tested utilising multiple construction strategies. New market-relevant options, such as innovative hybrid/composite pole products, arched and straight light structural round members and hardwood veneer-based engineered structural products, are discussed and compared with more traditional sawing approaches. These offer economically viable avenues to more profitable operations in smaller-scale plan-

tation resources and using smaller log sizes than required for conventional peeling, pulping and sawmilling uses.

Keywords: Hardwood, Thinning, Structural Round Members, Veneer-based engineered structural products, Sawing, Pole.

OP121

Physical, mechanical and biological properties of Australian Red cedar particleboards

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Australian red cedar (Toona ciliata var. australis) has stood out as a planted forestry species in several tropical and subtropical countries. Australian red cedar wood has several uses such as furniture, decorative veneer, civil construction, boats, floorings and others. However, it is important to consider that any wood processing such as veneering and sawing always results in the production of a great amount of residue. Particleboard is a generic term for panels manufactured from particles of lignocellulosic materials, which are combined with a synthetic adhesive or other suitable binder. This work aimed to evaluate particleboards produced with different compositions of Australian red cedar wood by determining their physical mechanical and biological properties.

18-year old Australian red cedar obtained from a commercial plantation was used. The work was divided in four stages: 1) Evaluation of the chemical properties of red cedar wood in order to verify its potential for particleboard production; 2) Analysis of the physical and mechanical properties of particleboards made from wood residues of Australian red cedar produced with different target densities of 0.65 and 0.70 g/cm^3 and different adhesive contents, 6 and 9%; 3) Selection of the best processing variables for the production of particleboards made with Australian red cedar mixed with Eucalyptus sp. and Pinus sp. woods at 50% proportion; 4) Study of the resistance of the Australian red cedar wood and particleboards to dry termite attack, using Pinus sp. wood as a control treatment.

The following results were found: 1) Australian red cedar presents a great amount of extractives compared to woods often used for particleboard production, as the average value found was 13%. However, average lignin content was low, 24%; 2) Particleboards made with target density of 0.70 g/cm^3 and 9% urea-formaldehyde presented the best results for physical and mechanical properties; 3) For physical properties, particleboards made from 100% Australian red cedar were similar to particleboards made from 50% of this species and 50% Pinus sp. and both had better results than particleboards made from 50% Australian red cedar and 50% Eucalyptus hybrid; 4) Australian red cedar wood presented much higher resistance to dry-termite attack than Pinus sp. wood. The inclusion of Australian red cedar wood resulted in resistant particleboards.

Keywords: Toona ciliata; biodegradation; target density; adhesive content.

OP122

Suitability of pulp production from Salix excelsa (willow) clones

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In this study, fiber morphology properties of Salix excelsa (willow) clones were studied in the view of suitability for pulp and paper industry. The second aim of this preliminary study was to reduce the pressure on forest resources and meet the demand alternative sustainable raw material for pulp.

Clones amples were supplied from The Poplar and Fast Growing Forest Trees Research Institute Izmit-Turkey. The discs which were cut approximately 4 cm diameter and then were divided into group three each ages from earlywood to latewood. These individually were cut chip woods as earlywood and latewood. According to Franklin method were easily obtained mikroscopic preparations. Salix excelsa woods from 64/12 and 84/28 clones grown in Turkey were measured fiber dimensions such as, fiber length, fiber width (diameter), lumen diameter and cell wall thickness. Also, relationships between fiber dimensions determined as felting power, elasticity, rigidity coefficient, Runkel classification, Muhlstep ratio and F factor. The effect of these on pulp strength properties were discussed. As known that there is strong relationships between the strengths of paper and morphologic structure of wood fiber.

Willow clones (84/28 and 64/12) fibers are of mean length with 776.24 µm, 853.90 µm. They also have a mean value of fiber width 18,89 µm; 20.77 µm. Consequently, according to the fiber morphology values it was found that pulp from Salix excelsa 64/12 and 84/28 clones wood would be suitable for use in paper board and corrugated board production.

Keywords: Salix excelsa clone; willow; fiber morphology; pulp; fiber dimension

OP124

Assessment of Wood Quality and Fibre Properties in Intensively Managed Douglas-fir Plantations using NDT Tools

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Current knowledge on the influence of intensive plantation silviculture on wood quality and fibre properties of conifers in the Pacific Northwest is limited and fragmented. Integration of wood quality into growth and yield simulators is also impacted by traditional methods of assessing wood quality being time consuming and expensive. Routine collection of fibre properties information using NDT technologies has the potential to improve predictions and understanding of contributing factors.

Douglas-fir is one of the major North-American commercial species. Intensively managed plantations are becoming increasingly important for the forest industry given the shift from the old-growth and unmanaged second-growth forests. Such plantations produce wood primarily intended for structural applications.

In our study we assessed wood quality and fibre properties with NDT tools at five long-term LOGS (Levels-of-Growing-Stock) installations, three in the United States and two in Canada covering a latitudinal gradient between 43-50° N. At each location we sampled plots with three levels of stocking: unthinned control, light thin (30% basal area removed), and heavy thin (70% basal area removed). Acoustic velocity in standing trees was measured with time-of-flight ST300 (FIBRE-GEN). Increment cores were collected and analyzed using X-ray densitometry and near-infrared spectroscopy. Ring and density profiles were also collected using the Resistograph (IML). We developed predictive models linking these variables to site and thinning effects. Results indicated that both acoustic velocity and wood density decreased with increasing site index across the productivity gradient. Acoustic velocity increased for higher stand densities and smaller diameter trees, while variation in acoustic velocity seemed to have increased with larger tree diameter. Results also indicated that the influence of intensive silviculture on fibre properties may have been site-specific.

Increasing implementation of NDT technologies will allow for quick and efficient evaluation of forest resources. Optimal segregation of individual trees, stems and logs for high value products has the potential to influence the operational value chain.

Keywords: NDT tools; Douglas-fir; intensive plantations; acoustic velocity; wood density.

OP125

How Environmental Temperature Affect Acoustic Assessment of Standing Trees and Green Logs?

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Previous research has proven the concept of acoustic wave propagation methods for evaluating wood and fiber quality in trees and logs in field settings. More recent commercial availability of field-ready tools has brought the operational assessment of acoustic velocity as a measure of stiffness into forest management and log and lumber processing sectors of the industry. The use of such technologies allows significant values to be captured through better decision making, allocation of resource to highest value users, and application of best processing methods dependent upon log-by-log measures. As commercial acoustic equipment is implemented in the field for such applications, one has to consider the influence of environmental temperature on acoustic velocity–a key parameter for wood property prediction. Our laboratory study on red pine (Pinus resinosa) small clear specimens showed a significant change in acoustic properties of wood as wood temperature changed from –45 to 35 °C. A dramatic shift in acoustic velocity and energy loss was observed when the wood temperature changed to above or below the freezing point. Our recent field investigation in a 45-year old red pine plantation stand indicated that the ambient temperature had a significant effect on acoustic velocities of trees and logs in winter when temperatures were below freezing point. Acoustic velocities increased dramatically as the ambient temperature dropped to below 0 °C, but then the change became less significant when the temperature decreased to below –2.5 °C. Above freezing point, acoustic velocities were found less sensitive to the ambient temperature changes. From a practical standpoint, acoustic velocities of trees and logs measured at different climate or different seasons can be adjusted to a standard temperature if measurements are conducted well above freezing temperatures or well below freezing temperatures. However, measurements conducted around freezing temperatures could cause complications in making temperature adjustments. Users should try to avoid conducting field acoustic testing when the wood temperature is around the freezing point.

Keywords: Acoustic velocity, ambient temperature, logs, wood temperature, standing trees.

OP126

A Portable NMR Imaging System for in-situ Measurements of Living Trees: The Tree Hugger

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Magnetic resonance imaging (MRI) can non-destructively and non-invasively characterise moisture and moisture transport in timber. However, to date, it has found only very limited application outside the laboratory where it has considerable potential for time course studies of living trees during growing cycles.

We present the Tree Hugger, an open access, 1.1 MHz 1H MRI magnet and spectrometer system that has been specifically designed for the imaging of living trees and felled timber drying studies. It is transportable and has an open access space of 21 cm. The Nd-FeB magnet is supported by a carbon fibre frame with a combined weight of 55 kg. The feasibility of imaging living trees, in-situ, using the Tree Hugger is demonstrated as well as its use as tool to investigate the effects of the local environment on the water content and water distribution in the tree

We present MRI results from a study of a bird cherry (prunus padus) tree over a summer growth cycle and preliminary drying studies of sapwood timber. The magnet was left continuously in-situ around the tree for three months during the summer 2011 and taken to site periodically at other times. Examples of the MRI experiments conducted include measurements of water distribution in the tree, the daily water cycle of the tree and seasonal changes in the tree water content and water transport. We show how these MRI measurements correlate well with other indicators such as relative humidity, temperature, soil moisture, solar radiation and conventional thermal dissipation sap flow measurements. For the drying study a high temperature probe was constructed for drying within the magnet sample space.

Keywords: nuclear magnetic resonance (NMR); magnetic resonance imaging (MRI); wood; tree; water; non-invasive testing;

OP127

Non destructive evaluation procedure for structural grading of sawn timber: preliminary works in Spain

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Good results in terms of material properties evaluation using non destructive techniques (NDT) have been achieved since decades ago. In Spain, during the last ten years, several research works conducted by different research groups using NDT for the evaluation of timber properties have been carried out. Those research studies have concluded different methodologies for Spanish timber species and proposed linear regression equations between non destructive values and mechanical properties.

To establish a common procedure within the NDT field for the use of these techniques in the evaluation of large gross cross section timber properties in Spanish species is necessary. The main objective of this paper is to present the preliminary works conducted in order to achieve this objective.

NDT parameters have been measured in the main structural Spanish sawn timber species: Scots pine (Pinus sylvestris L.), laricio pine (Pinus nigra Arn. Ssp. salzmannii), radiata pine (Pinus radiata D. Don.), maritime pine (Pinus pinaster Ait.) and sweet chestnut (Castanea sativa Mill.). Commercial equipments and techniques applied were: Sylvatest Duo and Trio (ultrasonic wave technique), Microsecond Timer (stress wave technique), Hitman and PLG (vibration analysis technique), Pilodyn 6J Forest (penetration resistance) and SWRM (screw withdrawal force technique).

Compilation of NDT results of those species and equipments is being made. A data sheet to collect all the data has been designed taking into account tests procedures and adjustment factors as: moisture content, temperature, slope of grain, length… Some of the obtained results and statistical analyses are presented.

Additionally, a NDT preliminary protocol is presented in order to standardize the test procedures and to homogenize the data analysis.

Keywords: ultrasonic wave; stress wave; vibration analysis; penetration resistance; screw withdrawal force technique; large cross section; sawn timber; Spanish species

OP128

Nondestructive Testing of Wood in China

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Nondestructive testing(NDT) of wood orientated in the middle of 20th centrury and it was getting popular since the 21st century in China. NDT of wood applied in aspects like wooden structure testing. standing tree testing, and wood product quality evaluation. Most of wooden structures involved NDT are from the historic buidlings. Standing trees involved in NDT are roadside standing trees and standing trees in the forest. Wood products involved in NDT are lumber, log and furniture.

The methods of wood NDT employed in China includes X-ray, stress wave, ultrasonic, pilydon, drill resistance, infrarded, and vibration. Among them, the accoustic methods, vibration, drill resistance and X-ray methods dominate most, around 90% of publications stated in these fields. Besides some studies regarding with NDT for wooden structure in historic buidlings or houses, most of NDT of wood concentrate on works in the laboratory testing. Only a few application of NDT of wood exsits in industry.

The institutions involved in NDT of wood in China include mainly the followings: Northeast Forestry University, Wood Industry Research Institute from Forestry Academy of China, Beijing Forestry University, Nanjing Forestry University.

The most important issue for NDT of wood in China in next decade is how to apply the techniques of NDT-Wood in industry, forest management and park or garden management as more as possible. The new testing equipment of NDT-Wood is also important task for the Chinese scholars nad researchers involved in this field.

Keywords: Nonsetructive testing, wood, China, development status, trend.

OP129

A portable method to estimate wood basic density from increment cores using spectroscopic techniques

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We will report the use of spectroscopic techniques for the measurement of basic wood density in Eucalyptus nitens, using samples in a state similar to that found in the field; the aim is to test the protocol of measurement hoping in the future to extend the current design to a portable instrument that could eventually estimate the wood characteristics of a standing tree. Model calibration was carried out using wet cores taken form eight-year-old trees. Each sample was scanned with Raman and near infrared (NIR). Several pre-processing techniques were applied to the spectra in order to obtain the best possible prediction models for wood basic density. The potential of NIR for this purpose was demonstrated. But Raman spectroscopy proved to be unfit for the application, yielding extremely low correlation values and models with low predictive capabilities.

Keywords: NIR, Raman, solid wood, cores, basic density, spectroscopy

OP130

Optimization of extraction of polyphenolic compounds from *Eucalyptus globulus* bark using Response Surface Methodology

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The bark of Eucalyptus globulus is one of the most important by-products of pulp and paper industry. Due to its chemical composition, bark is a promising source of polyphenolic compounds that could be extracted with polar solvents such as ethanol and water. Due to their properties, polyphenolics can find several applications as anti-oxidant, as anti-microbiologic additive, as precursors for chemical industry or as source of phenol group, for instance, for adhesive production. The integration of low-cost processes and technologies to increase bark's value is a key step for implementing the biorefinery concept in the pulp and paper industry.

The overall aim of this work is to increase the bark chain-value by the preferential extraction of polyphenolic compounds with antioxidant activity. Extraction experiments were planned according to Box-Behnken design with three central point replicates in order to evaluate the effect of the temperature, time of extraction and the ratio ethanol/water on the dependent variables: total phenolic content (TFC, as gallic acid equivalent, GAE), antioxidant activity (as mmol of acid ascorbic equivalent, AAE) and proanthocyanidins (as mimosa extract equivalent, MEE). The Stiasny number and the co-extracted carbohydrates were also quantified. The obtained responses were adjusted to non-linear mathematical equations and the optimal operating conditions were determined.

A maximum of 32% of TFC in the extract has been foreseen for 264 min, 82.5oC and 52% of ethanol corresponding to about 2% of bark weight. These conditions are close to those ones leading to maximum values of compounds with antioxidant activity (2.1 mmol AAE/g extract) and proanthocyanidins (14% wMEE/wextract). The experimental values were found to be in good agreement with the predicted values, with a satisfactory relative error (0-10%). The amount of total sugars in the extract and the Stiasny number predicted were 22.7% and 37, respectively.

Keywords: Bark, E. globulus, antioxidant activity, extraction, experimental design, phenolic compounds

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OP131

Biochemical conversion of Pulp and Paper Mill streams to valorize their carbohydrate content

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Lignocellulosic biomass is an interesting and viable feedstock, since it is a low-cost, renewable, readily available and abundant raw material. The pulp and paper industry is a good example of a lignocellulosic feedstock biorefinery, producing pulp, paper and energy from biomass wood. Other production processes can be integrated to valorize the lignocellulosic biomass used in the industry and produce value-added products, in addition to their mainstay products. By these means pulp and paper mills can increase their incomes and competitive advantages and decrease environmental impacts.

The aim of this study is to evaluate two different approaches to optimize the lignocellulosic biomass conversion in bioproducts (e.g. bioethanol), integrated in a Portuguese pulp and paper mill. In the kraft process to produce pulp from Eucalyptus globulus wood, nearly 50% of wood hemicelluloses are dissolved in the black liquor and burned in the recovery plant. Instead, a pre-treatment can be introduced before the kraft cooking stage to almost extract that amount in order to increase their value. Once extracted, hemicelluloses can be further hydrolysed to generate monosaccharides that can be used as carbon source in a fermentation process. The second approach consists in the valorization of the worthless primary sludge obtained in the pulp and paper mill. It is recovered from the first stage of the wastewater treatment, at the primary clarifier, and is commonly discharged in landfills. A useful primary sludge management and valorization includes its bioconversion into other value-added products, e.g. bioethanol, taking advantage of its carbohydrate content. This potential feedstock is composed of cellulosic fibers lost during the pulp processing stages. However, the presence of ashes (calcium carbonate) inhibits the primary sludge enzymatic hydrolysis to generate fermentable sugars, being mandatory a previous treatment. Several treatments had been performed to reduce the amount of ashes, including acid addition. This treatment has, however, the disadvantage of CO2 release.

Hemicelluloses pre-extraction was carried out by auto- and acid-hydrolysis of wood chips producing liquid extracts enriched in xylose and oligosaccharides. For both liquid extracts and treated primary sludge, enzymatic and chemical hydrolysis had been applied and compared, regarding monosaccharides yield as well as the following step of fermentation. In general, the production of fermentable sugars was enhanced when enzymatic hydrolysis was used, attaining a total conversion for hemicellulosic liquid extracts (mostly xylose) and yields of 90% for treated primary sludge (mostly glucose). Pichia stipitis was used to ferment the available monosaccharides resulted from both lignocellulosic resources. Saccharomyces cerevisiae was also tested in the fermentation of primary sludge monosaccharides. Ethanol concentrations of 7-10 g/L were obtained so far, with sugar-to-ethanol conversion up to 98%.

Keywords: Lignocellulosic biomass; valorization; enzymatic hydrolysis; fermentation; ethanol; primary sludge

OP132

The Application of Green Extraction Technologies in the Valorisation of Forest By-Products

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Forestry is primarily used for the supply of timber or as a raw material for paper but in the processing of the timber from felling to the paper making process there are by-products created at every stage. Of these by-products tree bark and leaves or needles contain a vast array of secondary metabolites including terpenes, flavonoids, phenols, alkaloids, sterols, waxes, lipids, tannins, resin acids and carotenoids.

Extraction of these using conventional solvents results in a complex mixture that requires considerable downstream processing to obtain any useful products. The application of a tuneable solvent such as carbon dioxide either in its liquid or supercritical state can result in the highly selective extraction of classes of compounds that can be used without further fractionation. For the more polar molecules co-solvents such as ethanol can be added to the carbon dioxide stream to increase polarity and therefore extract more polar or larger molecules.

Within integrated forest biorefineries, particularly those that generate ethanol by fermentation of hemicellulose, carbon dioxide will be generated as another by-product. This is very pure carbon dioxide can be easily captured, dried and liquefied for use within the biorefinery as an extraction solvent.

The practical application of this technology with examples of extractable secondary metabolites from commercial timber species and the integration of this within the forest biorefinery will be addressed in this lecture.

Keywords: Extraction, by-products, secondary metabolites, carbon dioxide, biorefineries

OP133

Production of *Pinus brutia* Bark Tannin and Its Application as Wood Adhesive

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Nowadays, the forest is not perceived merely as a site of trees but it is seen as a dynamic and renewable natural resource, providing different products and services to various living species.

The total forest area of Turkey accounts to 21,2 million hectares and covers 27,2% of the country soils. Highly rich in biological diversity, the forests are composed of approximately same ratio of softwoods and hardwoods. The Turkish pine (Pinus brutia) is the most widespread softwood species with 5,42 million hectares area. The area of P.brutia is close to 50% of the total softwood area and 25% of the total forest area in Turkey.

Turkish pine wood has been used commonly in woodworking industry, the main utilization areas being fiberboard, chipboard and paper production. However, the bark is considered as a waste product and does not have any utilization area. In the present paper, it was aimed to product bark tannins from Turkish pine along with two other native species, oriental spruce (Picea orientalis) and cedar of Lebanon (Cedrus libani). For this aim, the chemical compositions of the barks were determined and tannin production was realized at various conditions.

The condensed tannin content of the bark is an important parameter in commercial tannin adhesive production. The preliminary tests showed that the condensed tannin quantity in Turkey pine was higher than other two species. Therefore tannin production was realized in Turkey pine. To compare Turkey pine tannin with commercial tannins quebracho and mimosa tannins, the three tannins were mixed with formaldehyde in certain ratios and with resulting adhesives fiberboards were produced. The fiberboards were then subjected to chemical, mechanical and physical tests. The test results from Turkish pine tannin showed values close to commercial tannins, even some values were better. However, in all boards tested, the thickness increase and water uptake values were somewhat higher than the international standard values. This drawback is thought to be eliminated by incorporation of water repellents into the adhesive formula. In hardener formulation the best results were obtained with hexamethylenetetramine (HMA) in Turkish pine tannin while in quebracho and mimosa tannins paraformaldehyde gave best results.

Keywords: Pinus brutia, tannin, bark, fiberboard, hexamethylenetetramine

NOP134

New materials from cellulose fibres. A contribution to the implementation of the integrated biorefinery concept

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In recent years there has been an increasing interest in the search for renewable and sustainable sources of chemicals, materials and fuels, within the biorefinery concept. Following this trend, well established industrial sectors such as the pulp and paper industry are seen nowadays as the basis for the refineries of the future, the so called biorefineries, were lignocellulosic materials will be processed to produce platform chemicals to fulfil society needs in a sustainable way.

Among the lignocellulosic components, cellulose is considered as the most promising alternative to fossil resources, mostly because of its natural abundance, ubiquity and renewable nature, and also due to its unique properties. Although paper is still the main and most valuable final product of the pulp industry, it is essential to search for new and more valuable applications of cellulose fibers, which could be an important contribution to the valorisation of this raw material.

In recent years, we have been studying the heterogeneous chemical modification of cellulose fibers in order to produce materials with totally different properties, while keeping most of the bulk mechanical properties of the pristine material. Examples include (i) the

preparation of cellulose fibers derivatives with surface hydrophobic properties by the modification with fatty acids, that can be applied as reinforcing agents in composites with polyolefin and biodegradable polymeric matrices and with and (ii) derivatives with superhydrophobic/omniphobic properties by the surface modification with perfluorinated reagents. , , These studies have also considered the use of environmentaly safer reaction conditions using for example Ionic liquids as reaction media.

Furthermore combination of cellulose fibers with other polysaccharides possessing unique properties, like chitosan and other emerging natural materials such as bacterial cellulose and nanofibrillated cellulose, also opens wide perspectives on the preparations of papers with original features, as well as a wide range of promising functional materials such as for example transparent nanocomposite materials with promising applications in transparent electronics, , , with barrier properties, in membranes for controlled drug release among others.

A general overview of the preparation, characterization and properties of these novel materials will be presented in this communication.

Keywords: cellulose fibers, bacterial cellulose, nanofibrillated cellulose, chitosane, nanocomposites; functional materials, heterogeneous modification

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OP135

Bark Tannin-based Rigid and Elastic Foams

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Tannin based rigid foams are natural network structures obtained by polycondensations of polyflavonoid tannins and furfuryl alcohol. These foams have a wide range of characteristics. Mimosa, quebracho and even pine tannin bark extracts were used as building blocks. Physical tests such as water absorption, compression resistance, direct flame behaviour and measure of foam cells dimensions were carried out for each foam sample. A 13C-NMR analysis contributed to the chemical characterisation of the foams. Tannin based rigid foams appear suitable for a wide range of applications.

Tannin-based rigid foams, prepared from 95% natural material, are suggested for replacing synthetic phenol – formaldehyde foams in various applications. For that purpose, a few physical properties were measured: resistance to fire and chemicals, absorption of various liquids, permeability, thermal conductivity and mechanical (compressive and tensile) strength. Modifying the composition through the use of boric and/or phosphoric acid allowed substantial increase of fire resistance. The materials were also found to present good resistance to strong acid and bases, and to solvents. High affinity for water, but limited one for organic liquids, was also evidenced. Finally, slightly anisotropic mechanical properties were measured. The materials present a brittle behaviour, whether tested in compression or traction; nevertheless, their strengths, as well as their thermal conductivities, are fully comparable with those of their phenolic counterparts. Such materials of vegetable origins can compete with synthetic ones for most traditional applications.

Flexible tannin foams as opposed to the rigid tannin foams already prepared, were obtained by the addition of an external (non-reacted) plasticizer, namely glycerol. Glycerol was chosen for its high boiling temperature and the lack of evaporation, coupled to its lack of toxicity. Flexibility and spring-back of these experimental foams when subjected to a cyclic compression force followed by spring-back and compression again was quantified by both thermomechanical analysis at different temperatures as well as by compression/spring back hysteresis cycle tests in a universal testing machine. Tannin foams containing formaldehyde and without glycerol have been shown to reach a stress plateau indicative of structure crushing. Tannin foams without formaldehyde but without glycerol too, becomes very fragile, brittle and rigid just two months after its preparation again presenting structure crushing with ageing. Instead, tannin foams without formaldehyde but with glycerol added do not show any change of flexibility with time and remain truly flexible.

Carbonisation of polyflavonoid tannin-formaldehyde-furfuryl alcohol rigid foams were found by MALDI-TOF to yield a tridimensional network in which to polynuclear aromatic hydrocarbon chains of high molecular weight are also covalently linked some furan resin structures surviving carbonisation. Structure conservation on carbonizing extends to furanic structures derived by the self condensation of furfuryl alcohol which are integral part of the total network. Some complex, tridimensional structures derived by the rearrangement to polyaromatic hydrocarbons of polyflavonoid tannins, constituted of aromatic benzene and furane rings and some formaldehyde-derived methylene bridges appear to be formed.

New tannin-derived/furanic carbon foams with high surface areas were obtained by chemical activation. ZnCl2 and H3PO4 were used as activating agents and the stability of the foams structures obtained was evaluated. In addition to conventional textural analysis, the activated foam samples were analysed by nuclear magnetic resonance (NMR) and temperature programmed desorption with mass spectrometry analysis (TPD-MS). 13C-NMR analysis has allowed to understand the chemical rearrangements occurring and 1H-NMR has allowed to study interactions of the foam with water. TPD-MS yielded information on the surface chemistry of the activated carbon. Chemical activation was found to be effective for both treatments: the surface area increasing from 36 m^2/g up to 1875 m^2/g and 1265 m^2/g for foams synthesised respectively with zinc chloride and phosphoric acid. It has been demonstrated that the final carbon foams exhibit mainly micropores. Moreover, different surface chemistry were obtained depending on the chemical treatment used. Therefore, it was shown that carbon foams with high surface areas and tailored surface chemistry can be synthesised from this biomass based precursor.

OP136

Competitiveness of US Household and Office Furniture Industry

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Both the global and U.S. furniture industry over the last decade experienced a period of continuous growth followed by a steep downturn resulting from the global financial crisis. In this context, we attempt to provide a macroeconomic quantitative and qualitative analysis of the current situation and international competitiveness of the U.S. furniture industry based on the economic theories of inter-industry and intra-industry trade.

Indicators of U.S. furniture trade performance in terms of trade specialization index, export propensity, import penetration, and the ratio of exports to imports show that U.S. overall furniture trade performance is not good. The results of Balassa's revealed comparative advantage index and Vollrath's revealed competitive advantage indexes suggest that, among the furniture producing countries, U.S. doesn't has a comparative or competitive advantage. The standard Grubel-Lloyd index is used to examine the extent of intra-industry trade of U.S. and other major furniture trading countries. This index is also applied to U.S. bilateral intra-industry trade in furniture with its major trading countries.

The results indicate that the world furniture industry is more likely to be characterized by inter-industry trade, which is based on the significance of comparative advantage and factor endowments, rather than intra-industry trade. U.S. does not have a high level of intra-industry trade due to the fact that the U.S. furniture imports are very much higher than exports. The extent of bilateral intra-industry trade in furniture between U.S. and its major trading partners is also small except with Canada and Japan.

Keywords: Furniture, trade, competitiveness

OP137

Competitive Strategies for Wood Household Furniture

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Consumers historically indicate price and appearance attributes to be the major factors in their purchase decision of wood household furniture. However, these attributes, in addition to durability are traits that every furniture product will need to have to compete in the market place (or in other words, these are the standards of performance and costs of doing business in manufacturing). This study focuses on several attributes of purchase beyond these standards of performance which may be able to help furniture manufacturers differentiate themselves and gain a competitive advantage. Origin-based branding, environment friendly (green) nature of the wood-based furniture products, local sourcing and customization are four specific attributes that were included in this research study to understand how consumers' value each of these attributes in wood furniture industry. Each of these concepts separately, or in combination is successful in various allied fields, especially when marketed appropriately.

Results of data collected from over 400 consumer attendees at three home shows across the southern US show that the four measured attributes are not as important as appearance, price and durability attributes in the purchase of wood household furniture. However, a range of consumers do find these features very attractive making these attributes important in niche markets. Four unique consumer segments with specific attitudes of purchase (including the measured concepts) were identified. Specific product positioning and promotion strategies targeting each of these market segments could be successful in differentiating wood household furniture in the southern US market.

Keywords Wood furniture; household furniture; branding; customization, green; consumer segment

OP138

Sources of Competitivness in China's Wood Products Industry

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Fuelled by both increased domestic demand and export growth, the last decade has witnessed a dramatic increase in the demand for China's wood products. However, the fast-growing demand for wood products and the limited domestic resources has increased China's dependence on imported wood. As a result, China has emerged as the most important player in the global trade of wood products – China is not only the largest exporter of value-added wood products, but also the largest importer of unprocessed and semi-processed wood. The United States and the European Union are China's two biggest export markets of wood products.

The objective of this paper is to examine managers' perceptions of the sources of competitiveness, as well as the challenges and opportunities of China's wood products industry. In the theoretical background, we applied the resource-based view to examine the strategic resources that enable maintaining and developing competitive advantages in China's wood products industry. In empirical part, qualitative semi-structured interviews were conducted with 32 managers of 12 wood products companies in China.

Based on empirical data and analysis, we identified efficient wood procurement and utilization, competent workforce, continuously updated business strategy, well-functioning management system, and close collaboration with key stakeholders as the key strategic resources to achieve competitive advantage in China's wood products industry. Instead, labor costs are no longer perceived as the source of firm-level competitive advantage. With higher cost and shortage of sawlogs, Chinese farmers are showing higher enthusiasm for af-

forestation, and especially the fast-growing and high-yielding forests have been largely planted in China. Despite repercussions of the global economic crisis and the appreciation of Chinese currency, some Chinese export-oriented wood products companies have started to target more to domestic sales, where China's dynamic economic growth and huge market potential provide huge opportunities for the development of domestic wood products industry. It was also believed that in the future Chinese companies could take better advantage of China's exchange reserves to develop forest land and investments in sawmills in some lower-cost and more forest-rich countries to supply growing domestic demand.

Keywords: Competitiveness; China; wood products industry

OP139

Brazilian sector of wood flooring: opportunities and threats

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In the industry of wood based products, the flooring industries manufacture one of the products with high added value; but those industries constantly face different kind of difficulties.

In this way, the present research aimed to identify fragilities and potentialities affecting the development of the Brazilian sector of wood flooring, and to point initiatives to improve the competitiveness of the manufacturing industries.

It was collected economical information from the wood flooring industries, using interviews, local visit and oriented questionnaire application; followed by a competitiveness analysis to identify the most significant opportunities and threats.

The results showed that the more important threats are related to the environmental and forest policies, legal insecurity, Brazil cost, exchange rate policy and land ownership legalization. The present international context, the availability of planted raw material and the internal market potential were considered as the most relevant opportunities.

The main conclusion from this present analysis is that the strategic position of Brazilian wood flooring sector can be qualified as a low competitiveness industry; due the fact that threats are more relevant than opportunities.

Keywords: Forest products market, wood based products, competitiveness analysis.

OP140

Innovation strategy, innovative working climate and learning orientation as drivers for success in the Norwegian wood industry

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Growing attention is being paid to innovation and creativity and learning as success factors for sustainable competitive advantage and financial performance. This paper examines the relationships between innovation strategy, innovative working climate, learning orientation and financial performance in the context of the Norwegian wood industry. A questionnaire-based survey was sent to CEOs of firms in the wood industry in Norway (241 usable replies, response rate of 49 percent).

Innovation strategy embodies four dimensions: the degrees to which innovation in the form of products, processes, and business systems are embedded in the management values and priorities as well as the degree of expenditure in R&D. An innovative working climate is exemplified by team cohesion, supervisory encouragement, resources, autonomy, challenge, and openness to innovation. Both learning orientation and firm innovativeness were conceptualised and analysed as latent second-order constructs using structural equation modelling.

The result implied that innovation strategy and an innovative working climate enhanced financial performance in Norwegian wood industry. Furthermore, the findings showed that learning orientation had a positive affect on financial performance positively via firm innovativeness (full mediating effect). Findings suggest that managers in wood industry will not likely benefit financially from a learning orientation without also achieving high levels of firm innovativeness. Moreover, findings suggest that managers should focus on creating an innovative working climate and prioritising an innovation strategy.

Keywords: Learning orientation, Innovativeness, Innovation strategy, Innovative working climate, Traditional manufacturing firms, wood industry.

OP141

Sawmill Firms' Operational Challenges when acting as a Subsupplier of Advanced Wooden Blanks and Components

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During the recent decade, major Northern European joinery and furniture firms have outsourced their wood processing activities. Thus, some Nordic sawmill firms have increased their further-processing, integrating forward by taking over outsourced production of wooden blanks and components. This trend has brought strategic

and operational challenges connected to outsourcing, respectively to customer adapted further-processing and forward integration, in the wood-mechanical supply chain to the fore.

Recent research has indicated that conventional theories and decision models in these areas might not be directly applicable in the wood-mechanical supply chain. For example, general outsourcing advantages such as access to expert knowledge and economies of scale in component manufacturing can be difficult to reach in this industry context. Moreover, sawmills engaging in advanced further-processing struggle with uncertainties and complexity stemming from a diverging product flow and the development of new competencies. Little research has been done to adapt general theories and models within the area to the specific conditions in the wood-mechanical supply chain. This study is based on five case studies of pioneers within sawmill-integrated production of advanced blanks and components in Sweden and aims to fill this gap.

The study examines driving forces, key factors addressed, and development needs for sawmill firms taking over outsourced production of advanced blanks and components. Findings contribute to operations management theory in general and to development of practical tools for operations management in the sawmilling industry in particular.

Keywords: Innovation, operations management, product development, strategy, resource-based view, forest industry, wood industry, exploratory study

OP142

Developing Appropriate Strategies for the Non-timber Forest Products Utilization: Field Force Analysis of challenges and conflicts (A case study of northern Zagros forests, west of Iran)

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Utilization of non-wood forest products (NWFP) can happen in all forest types, range lands and farms. Main strengths of NWFPs harvesting are that this activities provide income for local people without notable costs and making low damages on natural resources. Zagros forests, with an area of around 6 million hectares, account for almost 40% of the Iran's forests. Incapability of traditional management systems, inadequacy of forestry knowledge and high dependency on natural resources, addresses common issues for management of natural resources in dry lands. High dependencies of local communities on the forests for their primary livelihoods appear to be the main reasons for the forest decline in Zagros area. Forests and rangelands in Iran are under the governmental authority and supervision of the Forest, Range, and Watershed Management Organization (FRWO). This study was conducted to develop appropriate strategies for the Non-timber Forest Products utilization and tested by participatory appraisal of natural resource and also investigation of challenges and conflicts of NWFPs utilization in three forested village (Kochar, Belakeh, Kandesoureh) in Baneh, Kurdistan province, Iran. Qualitative and quantitative methods were used to collect data. Field force analysis was used as a theoretical framework and also in this research interviews, questionnaires, brainstorming and discussion group techniques were used. Results showed that the most important problems with NWFPs harvesting were insufficient rules and administrative facilities, deforestation, overgrazing, drought, weakness of market network and marketing service and the transfer of forest to agricultural fields. The best solutions to these problems were identified as including: strengthening the cooperative society, development of market network and marketing service, organizing NWFPs harvesting plans and establishing the small scale agro-food industries in this area to prevent the destruction of natural resources within the framework of an 'integrated' approach towards the natural resource management.

Keywords: dependency to natural resources, force field analysis, NWFPs, Zagros forests

OP143

Empowering Livelihoods through NWFP Certification in India

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With the liberalization of economies, broader implications of setting standards for Non Wood Forest Products, (NWFP) for industry, governments, communities and small producers is increasingly being felt in India. The paper proposes group certification regime for NWFP suggesting global-local linkages diminishing vulnerability of biodiversity-derived products creating better marketing opportunities for national/international trade. Compliant certification standards for industry, governments, communities' small producers and applicability of relevant trade-related instruments can facilitate export of biodiversity-derived NWFP products, improvising local institutions contributing towards rural well-being. Commercialisation of NWFP is complex and many times poorly understood and when associated with biology and ecology may also result in vulnerability of the NWFP resource. The foundations of NWFP certification regime answers under what conditions certification can be a useful tool for NWFP collectors and further lays foundations for management and harvesting standards, involving consumers and local institutions. Characterisation of NWFP with proposed certification initiative can reduce cost of certification and help overcome seasonal employment with management oriented certification of medicinal plants and biodiversity related NWFP Products resulting in improving livelihoods, strengthening multilateral collaboration improving economy leading to human well being of the Country. Rural Consumers through proposed innovative group certification scheme can empower people and promote sustainable livelihoods in India.

Keywords: Non Wood Forest Products; Group Certification; Certification standards; Vulnerability

OP144

Use of non-timber forest products (NTFP) by a community in the Brazilian Amazon.

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The sustainable harvesting of NTFP has been disseminated as a way to reconcile forest conservation and development. Across the globe, human populations use and often depend on forest resources, both for their survival and to maintain their culture and also as a source of income. In order to know a little of the reality of families who live in the Amazon, this paper seeks to know the plant species used by a community in the Upper Rio Jurua in the state of Acre, Brazil. In November 2009, interviews were conducted with all families (31 total) that form the riverside community of Rio das Minas. Only seven species were cited by respondents. Of these, four are used in the form of "wine" to the family diet, and are not marketed, they are the fruits of açaí (Euterpe precatoria Mart.), patauá (Jessenia bataua (Mart.) Burret), buriti (Mauritia flexuosa L.) and bacaba (Oenocarpus mapora H. Karsten). Of the other three species mentioned are extracted fibers, which are used in making baskets and brooms mainly, and they are piaçava (Aphandra natalia (Balslev & Henderson) Barfod), the titica vine (roots of epiphytic Heteropsis flexuosa, Araceae) and timbo vine (the roots of hemi-epiphytic Thoracocarpus sp., Cyclanthaceae).The annual average quantity of harvested fruit to feed each family was approximately 652 kg of açaí, 380kg of patauá, 180kg of bacaba and 173kg of buriti. Each family produces 350 brooms a year on average. It is worrying that most of the local production of brooms comes from material that is extracted by cutting down the palm piassava.

Keywords: NTFP, extractivism, Acre, Amazon.

OP145

Economic Importance and Sustainability of Myrtle *(Myrtus communis L.)* as a Nonwood Forest Product in the West Mediterrannean Region in Turkey

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Nonwood forest products play an important role as cultural, economic and aesthetic values in human life. Demand from domestic and foreign markets for these products is increasing day by day. In recent years, except for cosmetic, food, chemistry and medicine use, the use of non-wood forest products are in a very diversified. In this study, a non-wood forest product Myrtle (Myrtus communis L.) is investigated under the Western Mediterranean Region of Turkey.

Myrtle (Myrtus communis L.) is a genous of flowering plant in the family Myrtaceae, an evergreen shrub or small tree, growing to 1-5 m height. Myrtle (Myrtus communis L.) is widespread in the Mediterranean region and is commonly cultivated. Myrtle flowers are traditionally worn in bridal wreaths. Its oil is used medicinally and in the parfume production. It is also used for landscaping purposes as a garden shrub. On the other hand, its fresh shoots are mostly preferred plants in crown wreath production.

Myrtle (Myrtus communis L.) is benefited from its fresh shoots for producing crown wreath as a different usage type of non-wood forest products in West Mediterranean Region. It is preferred because its leaves maintain green color for a long time. Usually it is collected from nature and forest areas and official data are not enough available for these products.

In this study, economic importance and sustainabilitiy of Myrtle (Myrtus communis L.), utilization on crown wreath production and importance in wreath exportation, collection method and time of the year and effects on the forest willagers economy is going to be examined in the West Mediterrannean Region in Turkey.

Keywords: Myrtle (Myrtus communisL.), non wood forest products, wreath.

OP146

Ecological Wood Anatomy: Within-Tree Variability

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Wood's structure usually varies among species and environments, and within the tree, vine, or shrub itself. This variability or lack thereof can provide clues to the ecological and physiological functioning of plants. Regardless of whether the structural variability derives from plasticity or pre-programmed intrinsic signals, we interpret that it reflects the adaptive value of the structures' various roles in the location in which it occurs. For example, one would expect to find different anatomy in fine roots, coarse roots, lower trunks, upper trunks, and branches because these organs differ in their mechanical and hydraulic roles. Hypothesis testing is necessary to tease out what the roles of those structures are. The following example on why conifers have radial xylem variation still needs much more work, but it is an example of what can be inferred if we focus on the variability rather than the mean. Corewood in softwoods appears to have structural adaptations that facilitate resistance to embolism, useful in small plants and plant tips with little access to stored water. The outerwood, in contrast, has adaptations that facilitate water transport, useful in tall plants that have long water-paths from soil to leaf. On the mechanical side, the high microfibril angle of corewood could allow large strains before stems break, useful in axes that are not 'protected' geometrically by a large diameter that would deter extreme bending. The outerwood appears to be aided biomechanically by the low microfibril angle, which should confer strength and help the larger tree avoid large deflections; if allowed,

these deflections in large trees would place large bending moments on the wood leading to stem failure. Furthermore, there is no a priori reason to expect an interaction between the hydraulic and the mechanical changes across the radius. The ultimate goals are to better understand plant function, tradeoffs among roles, the contribution of stems to plant function, and the relationships between wood quality and tree biology.

Keywords: xylem anatomy; variation; juvenile wood; mature wood; branch; root

OP147

Ecological Bark Anatomy from the Woody Flora of the Island of Cyprus

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Scientists often use correlations between wood anatomical features and environmental factors to hypothesize the primary drivers of evolution. Bark anatomy, in contrast, have been much less studied. We applied these principles to bark anatomy using the entire indigenous woody flora (158 species, in 106 genera and 50 families) of the Island of Cyprus. Based on characteristics that were visible with light microscopy of stained transverse sections from one individual of each species, we developed a codified list of 33 bark features. These features describe sieve tube morphology and distribution, sclerenchyma presence and arrangement, rays, phellem, phelloderm, crystals, secretory structures, and appearance under polarized light. Each species was codified for bark features as well as lifeform, whether endemic/close-to-endemic ("endemic/cte") or Mediterranean, and habitat. We then performed chi-squared tests or exact Fisher tests to detect statistically significant relationships between the bark features and the other variables, and visualized significant relationships with association plots. Sieve tubes were typically arranged tangentially in nanophanerophytes but not in woody chamaephytes. Bark ray dilatation was noted in moist site species but lacking in endemic/cte, shrubland, and forest species. Sclerenchyma tended to be lacking in woody chamaephytes, and in endemic/cte and dry site species. The tangential arrangement of fibers tended to be lacking in woody chamaephytes and Mediterranean species. The presence of prismatic crystals was associated with nanophanerophytes and phanerophytes, but not with endemic/cte, shrubland, or forest species. Phloem homogeneity was associated with endemic/cte species. Phellem homogeneity was associated with climbers, phanerophytes, and species of moist habitats. The association of sclerenchyma with lifeform suggests a biomechanical role, especially for young twigs. The level of endemism and the species' habitat were strongly linked to a number of bark features opening new fields of ecophyletic and ecophysiological investigation.

Keywords: bark, habitat, endemic, phloem, cork, Mediterranean

OP148

Variation of phloem properties in Norway spruce

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Radial growth in trees is controlled by cambial activity that shows seasonal pattern in temperate and boreal vegetation zones. Cellular divisions in vascular cambium produce new xylem inward and phloem (i.e., inner bark) outward, followed by different phases of cellular differentiation. The processes of xylem and phloem formation are under genetic and environmental control. The timing and rate of xylem and phloem formation, as well as the properties of these tissues, are fundamental for whole-tree functions but also determine the quantity and properties of woody biomass for industrial utilization. However, our knowledge on cambial growth is still fragmentary, and surprisingly little is known about the seasonality of phloem formation, as well as the structure and topochemical characteristics of phloem and outer bark.

The aim of an ongoing research project (postdoctoral project funded by the Academy of Finland) is to increase our understanding on: 1) the variation in phloem properties of Norway spruce (Picea abies (L.) Karst.), 2) the environmental and genetic control of phloem formation and 3) the topochemical characteristics of phloem and outer bark.

In the first sub-project, for the analysis of phloem geometry, altogether 24 Norway spruce trees representing six cutting clones (of known growth rate and quality traits) and two age groups (young and mature stands of 23 and 42 years old, respectively) were harvested at Haapastensyrjä tree breeding station in southern Finland on autumn 2011. Samples were collected from eight different heights on the stems. The effect of growth rate, clone and stem position on the proportions of different tissues (i.e., outer bark, conducting and non-conducting phloem) and dimensions of cells (e.g., sieve cells, parenchyma cells, sclereids) will be analysed by the means of bright field and fluorescence microscopy, and x-ray microtomography. The geometry of phloem in relation to tree growth rate, clone and physiology is to be addressed.

Keywords: Bark; cambial activity; phloem geometry

OP149

Mazur, Curly or Hazel – Figured Wood of Norway Spruce and Scots Pine

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This study focuses to the investigation of different figures in Norway spruce, Picea abies (L.) Karst., and Scots pine, Pinus sylvestris L. The anatomy and chemical compostion of mazur-like wood, hazelwood and burls are compared to each other and normal wood.

In Norway spruce the figured wood is represented with three abnormal cases, the mazur-like wood, the hazelwood and wood in burls.

The mazur-like wood resembles to some extent the mazur from the Karelian birch (curly or mazur birch), Betula pendula Roth var. carelica (Mercklin) Hämet-Ahti. The hazelwood is characterized with indentated growth rings and is known from a variety of conifers. The burls with buds share certain anatomical structures with mazur wood. Figured wood of the Scots pine is embodied with mazur-like and hazelwood.

The lignin content of a sample including mazur-like wood and clear wood is analysed with FTIR and determined using acetyl bromide method. The lignin in cell walls was also observed under a fluorescence microscope. The extractive content in mazur-like and clear wood is analysed with GLC-MS (phenolic compounds, resin acids, lipids and carbohydrates). The wood anatomy of the three different planes (transverse, radial and tangential) from each sample are studied with conventional anatomical methods, light and scanning electron microscopy.

The mazur-like wood in both conifers is fairly similar but they show also variability with regard to the appearance of anatomical characters as a weak and a strong type. The growth rings are undulating, and sporadically deeply indentated. The orientation, the size and shape of cells has changed significantly in and close to the indentations. There are also brown flecks of parenchyma with dark contents and sometimes blackish spots containing phloem. Traumatic resin ducts are present. In the hazelwood the growth rings are indentated very regularly and only shallowly. The orientation and shape of cells has changed in a lesser extent than in the mazur-like wood. There are no brown or blackish flecks. In the wood of spruce burls the growth rings have risen up on the spot where the buds are present. The orientation, the size and shape of cells has changed considerably but there are no flecks. Chemical composition of mazur-like wood will be discussed.

Keywords: lignin, microscopy, hazelwood, mazur-like wood, burls, Picea abies, Pinus sylvestris

OP150

Developments in Spiral Grain Assessment from Wood Samples

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Distortion of wood during drying and in use is a major issue for many plantation softwoods. Spiral grain has been strongly implicated in many studies, particularly if grain angles exceed 5 degrees from the longitudinal axis of the stem, and several assessment methods have been used by researchers, both for standing trees and wood discs. Most studies have looked for patterns in grain variation, in order to compare stems, crops or regions. Scribing and cleaving of discs have been the most common methods employed and the data averaged to give a "representative" values. These approaches have several disadvantages, including the time involved and errors due to low sampling intensity, stem orientation, and the lack of documentation of spatial variation between sample points. Thus spiral grain measurements are subject to a high degree of variation and interpretation, depending on the assessment method used

A number of recent studies have begun to investigate the extent of spatial variation in discs or logs and it has become apparent that grain angles vary .more than has generally been reported. Recent work in New Zealand has focussed on two aspects:

1. Documenting the magnitude of spatial variation within stems to improve future sampling strategy. Intensive measurement radial, tangential and longitudinal variation using traditional methods (scribing and cleaving) confirmed that grain angles can change significantly within small distances, emphasising the need to consider an appropriate sampling methodology in the light of study objectives.
2. Improving both the cost-effectiveness and accuracy of measurements. A radically new approach was investigated, involving the transmission of light through wood discs. This destructive method offers some real advantages in terms of sample preparation time, quantification of within-stem spatial resolution, and the elimination of errors due to tilting of disc samples. The current priority is to automate the scanning system to allow continuous assessment of large numbers of discs.

Keywords: Spiral grain, wood discs, spatial variation, sampling strategy

OP151

Carbon Capture and Productivity of Plantation Forests in North-eastern Australia

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Approximately 130,000 ha of hardwood plantations have been established in north-eastern Australia in the last 15 years. As a result of poor taxa selection approximately 25,000 ha have failed due to drought, pest and disease or extreme weather events (drought and cyclones). Given the predicted impacts of climate change in north-eastern Australia (reduced rainfall, increased temperatures and an increase in extreme weather conditions, particularly drought, storms and cyclones), selection of the right taxa for plantation development is even more critical as the taxon planted needs to be able to perform well under the environments experienced at planting as well as those that may develop over in 30 years time as a result of changing climate.

Data was compiled from 37 taxa trials within a network established across the subtropics of eastern Australia with trials selected using taxa linkage, stocking rates, age (10 ±2 years) and regional (climatic) representation. Significant differences in survival, height, diameter, basal area, volume MAI, stem borer incidence, carbon sequestration rates and pulp productivity were observed at age 10 years. Across all regions, at age 10 years, the largest volume increment (30 m3/ha/y) was observed in E. pellita in the North Tropical Coast whilst the largest average breast height diameter (19.6 cm) was observed in E. dunnii in the Northern Rivers region. In the case of E.dunnii, this equates to 274 tonnes of CO2 equivalents or 74 tonnes of pulp per hectare at age 10.

Of the 65 taxa included in the study, those that were the most robust (based on volume growth, survival and carbon sequestration rates) under the drought conditions experienced in north-eastern Australia, during the study period were Corymbia citriodora subsp. vari-

egata (CCV), Eucalyptus dunnii, E. longirostrata and E. argophloia. Of these species only CCV and E. argophloia had low borer attack, making them potentially suitable for solid wood production.Analysis of the climatic conditions resulted in key climatic drivers for individual taxa being identified with E. dunnii performing best on sites with a higher incidence of raindays and higher mean annual rainfall, while E. argophloia performed best on sites with higher daily minimum temperatures.

Keywords: carbon sequestration, taxa trial, productivity

OP152

Fire, Water and Owl: Multi-objective Forest Planning in the Deschutes National Forest, central Oregon, USA

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Forests produce a multitude of ecosystem services many of which are in conflict. As an example, timber production can compromise recreational opportunities, as well as the quality of wildlife habitat. Recreation can also pose a threat to wildlife and increase the risk of forest fires. Quantifying the tradeoffs among the competing services can be useful for forest planners. They are in a better position to make sound decisions if they can answer such questions as how many hectares of old-forest habitat would have to be cut to reduce the risk of fire by a certain amount. We present a case study from the Deschutes National Forest, in central Oregon, U.S.A., in a municipal watershed, where water quality, Northern Spotted Owl (Strix occidentalis caurina) habitat, and fire risk mitigation are all critical but also competing forest functions. In the short term, fuel removals, via thinning and prescribed burning, may increase sediment levels in the water system. This can lead to higher filtration costs for the municipality. However, the long term risk of catastrophic wildfires will be lower because there is less fuel accumulation. Lower risk of fire means higher soil stability and less sedimentation. Conversely, if fuel treatments are postponed, or foregone altogether, there will be less sedimentation in the short term but more in the long run due to a higher risk of fire. To complicate the analyses, fuel treatments can have both positive or negative impacts on the quality of owl habitat. How should fuel treatments be allocated across the watershed and over time to achieve various combinations of short and long term water quality, fire risk and owl habitat objectives? We present a multi-objective mathematical programming approach that can map out the "bundles" of ecosystem services that are efficient with respect to the three competing outputs and are financially viable for the National Forest. If time permits, we discuss how the tradeoff information generated by the optimization model can be used to solicit public input in support of alternative management plans.

Keywords: Multi-objective optimization; spatial forest planning; tradeoffs, ecosystem services

OP153

The role of *Khaya ivorensis* plantation on improving the productivity and fertility of three degraded soil series in Johor, Malaysia

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Deforestation leads to declining soil fertility due to imbalance inputs and outputs of carbon and other nutrients. Declining soil fertility levels resulted in low growth performance and will affect the productivity and carbon sink. Kyoto Protocol within the framework of the Clean Development Mechanism Project (AR-CDM) of Forestry, emphasizes the function of forests as carbon sinks. Forest Plantation has been proposed as a tool for forest rehabilitation of degraded lands which concomitantly act as carbon sequestration and improve the productivity of soils. This study aims to emphasize the growth exotic species of Khaya ivorensis and develop allometric equation towards estimating biomass accumulation of K. ivorensis plantation under three different soil series (Padang Besar, Rengam and Durian) which belongs to Ultisols at five years after planting. The study was conducted at K. ivorensis plantation in Forest Research Institute Malaysia (FRIM) Research Station in Segamat, Johor, Malaysia. Tree height (H) and diameter at breast height (DBH) were measured to evaluate growth performance of K. ivorensis plantation. Five sampled trees of K. ivorensis at each soil series were destructively. The highest growth rate of MAI diameter, height and basal area in Padang Besar soil series, followed by Durian and Rengam soil series. The best fit regression of site specific equations were developed from independent variable D is recommended for estimating tree component biomass and stem volume in each site. A single allometric equations using D was applicable for estimation biomass and stem volume, except in Padang Besar, estimation stem biomass and stem volume, the equation using D2H. The highest stem volume and biomass accumulation recorded at Padang Besar (77.99 m3 h-1 and 63.16 t ha-1, respectively), followed by Durian (53.10 m3 h-1 and 46.33t ha-1, respectively) and Rengam soil series (43.13 m3 h-1 and 40.96 t ha-1, respectively). Differences of growth and biomass accumulation result provide some guidance that forest productivity of K. ivorensis was affected by different site conditions. The highest growth performance and productivity of stem volume and biomass accumulation of K. ivorensis in Padang Besar compared that in Durian and Rengam soil series, shows that the species high adaptability to the soil characteristics in Padang Besar soil series.

Keywords: Biomass, carbon sink, forest plantation, allometric equation

OP154

The role of wooden construction products in the mitigation of climate change: Finnish case studies

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The building sector is responsible for a significant share of the total primary energy use and greenhouse gas (GHG) emission. Action should be taken to increase the environmental performance of the built environment. In relation to other building materials, wood building products consume less energy and produce fewer emissions when manufactured.The development of a sustainable built environment can be achieved through the increased share of wood-based materials.

LCA addresses the environmental aspects and potential environmental impact throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal. When focusing on climate change issues, the method should be used in order to create knowledge about the products' influence on greenhouse gases balance.

The aim of this paper is to assess, through LCA methodology, the potential of wooden products as building materials in the carbon sorption and sequestration and thus in the mitigation of climate change. This includes the analysis of different scenarios for the increase of the share of wooden buildings in the Finnish stock of residential multi-storey buildings. In Finland wood is used in 2% of the buildings in this segment while the remaining 88% are concrete. The LCA is compared to different scenarios with increased share of wooden buildings. In addition the study outlines the main research questions when considering to move the system boundaries of the LCA to include the Forest growth and the consequences of different management strategies, specially the rotation length. The paper also summarises recent results about the effect of stand and forestry on the carbon sorption.

Because of the potential of forests in carbon sorption and carbon sequestration, the use of forestry products may be significant issues when seeking solutions for the mitigation of climate change. However, when the focus is strictly directed on seeking information about the potential effect of wooden products contra corresponding other functionally equal products on the mitigation of climate during the coming decades, the past sequestration is not that relevant - it has taken place independently of the coming use of forestry products. The important questions are 1) what is the carbon balance if trees are harvested in order to use wood for different kinds of products, 2) what is the effect of the rotation and stand age and 3) what is the effect of forest management strategies on carbon absorption and sequestration.

Keywords: wood products, LCA, residential buildings carbon sorption, carbon sequestration, climate change

OP155

Sustainability Impact Assessment (SIA) of Wood Supply Chains of natural Forests versus plantation forest. A case study from Vietnam

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Vietnam has a total of 13.26 million ha of forests in which 10.34 million ha is natural forest and 2.92 million ha is plantation, providing annually more than 2.53 million m3 round wood for all kinds of wood industry in the country and export. The forests are distributed on various terrains, 35% of natural forest and 20% of plantation on moderate slope (less than 30%), and 65% of natural forest and 80% of plantation on steep slope (more than 30%).

In Vietnam, the method as well as level of mechanization of logging and transport mainly depends on the type of forests and the slope of terrain. In logging natural forests, selective cutting method is applied. Harvesting operations are partly mechanized on moderate slope by using chainsaw for felling and de-branching followed by extraction with wheel tractors equipped with cables or winches to the lower landing and then further with bigger trucks to the industry. On steep slope, harvesting of natural forest is usually carried out manually by chainsaw for felling and sawing logs into small boards (0,2 – 0,35 m^3) right at the felling site (pit sawing), the sawn timber is then extracted by buffaloes to the lower landing and transported further by small trucks to the industry. In plantations, clear felling is used in most cases. Logging on moderate slope is mainly carried out by using chainsaw for felling, de-branching and crosscutting and using animal for hauling. On steep slope, felling, de-branching and crosscutting are also done by chainsaw but manpower is used for hauling.

The difference of harvesting methods and the level of mechanization in logging leads to different impacts of the whole forest wood supply chains with respect to economy, society and environment. In order to assess and compare the overall sustainability of logging and transport activities, four typical case studies were carried out. All the related processes starting with the harvesting planning and ending with the wood transport to the mill gate where studied and partly accompanied by detailed time studies. A set of nine sustainability indicators covering selected aspects of economy, environment and society was chosen and indicator values where linked to each single process of the four chains. The parameters for each indicator were collected in the field by using time study results, personal observations or interviews with workers and the managing team. Quantitative and non-quantitative parameters were then processed by Excel and the LCA software UMBERTO.

The results are compared and discussed regarding the advantages and disadvantages of each chain. The weak points of the chains in terms of sustainability impact are analyzed and proposals to improve the chain are developed. This leads to a set of optimized supply chains. The respective re-calculation of the indicator values shows significant improvement of the overall sustainability. This opens better chances on the national and especially on the international markets for wood and wood products from Vietnam.

Keywords: Sustainability Impact Assessment (SIA), logging systems in Vietnam, logging natural forests, logging plantation.

OP156

Remote Sensing In The Assessment Of Dynamics Of Deforestation In Chico Mendes Extractive Reserve In The Acre State, Brazil

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In the state of Acre there are 19 Conservation Units distributed in three of Integral Protection and 16 of sustainable use, recognized by the Government, with aggregate acreage of 5,107,836 hectares (ha), representing 31.10% of the of the state area. The Acre has pioneer areas and historical significance, resulting from the organized struggle of rubber tappers who produced a nationally spread and internationally acclaimed management model, RESEXs extractive reserves, representing the efforts of public policy in the establishment of protected areas at the same time the recognition of territorial and cultural traditional populations. In this context it was created the Chico Mendes Extractive Reserve with an extension of 930,203 hectares representing 5.66% of the state. Among these public and private institutions to the Amazon Protection System (SIPAM), under the Civil House of the Presidency and the Institute of Man and Environment in the Amazon (IMAZON) has published data showing increased deforestation in this RESEX in Acre. Data provided by the Central Unit of GIS and Remote Sensing - UCEGEO, which has done work and others monitoring the accumulated deforestation dynamics with a time of 21 years (1989-2009), building a series, using images taken by the Thematic Mapper - TM satellite Landsat 5, classified software environment ENVI 4.6.1. Data used in this study demonstrated, regarding the Chico Mendes Extractive Reserve as a model of development, the need to evaluate the dynamics of deforestation and the second temporal dynamics analysis yielded an average of 55,688.000 ha deforested area at the end of the last decades. Therefore, it is clear that their populations have focused on specific areas of the territory, leading to greater pressure on these sites. The work presented here also assessed the dynamics of deforestation in the Chico Mendes Extractive Reserve a comparison with data from other institutions of deforestation, mapping their location and extent within this territorial unit and taking into account their population density.

Keywords: Conservation Units, Chico Mendes, Deforestation

OP157

Preparation of nanocellulose from Bleached Hardwood Kraft Pulp

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Extracting more value from wood is currently a hotly pursued research objective in the field of forest biomass. In search of alternative applications of lignocellulosic biomass, biorefinery and production of cellulose nanofibres (or nanocellulose or cellulose nanocrystals) from native cellulose have been the subject of intensive investigation nowadays.

Fundamentally, lignocellulosic biomass is made up of nanometer-scale cellulose building blocks that provide mechanical, optical and other properties to wood and other types of renewable lignocellulosic and cellulosic biomaterials. These nanosized cellulose building units, which are networked, and irreversibly fixed in the supramolecular cellulose structure, and determine the product properties and functionality, have been described as nanocellulose. It is clear that one of the priority areas in using wood fibres as a source of nano-sized elements is the liberation of nanocellulosic fibrils. These nano-elements are defined to have at least one dimension in the 1-100 nm range. However, the length and width of the nano-structures could vary greatly depending on the material sources and the methods used in isolation. Due to its inherent nature nanocellulose has numerous high technological applications. For example, its optical transparency can be used to produce organic visioning system. Nanocellulose has the capability of conducting current, permitting use to produce electronic papers. Other potential applications include medical and nanocomposites.

There exist several techniques for the preparation of nanofibrils that can be employed individually, in combination or in sequence. This paper describes an oxidative technique by which a TEMPO-NaBr-NaClO system is used to isolate nano-sized structures from a bleached hardwood kraft pulp. The principle of producing nanofibres from pulp fibre is to remove the wood binding component, the lignin, in chemical pulping and bleaching, and dissolve the amorphous regions of cellulose chains, liberating the crystalline elements. The TEMPO-NaBr-NaClO system reduces the adhesion between the microfibrils but not separates them. The separation of microfibrils can be achieved by mechanical means such as stirring by magnetic rod or by a blender or by ultrasound. Further, the TEMPO-mediated-oxidation gives higher yield when compared to the acid hydrolysis technique and its reaction is more rapid than the enzymatic method.

OP158

Investigation on Properties of Soda and Soda / AQ Pulps From Corn Stalk

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Soda and soda-AQ pulping of corn stalk applying different charges of active alkali and pulping time was studied. The average value of fiber length, diameter and cell wall thickness were measured as 1.03 mm, 23.64 µm and 5.26µm, respectively. The content of alcohol-acetone extractive, cellulose, lignin, extractive soluble in 1% NaOH and ash content of corn stalk were determined as 15%, 51.2%, 23%, 45.95% and 2 % respectively. Pulping with four levels of sodium hydroxide (12, 14, 16 and 18%, based on NaOH), and two cooking times (15 and 30 minutes) and constant cooking temperature at 145ºC was performed. 0.1 % AQ was added to soda/AQ cooking liquor. After analyzing the pulping yield and kappa number, two pulps were selected (NaOH; 12, 18%, cooking time; 15 minutes and cooking temperature; 145ºC) as brown and bleachable stock respectively. Eventhougth addition of 0.1% AQ showed no significant effect on pulping yield but its effect on paper strength properties was significant. The result of handsheet evaluation revealed that the strength of pulp produced applying 18% NaOH, 0.1% AQ, and 15 minutes pulping time with breaking length of 8.21 Km, and 80.59 N.m/g tensile index is superior to other pulping conditions. The tear index of the pulp produced applying 12% NaOH , 0.1% AQ and 15 minutes pulping time was determined as 10.60 mNm2/g. The burst index of pulp produced using 18% NaOH, 15 minutes pulping time without AQ addition, was the highest.

Keywords: corn stalk; soda/AQ; yield; strength

OP159

Cellulose/titania nanostructured composites for electronic applications

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Any perception that paper, by its nature, is a low-tech product is misleading. With the advent of printed electronics, paper has emerged as a focus area for researchers developing innovative paper-like substrates for lightweight, flexible, biodegradable electronic devices. The use of such materials enables applications like smart cards on paper, embedded intelligent sensors for medical diagnosis, pollution-monitoring wallpapers, interactive screens and product labels. Even today photoluminescent and photochromic thin films provide designers with light sources for day-to-day applications or sophisticated architectural projects. Coated paper-based electronics are already a commercial reality and prototypes of things like thin film photovoltaic devices made of cellulose are under development. In fact, paper surfaces can be modified to different stages such as conducting or semiconducting surfaces by coating the intrinsically rough paper's surface with thin-films, nanoparticles or other nanostructures with enhanced electrical and optical properties. Several coating methods like spray pyrolysis, chemical vapor deposition, spin coating, pulsed laser deposition have been used for thin-film formation but the quest today is how to grow those nanostructures directly onto flexible substrates avoiding the often energy-consuming and expensive transfer processes. To this extent, the present work demonstrates the potential for organic/inorganic hybrid p-n junction devices by incorporating light-harvesting nanostructures and titania nanoparticles (anatase TiO2) into cross-linked cellulose fibrous structures. Sintering of colloids and TiO2 precursors at moderate temperatures (< 200 ºC) was performed paving the way to produce mechanically stable, electrically conducting TiO2/cellulose nanostructured films on glass or plastic substrates. At the present time, research is being oriented to solve up-scaling issues related to film adhesion to make thin photosensor/photovoltaic devices working as cost-effective, high-performance devices for energy and biological applications.

Keywords: light weight electronic devices, cellulose/titania nanostructured composites, innovative manufacturing processes, paper industry.

OP160

Demand-Driven Wood Supply: A Flexwood Study Case In Aquitaine (France)

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In the Maritime Pine supply-chain in Aquitaine, wood mobilization is handled by multiple actors from forest cooperatives, wood supply companies, or mills who integrate logging operations. This diversity is combined to a current indetermination on the forest resource and a fierce competition for round wood between users. This results in a situation where the answer to "which stand should be harvested to get the right logs to the right mill?" could be optimized.

Industrial users wonder if newly developed laser scanning tools and methods can be considered as a way to improve information along the supply chain and reach a better adequacy between demand (logs specifications in terms of dimensions and quality) and what is actually delivered at the mill gate. Through its local study case, one of the goal of the FLEXWOOD project is to demonstrate whether these expectations can be met and under which conditions.

The method evaluates the relevance of integrating LIDAR technologies in supply operations, for a better understanding of the resource, including mechanical properties, to be matched to a better description of demand.

Quantitative and qualitative forest data were collected in 2011 over 6 000 ha from different sources including ALS and TLS (airborne and terrestrial laser scanning). Existing algorithms, quality models and allometric functions were used to process laser & field data thus providing characteristics such as dimension, shape and capacity to match specific industrial needs. The resulting information was used to simulate logging operations while taking into account supply specifications from a few local mills. Real logging operations were also monitored to compare the simulation with truly harvested log products.

Indicators were designed, combined with a qualitative analysis, to evaluate this demand-driven approach. A comparison of two scenarios, "Business as usual" and Flexwood, is planned to be done in early 2012 with some of the operators involved in the decision making process on a daily basis. Results will be presented and discussed in the presentation.

Keywords: LIDAR, Demand-driven supply, Wood quality

OP161

Procedures to match laser based forest resource information with industrial wood requirements

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Despite several attempts in the past to move the decision to allocate the right raw material for specific products upstream to an earlier stage in the wood supply chain in order to increase efficiency in the wood industry, these decisions are currently mainly still taken downstream at the wood yards of the wood processing industry. This is due to lack of information about the forest resource and incomplete information chains. Relatively good volume information goes along with fairly poor quality information. Already today – depending on the type of forest resource – the forest industry can make use of technologies like terrestrial (TLS) and aerial (ALS) laser scanning to gain the necessary information to overcome this gap.

Therefore allocation procedures are described following the objective to increase the information on the forest resource derived from laser scanning data in order to match it with the raw material requirements of the wood processing industry.

Tree quality information based on dimensional parameters of external features like branchiness, sweep, ovality and taper are to date assessable by TLS. ALS gives information on tree height and crown parameters. Combining these information sources allows retrieving stand quality information and amalgamating quality classes which is necessary to match forest resource with industrial demand.

With the currently rising capabilities to predict internal wood quality from automatically detected external features, the industry is increasingly in the position to define its raw material requirements more specifically and precisely. The respective procedures need to be in place to transfer this information upstream to the forest and match it with the resource information gained from or enhanced by laser scanning data. These are the prerequisites to allocate the right material to the right customer early in the wood supply chain.

Keywords: round wood quality, wood supply, forest resources, standing quality assessment, laser scanning

OP162

Converting product requirements into wood raw material specifications

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The stages involved in converting the wood raw material into final products influence on each other. To obtain a good economic result, the chain must be seen in its entirety. The wood raw material has to be chosen taking into account the requirements of the final products. Wood raw material to be harvested has to match the specifications of the products to be manufactured. The incompatibility between the wood raw material, semi-finished products and final product may cause a lot of waste and considerable economic losses. Consequences are also loosing markets due to decrease of customers' satisfaction.

VTT has developed WoodCIM® model system for optimisation supply chains from the forest to the end products. The model system is a tool for research. It has been implemented in industrial environment for supporting long term and operative decision making. The paper demonstrates thorough industrial case studies executed by industrial implementations of WoodCIM®:

- how to convert product requirement into wood raw material specifications
- how to determine log orders to be harvested
- variables influencing on the miss-match between wood product requirements and available wood raw material specifications
- economic losses in profit to be realised through miss-match

Future concepts for stronger integration of wood raw material harvesting and primary (sawmill) and secondary (production of wooden components) manufacturing phases will be presented.

Keywords: supply chain, value yield, simulation, optimisation, wood products, wood raw material

OP163

Quality assessment on standing beech trees, logs and sawn timber – a trial on knottiness

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In the Flexwood project a system should be established to provide information on trees and logs that will match customer demands in subsequent processing stages. Scanning technologies have improved rapidly in the last years and are already implemented in practice. This is not only true for Aerial Laser Scanning (ALS) for inventory purposes, but especially also for Terrestrial Laser Scanning (TLS). Both systems have been developed and tested mainly in even structured conifer stands. However, broadleaved stands are more heterogeneous in structure and quality and therefore these stand types are still a challenge for ALS and TLS. In particular when detailed individual tree information close to the ground is required, TLS would be the technology to apply as ALS is not able to provide such information. Besides external quality characteristics of a tree trunk such as curvature, ovality and diameter, branch scars can quantitatively be analysed from TLS data. Such branch scars reveal already internal quality information on roundwood produced from such trees. The external scar characteristics are closely related to the percentage of knot free and knot containing wood which is relevant for grading round wood into quality classes according to current round wood grading standards.

In this approach single trees were scanned by a TLS system for complete three-dimensional representation. From TLS, branch scar information such as width, height and Chinese beard height could be identified. After felling the trees, branch scars were manually as-

sessed on the round wood prior to scanning of the logs with an industrial Computer Tomography (CT) scanner. The exterior knot information from the TLS scan is then matched with the manually assessed branch scar on the log and with the interior knot information obtained by CT scanning. This approach aims at developing a system, which can provide reliable information about knottiness already on the standing tree with the background information of the interior knot information from CT scanning. In this case different branch scar sizes and shapes were considered, reflecting recent and long time over healed knots. To verify the internal knot measurements by CT the logs were sawn into sawn flitches of 35 mm thickness and knots were measured on both sides of the boards.

Keywords: beech; wood quality; TLS; CT, knottiness

OP164

How to describe wood supply chains and evaluate their agility and personalisation capabilities?

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The objective of the Flexible Wood Supply Chain research project (www.flexwood-eu.org) is to propose a novel Wood Supply Chain (WSC) that increases value recovery through higher agility and personalisation capabilities, as well as aerial/terrestrial laser scanning for forest inventory and enhanced optimisation models in procurement activities and in the demand definition by the mills. To support the design of this novel WSC, a framework for describing different WSCs in a generic way and assessing their agility and personalisation capabilities was developed. The framework focusses on operational planning and execution of the procurement activities from the sourcing of standing timber to the delivery of harvested timber at demand sites.

In this presentation, we introduce the developed framework consisting of five main components: external environment, competitive business and supply chain strategies, supply chain structure, enablers and practices, and performance. It includes, in particular, a description of the actors involved in the WSC, their planning and execution processes, the decoupling points used and the information, material and financial flows within the WSC. Moreover, according to the four dimensions of an agile supply chain by Christopher (2000), the framework includes a qualitative assessment methodology of the WSC agility capabilities based on a 0-4 increasing score of how well each of these four dimensions are developed along the main processes within a WSC. The assessment of the personalisation capabilities is based on the localisation of the decoupling points along the WSC and their respective order fulfilment cycle time.

The framework was applied in case studies of WSC in six countries (Canada, Chile, France, Poland, Sweden and USA) where fieldwork collected information from more than 85 local actors and experts. Results are presented, in particular, for the planning and execution standard processes based on an adaptation of the Supply Chain Operations Reference (SCOR) model, models of planning systems, personalisation options and a generic list of operational planning decisions, pricing mechanisms and decoupling points. We also discuss the agility capabilities evaluated in the cases and those required according to supply/demand uncertainty. The framework should prove useful to organisations interested in analysing their WSC and identifying actions that could improve their agility and personalisation capabilities.

Keywords: Wood supply chain, decoupling point, SCOR model, agility, personalisation

Reference: Christopher, M., 2000. The agile supply chain: competing in volatile markets. Industrial Marketing Management, 29(1): 37-44.

OP165

Integrating small non-industrial private forest ownership (sNIPF) in novel logistic concepts

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Advanced harvesting and logistic concepts are primarily developed for and used by bigger and professionally organized users like state or private forest companies, sawmills, pulp and paper industry or integrated forest based enterprises. They have the financial resources, the organizational structure and also the manpower to operate advanced IT-based systems in order to shape the material and information flows according to their needs and they therefore have the full benefit.

Small forest holdings represent a substantial part of the forest resources in most European countries. However, not all private forest owners may be integrated into modern logistic systems in the same way due to differences in the forest ownership structure, the involvement of small non-industrial private forest ownership (sNIPF) in the wood supply to the industry and the equipment and communication media in use. As a consequence, to create flexible logistic systems it is therefore of high priority to integrate their operations.

Based on the demonstration cases of the Flexwood project, the structure, the operational methods applied today, the specific preferences and future needs of small non-industrial private forest owners and cooperatives are explored and mapped using enquiries and a process modelling approach. Possible links of their operational methods to the Flexwood concept are identified and the respective improved processes are modelled, the advantages compared to the existing operations are stated and – if applicable – quantified.

Keywords: small-scale forestry, small non-industrial private forest ownership (sNIPF), wood supply, logistic systems, material and information flow.

OP166

New Methods to Demonstrate Wood Property Variation

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Deterministic prediction of lumber stability requires an ability to predict high-resolution, three-dimensional patterns of wood property variation within individual tree stems. Traditional methods are time-consuming and labour-intensive, so new approaches are required for efficient data collection by empirical means, along with suitable mathematical and analytical tools. Four wood quality variables key to stability prediction have been identified: chemical composition, microfibril orientation, wood density and grain orientation.

Equipment for rapidly measuring and mapping these properties in two dimensions using 30mm thick discs is under development, along with a methodology for economically serially-sectioning stems at the required intervals. To date this methodology has been used to map 50 radiata pine stems - 24 seven-year old stems (2 ramets each of 12 clones); 5 XX year old from a single family???; 20 seventeen year old ramets of a single clone. In this paper, the rationale for method development will be covered and results of the most recent set of 20 stems (all ramets of a single clone), presented and discussed in terms of within and between tree variation and implications for product performance.

Keywords: Sampling methods; product stability; wood material science

OP167

A new process-based model of wood formation in Pinus

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New modelling developments now allow us to simulate wood formation in plantation species. In the past, tree growth models based on our understanding of tree biology have been used in commercial forestry to predict volume. Many underlying processes invoked in these models are those that also regulate wood variability. We report here on a process-based model ("Cambium") that interfaces with existing processed based models in a hierarchical modelling approach, and that is designed to predict variation in wood properties of commercial importance, and ultimately log quality, in radiata pine. The model has been written as software, and is flexible with regard to input data types, temporal resolution and stand spatial variability. Using the outputs of existing, well tested stand-level process-based growth models (including CABALA), radial pith-to-bark profiles of wood density variation and cell size are predicted at a daily time step. These profiles are then converted to a sampling interval similar to that produced by the SilviScan wood analysis system. Comparisons between actual and predicted SilviScan data allow the model to be thoroughly validated and refined over a wide range of growing conditions. Preliminary analysis of model performance is promising. Examples of how the model can be used to assess wood properties outcomes of different silvicultural scenarios, or climate futures, are presented, showing its potential to more precisely quantify levels of carbon storage in woody biomass than is currently practical, and contribute to forest management strategies.

Keywords: Cambium, CABALA model, xylem, Pinus radiata, climate change, carbon sequestration

OP168

Decorative Wood – Properties and Quality Model

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Quality criteria can only be applied for the specific purpose for which the wood is used. The diversification of customers' demands for specific wood properties leads to a gain of sawed or cut wood surfaces which supply the fine or decorative appearance of wood products. While foresters think of tree size and form, and lumber manufacturers see large, straight and clear logs, customers associate wood quality with aesthetic characteristics. Special figures in wood have been defined as unusual grain or abnormal grain pattern that adds value to solid wood products. In Ukraine, a variety of sycamore (Acer pseudoplatonus L.), European beech (Fagus sylvatica L.) and ash (Fraxinus excelsior L.) represented by special wood anomalies like birdseye and wave grain are typical.

These valuable broadleaves tree species deliver high-value decorative wood and also special acoustical wood for the music instruments production. While traditional decorative wood surfaces face big challenges and veneer manufacturer complain about difficult markets and declining market shares, digital printing technology for wood and wood based panels with improved reproductions of natural wood surfaces show a rapid growing market share. There are evidences as well as that the final consumers are ready to pay a higher price for individual and customized wood products (e.g. furniture, interior design, floors with highly decorative wood surfaces). Additionally, from a socio-economic viewpoint sycamore, European beech and ash possessing decorative features have higher economic value for the forestry and wood technology. The research objective is focused on properties and the development of the quality model of decorative wood.

Keywords: Wood anatomy; birdseye; wave grain; wood selection; quality model

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OP169

Exploring the diversity in wood (dynamic) mechanical properties: What can we learn on affecting factors and on potential utilisations?

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A better knowledge on the diversity of wood would have implications in several domains of pure and applied research. Large databases of wood physical-mechanical properties are the pre-requisite for applying material selection method, which could allow more efficient, diversified and potentially sustainable utilisation of wood materials. They can also provide insights into the physical understanding of traditional preferences for specific woods in various cultural uses. In addition, wood diversity is increasingly taken into account by research into biomechanics and functional ecology, as properties and their microstructural / chemical affecting factors can reflect growth strategies related to taxonomy and/or biogeography.

Exploring the diversity of wood properties requires obtaining very large datasets. However, if a significant number or species have been characterised for some properties (such as density or modulus of elasticity along the grain), information is still scarce on other important aspects of wood behaviour (such as viscoelasticity and anisotropy).

The present work aims at contributing to overcome this lack of knowledge. Experimental characterisations of dynamic modulus of elasticity and of damping coefficient of many lesser-known wood species are combined with an extensive compilation of data scattered in the literature. This new "viscoelastic vibrational properties of wood" database, which covers 450 species, is linked to the CIRAD database of technological properties of tropical woods which covers 1000 species. The global dataset covers 1310 species.

Observed correlations between properties are discussed in connexion to affecting factors such as porosity, orientation of wood elements, presence of extractives. Properties distributions are compared between softwoods, temperate or tropical hardwoods, and between botanical families. The new dataset on vibrational properties could be used to select appropriate species for applications requiring specific ranges of damping.

Keywords: Biogegraphical origin; Databases; Diversity of wood; Mechanical properties; Structure-properties relationships; Viscoelastic damping

OP170

Effect of growth rate and radial position on the natural durability of Douglas-fir

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In terms of natural durability, Douglas fir (Pseudotsuga menziesii) fame owns to the favourable characteristics of centuries-old trees harvested in old-growth North American forests. The properties of such material are susceptible to be different from those of wood coming from plantations harvested between 50 and 100 years-old. In such stands, plantation density and thinning intensity may vary: these silvicultural choices critically influence the trees growth rate. Since this parameter is known to affect some properties of the wood, it was decided to assess to what extent an increase in Douglas fir growth rate affects the natural durability of its wood. This issue is indeed poorly documented in the scientific literature.

This parameter was evaluated on standardized heartwood specimens taken from 66 trees originating from 11 stands in Wallonia (Belgium). In all these stands, the average girth of the trees ranged between 140 and 160 cm, whilst their age (from plantation) ranged from 38 to 66 years old: These stands are thus representative of very contrasted sylvicultural management practices. In the most dynamic stand, Mean Annual Girth Increment exceeds 4cm/year, whereas it is lower than 2.5cm/year in the stand with the most conservative management. In terms of tree growth, the Mean Ring Width ranges between ca 3 and 7mm. The mass losses caused by the wood decaying fungus Poria placenta were assessed according to Cen/ts 15083-1 (2005). Globally, 624 tests specimens were taken from two radial positions in each tree. Half of the specimens were taken close to sapwood; the other half enclosing the 20 years old ring, counting from the pith. The natural durability of the wood is discussed as affected by growth rate, sites, trees and radial positions in tree.

Keywords: Douglas-fir, natural durability, growth rate, radial position

OP171

Wood Property Variations of Indian Teak Provenances

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The Indian teak provenances were clearly differentiated from the rest of the world populations by several studies. Wood property variations of Indian teak provenances from 23 geographic locations were studied with references to growth rate, heartwood proportion, wood colour, density, extractive content, lignin and anatomical variations in order to utilise the provenance variations for future tree improvement programmes. A total of 150 samples from 82 trees of various ages were collected from the natural teak populations of the moist and dry deciduous forests of 10 Indian states, viz., Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, Adhra Pradesh, Kerala, Gujarat, Orissa, Chhattisgarh and Rajasthan. The distinct age group of the collected samples were: Age group I (upto 24 yrs); II (25-34 yrs); III (35-44 yrs); IV (45-54 yrs) and V (>55 yrs) for studying various wood properties. The analysis of variance (ANOVA) revealed that there was significant difference between provenances with respect to diameter of trees at breast height (dbh), heartwood percentage, ring width and basic density for all the age classes taken separately and together. Tree diameter at dbh of all the trees showed a positive relationship with age and heartwood percentage. Higher growth rate with mean ring width of above 4.7 mm and greater heartwood content (>90%) were recorded in trees grown in the southern Indian states like Kerala, Tamil Nadu and Karnataka. The Teli variety teak from Karnataka showed highest percentage of heartwood (about 93%) in age class II and III despite small log size. Nilambur provenance from Kerala produced large diameter logs (72.5 cm) having high proportion of heartwood (94.8%) with wider growth rings indicating high growth rate at the rotation age above 55 years. Teak from drier areas of Central India produced 10-15% less heartwood with narrow rings and darker coloured wood than teak from high rainfall (2000-3500 mm/year) areas as evident from this study. However, for a given age

group, dbh and heartwood percentage varied considerably among the geographic locations implying the greater role of provenance in determining growth rate and heartwood content.

Basic density of wood stabilised after attaining maturity in age class I and thereafter it showed no significant variation except age related structural changes. The densest wood (692 kg/m3) was obtained from Banswara (Rajasthan) where the rainfall was less (853 mm/year) with small dimensional logs. And the lightest wood (473 kg/m3) was obtained in age group I (upto 24 yrs) from Khariar provenance (Orissa) due to faster growth rate with a wide early wood, large vessel diameter/percentage. Total extractive content increased with age and offers increased natural durability. Lignin content was found high in Burgi provenance (36.9%) from Madhya Pradesh and the values are standard for mature tropical hardwoods indicating its relative mechanical properties. The study proved that the South Indian teak provenances showed superior wood quality attributes as well as growth characteristics suitable for future genetic conservation programmes.

Keywords: Teak provenance, heartwood content, ring width, growth rate, extractives, lignin

OP172

Teak bark as a source of new products: Fractioning and characterization of different granulometric fractions

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Teak (Tectona grandis) grows naturally in Southeast Asia and was introduced into other tropical and sub-tropical regions in Australia, Africa and Latin America. Teak is present in East Timor, an island in Southeast Asia, characterized by tropical and subtropical moist mountain forests totaling 507 thousand ha that represent 34.3% of the land area. In East Timor, an independent country since 2002, forests are considered strong drivers for economic development, since they include some valuable timber species, particularly teak.

The bark of Tectona grandis has not been previously characterized although the chemical composition of its wood has been. The valorisation and efficient use of waste products constitutes an increasingly important challenge for economically sustainable and environmentally friendly industrial processes. Bark from forest species represents one major biomass feedstock that is currently considered as an under valorized resource and often a solid residue in wood processing. Most of the bark is burnt in the mills where logs are debarked. Barks are rich in chemicals that could be used in a variety of fields, from pharmaceutical and bioactive compounds to green polymers and bio-based materials.

In this study we analyzed the chemical composition of teak bark, from trees collected from a pure teak stand located in the northeast of East Timor, after fractionating into different particle sizes and analyzed the potential of granulometric fractioning for selective component enrichment within a biorefinery route of bark use.

Keywords: Tectona grandis, bark, chemical composition, particle size

OP173

Wood quality of plantation teak (*Tectona grandis* L.f.) trees in Brazil

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Teak (Tectona grandis) is a highly valued durable tropical timber occurring in the natural forests of India, Thailand, Myanmar and Laos. Teak was introduced from different provenances of the natural range into many tropical regions of Africa and America. In Brazil, the species was introduced in 1930, in the Experimental Forest Station of Rio Claro, SP, but the first experimental plantations were started in 1959 in Piracicaba, SP, by the Department of Forest Science, University of Sao Paulo. At the end of the 60's extensive plantations of teak were initiated in Caceres, MS., where the climatic conditions are similar to those of the origin of the species. Under favorable conditions of climate and soil, the rotation cycle of teak in managed forests was reduced to 25-30 years as against the rotation period of 60-80 years in the region of origin.

In Brazil, the teak plantations occupied 10,000 ha in 1986 and currently 50,000 ha in the state of Mato Grosso, with expansion in other states (Amazonas, Acre, Rondonia, etc), in pure forest plantations and intercropping with other species in agroforestry systems. Total area of teak plantations in the world exceeds 3 million ha, largest area being the Asian countries and other tropical nations of Africa and America. The world production of teak wood is estimated at 3 million m3/year of which 90% concentrated in Asian countries and about 16% destined for the international market which is much less than the current demand, leading to a significant appreciation of its wood.

Teak wood from natural forests is known to be highly durable due to its peculiar anatomical, physical and chemical composition and less durable from short-rotation and fast-growing trees. The natural durability of commercially-grown teak wood was studied and correlated in several publications in the world literature. The ever increasing demand for teak timber has resulted in large scale plantations, it is necessary to analyze the variability of wood properties affecting the utilization potential of this valuable timber by the industries and end-users. Concerning the wood quality of teak from fast-growing plantations in Brazil, the routine laboratory procedures to analyze the wood properties has been applied in several research institutions. These analyses include qualitative assessment based on wood anatomy, characterization of juvenile-adult wood, heartwood-sapwood, growth defects (knots, reaction wood, pith, etc.), tree-ring features, in addition to the chemical, physical and mechanical properties. In this paper, the wood properties of fast-growing teak trees of Brazil were compared with the wood properties of older teak trees of Brazil and older teak trees obtained from other countries.

Keywords: wood quality, fast-growing teak trees, wood properties.

OP174

Tannic substances in *Tectona grandis* L. F.

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As secondary metabolites, tannins are phenolic compounds of great economic and ecological interest. They can be found in roots, flowers, fruits, leaves, barks and wood. In the industrial processing of wood, the barks and pieces of wood are discarded. For teak (Tectona grandis) from thinning, waste is even greater. Is necessary find other uses besides energy for materials from young forest stand with a diameter less than the industry standards, because it's a noble material with high investment.

In view of this, it is important to propose alternative uses for this raw material, such as tannins that have many applications. The objective of this study is examine the proportion of tannin in the bark and wood from first thinning of teak.

Were used five teak trees with 6 years old from Mato Grosso State, Brazil. The timbers were collected at 1.30 m above the ground (D1, 30m) with 50 cm in length. The bark was removed from the timber, and air dried and then ground in a mill type Willey. To determine the yield of condensed tannins from the bark and wood, was used the methodology described by Stiasny. The Stiasny index is a measure of the percentage of the extract that reacted with formaldehyde. The results showed 19% of Stiasny index for bark and 28% for wood. The yield for tannic substances was 1,61% for bark and 1,3% for Wood, the yield for non tannic substances was 5,25% for bark and 1,92% for wood. Thus the bark and wood of the first thinning of teak with 6 years old did not show good performance in tannin.

Thus it is possible to suggest other ways of using young teak forests. Woods with lower extractive content has the higher permeability, thereby the performance in the bonding process in better, using less chemical reagents for the production of fibers and the drying process tends to accelerate.

Keywords: Tectona grandis (Teak), first thinning, bark, wood, tannin

OP175

Nirs Tools for Prediction of Main Extractives Compounds of Teak (*Tectona grandis* L.) Heartwood

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Biochemical and physiological process which occurred during heartwood formation have consequences on wood properties such as colour, natural durability and some mechanical properties. However, it is very time-consuming to take measurements of extractives contents. Teak has been reported to contain 1-hydroxy-2-methyl-anthraquinone, 2-hydroxy-methyl-anthraquinone, 2-methyl-anthraquinone, lapachol, 1,4-naphthoquinone for the main compounds.

In teak, natural durability is ascribed to extractives. Consequently, it's possible to estimate natural durability by measurement of extractives indirectly. For the purposes of selection for the production of improved varieties, the number of samples to be measured rapidly exceeds the capacity of a traditional laboratory.

Near-infrared spectroscopy approach, based on spectral data and reference data, is a tool enabling many of the chemical properties of wood to be predicted and the number of laboratory measurements to be reduced exponentially. The issue here is a question of checking the effectiveness of NIRS tool to build models and predict the main extractive compounds of teak wood from Ivory Coast. We try to calibrate these chemical properties with Nirs spectral information measured on grounded wood.

The results show the possible use of NIRS to predict total phenol content and some main extractive compounds of teak heartwood as tectoquinone, 2-hydroxymethylanthraquinone, …

Consequently, after verification on other sets of teak samples, which may or may not be included in the prediction model, NIRS can be used to predict extractive compounds accurately for a large number of samples, making it possible to estimate natural durability indirectly and to include these characteristics in the selection criteria for classifying wood and high throughput phenotyping.

Keywords: wood extractives; Nirs; teck; polyphenol

OP176

Development of a quality control assessment method to predict properties of heat treated wood

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Heat treatment has been used to improve properties of non durable European species. Chemical modification of some of the wood components provides improved dimensional stability and biological performance against decay fungi while mechanical properties such as modulus of rupture are reduced. Quality control of commercially made thermally treated wood is one of the major challenge to allow its industrial development. The variability inherent within a wood species and between wood species, density and chemical compositions variation combined with the heat treatment parameters such as temperature duration and levels contribute to the production of heteregenous heat treated wood. The development of a heat treatment process by convection which monitor the weight changes during the process will facilitate and help in controlling, in understanding and predicting the properties of heat treated wood. Data collected from a pilot study of heat treated wood using conditions similar to commercial process show that hardwood species were more susceptible to thermal degradation as compared to softwood. It was also established that wood chemical composition is directly

connected to the percent of weight loss due to thermodegradation, allowing the use of chemical composition to predict fungi durability. Carbon and oxygen contents and/or oxygen to carbon ratio of heat treated wood can be therefore used as valuable markers to develop quality control assessment of heat treated wood.

Keywords: heat treatment, thermodegradation; mass loss; elemental composition, durability, treatment intensity; quality assessment; wood

OP177

Decay Resistance and Durability of hygro-thermally treated European hardwoods

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German Hardwoods, especially Beech (Fagus silvatica) and Ash (Fraxinus excelsior) are highly appreciated for interior use. but their use under changing humidity/outside climate conditions is limited due to relatively high swelling/shrinking coefficients and limited natural resistance to fungal decay. Thermal treatment may improve resistance to decay.

Extensive studies have been carried out on beech, ash and oak (Quercus petreae) samples on which . a hygrothermal pressure treatment (WTT) was applied with 2 temperature levels (160°, 180°C)

Durability tests according to ENV 807(CEN/TS 15083-1:soft-rotting micro-fungi-soil contact trials) and EN 113 (CEN/TS 15083-2:basidiomycetes-agar-block tests) were carried out for the assessment of durability in accordance with EN 350-1.

Compared to the untreated samples, the test specimens showed a significantly lower weight loss already at the 160° C level and was further reduced at 180°C. Accordingly and in line with CEN/TS 15083-1 an upgrade of the species from durability class 5 (DC 5: non-durable) to DC 2 (durable) in most cases or even to DC 1 (durable) in some cases was possible.

However all tests were carried out with defect-free small test samples, and a long-term testing of real-size specimen may be advised to verify these results.

Furthermore it must be considered that thermal treatment especially at the 180°C level reduces strength and elasticity properties, which limits the use of thermally treated products to non load bearing constructions like floors, decks ore wall claddings.

Keywords: Thermal treatment, durability,. fungal decay, European hardwoods,

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OP178

Differences between heat treated *Pinus pinaster* heartwood and sapwood

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Heat treatment is a well known process to improve the durability and dimensional stability of less noble wood. The treatment can be applied for heartwood unlike the traditional treatments based on impregnation due to the difficulty of impregnating heartwood.

Pure sapwood and pure heartwood samples were treated in an oven at 190ºC and 200ºC for 2h, 4h and 6h. Dimensional stability, measured as Anti Shrinking Efficiency (ASE) between 0% and 65% relative humidity, durability, mechanical resistance (MOE and MOR) and density were determined for both treated and untreated sapwood and heartwood.

One of the main differences between treated sapwood and heartwood was the presence of resin on the surface of the heartwood treated wood samples. The results showed that for the same treatment conditions the dimensional stability improved more for sapwood than for heartwood. However when the comparison is made at the same mass loss, the differences were not significant. ASEradial reached 80% for sapwood and 50% for heartwood while ASEtangential reached 50% and 40% respectively. In relation to mechanical properties, MOE increased slightly at the beginning of treatment decreasing afterwards. No significant differences were found between sapwood and heartwood. MOR decreased for both heartwood and sapwood reaching almost a 50% and 30% decrease for sapwood and heartwood respectively. Once again if the comparison is made at the same mass loss, no significant differences were found between sapwood and heartwood. Durability against Postia placenta was only evaluated, by the mini-block method, for sapwood and heartwood samples treated at 190ºC and 200ºC for 2h and 4h. A significant increase in durability was found for both heartwood and sapwood at the higher temperature and for heartwood only at 190º for 4h.

The results showed that the heat treatment is equally efficient for sapwood and heartwood when comparing at the same mass loss. Since temperature and treatment time influenced differently on heartwood and sapwood i.e. on mass loss, the extent of improvements varied between sapwood and heartwood with the same treatment conditions i.e. the improvement was higher for sapwood.

Keywords: Dimensional stability; durability; heartwood; heat treatment; mechanical properties; sapwood

OP179

Hydrogels incorporating boron for wood protection: a solution to reduce boron leachability without reduction of its biodisponibility

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Products used today for wood protection must fulfill to more and more environmental constraints, such as being of low toxicity in answer to the Biocidal Product Directory, but also to involve water-borne treatments to limit rejection of volatile organic compounds in the atmosphere.

Boron preservatives have been described as valuable alternatives for wood protection for non-ground contact applications. Disodium octaborate tetrahydrate (DOT), boric acid and borax are the most widely used boron-based wood preservatives. They possess many advantages such as being colourless, odourless, non corrosive, non flammable, inexpensive, having low vapour pressure and low toxicity for mammals and the environment, but suffer of an important drawback due to their high susceptibility to leaching which limits their use in outdoor applications.

Numerous studies have been described to reduce boron leachability involving mainly the use of organic chemicals to reduce boron solubility in water through formation of insoluble or hydrophobic complex. However, complexation reduced boron biodisponibility to fungi, limiting the application of such complex to develop antifungal treatment.

The objective of this work was to design supramolecular hydrogels, built on low-molecular-weight amphiphilic molecules and containing boron salts conferring fungicidal properties. Mixing boron with thermoreversible hydrogels allows the formation of a supra molecular network incorporating boron and important amount of water upon gelification of the solution when the temperature decreases. Hydrogels obtained from several amphiphilic peptides, pseudo-peptides or various gelling molecules of the same type were impregnated in pine wood block using vacuum pressure treatment and subjected to leaching. Results indicated that incorporation of boron salts in the hydrogel network, allowed to protect effectively wood from degradation caused by the brown rot fungus Poria placenta even after leaching. It was assumed that these hydrogels are able to fill the cell walls and the lumina of the tracheids limiting the leachability of boron salts when the wood is subjected to re-humidification.

Keywords: boron; decay; hydrogel; leachability; preservation; wood

OP180

Effects of Combined Boron-Impregnation and Oil-Heat Treatment on the Properties of Two Species of Philippine Wood

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The study investigated the effects of combined boron impregnation and oil heat treatment on the physical and mechanical properties as well as the resistance to subterranean termites of two species of Philippine wood. Swietenia macrophylla King and Paraserianthes falcataria (L.) Nielsen specimens treated with 5% disodium octoborate tetrahydrate (DOT) solution were heat-modified in virgin coconut oil at either 160 or 200°C for 2 hours. The effects of the combined treatment were compared to that of separate boron impregnation and oil heat treatment as well as to untreated specimens.

All treatments altered the color of the specimens. Oil heat treatment caused darkening of the two species which was more pronounced at higher temperature. Specimens impregnated with boron alone and those followed by oil heat treatment were lighter in color compared to those subjected to heat treatment alone. Oil heat treatment reduced the hygroscopicity and increased the dimensional stability of the two species which was improved at higher temperature. On the other hand, both boron impregnation and combined treatment had reverse effects.

Boron impregnation and oil heat treatment at 160°C caused slight improvement on the flexural modulus but both the toughness and flexural strength were negatively affected. On the other hand, heat treatment at 200°C as well as the combined treatments caused reductions on all the mechanical properties evaluated. However, the reductions caused by the combined treatments are lower compared to thermal modification alone.

Oil heat treatment was not enough to reduce termite's attack of Microcerotermes losbañosensis though specimens treated at 200°C had lower mass losses compared to those untreated and specimens treated at 160°C. The combine treatment improved the efficiency against termites which was attributed to the improved boron retention.

Keywords: boron-impregnation; oil heat treatment; Swietenia macrophylla; Paraserianthes falcataria, Microcerotermes losbañosensis

OP181

Innovative coating materials for wood and wood-based product protection: Nano-coating materials

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In the present comprehensive study, the potential use of nano-coating materials for wood and wood-based product protection was evaluated. The protective properties of several innovative nano-materials, including nanozycosil, nanozycofil, nanosilver and nanocaly (Sodium Montmorillonite "NaMMT") were investigated. Our results revealed that both nanozycosil and nanozycofil can improve water- and UV resistant properties of wood (Poplar wood, in the present study). In addition to weathering-resistance properties, they decreased air permeability and water vapor diffusivity through the wood. Nano-silver showed anti-mould behavior for Picea abies L. wood. Nano-clay successfully acted as fire-retardant material for Medium Density Fiberboard (MDF) and also decreased the rate of mass transfer. Overall, the nano-materials used in this research showed useful potential for environmental friendly protection of wood and wood-based materials against common degradation factors, such as weathering (UV and water absorption), water vapor diffusion, mould fungi and fire.

Keywords: Nano-coating material, wood protection, nanozycosil, nanozycofil, Nanosilver and nano-caly

OP182

Potential of Bioenergy Production from a Prosopis alba plantation in Northeastern Mexico

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The genus Prosopis comprises about 44 species of trees and shrubs, it occurs naturally in arid and semi-arid areas where it has been used by locals as a good source of timber, fuel and fodder. Prosopis species have the capacity to positively influence soils nutrition, thus improving the environmental conditions for themselves as well for other plants, animal and microorganisms. In this study the bioenergy forest potential of Prosopis alba planted in a degraded area in Northeast Mexico was determined. The plantation is located 24°18' N latitude and 99°05' W longitude, at an altitude of 600 m in the municipality of Linares, Nuevo León, México. Climatic condition in the area is semi-dry to sub humid and moderate warm, the mean annual temperature is higher to 18°C and soils are vertisols. Seedlings of P. alba were planted in summer of 1983 and distributed in contour lines, the distance between lines was 4 m and 1 m between plants, with a plantation density of 2500 trees ha-1. After 27 years of growth the following variables were measured: total height, basal diameter, diameter at breast, number of branches, number of tree per diametric category and the estimation of calorific value by using the average of 5000 kg cal kg-1. The data were processed in order to obtain the main forest growth indicators. Results showed an average of basal area of 228.50 m2 ha-1 and 27.24 m3 ha-1 of wood, two branches per tree, and the major percentage of diametric category were 5 cm and 10 cm with 44% and 50% respectively and with a calorific value of 455,453 MJkg-1 ha-1. Our results showed that this species can be an important source for bioenergy production especially in arid and semiarid lands; other important characteristics such as physical and mechanical wood properties will be determined in future research approaches.

Keywords: Prosopis alba, plantation, wood volume, calorific value.

OP183

Correlations between the *Eucalyptus* wood characteristics and the quality of its charcoal

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The researches about the determination of existent relations between wood characteristics and charcoal, mainly by non-destructive methods, are important to subsidy the most adequate uses of wood, as much as to understand which characteristics should be considered in the genetic improvement programs. The non-destructive methods may be very useful for cost and time decreases in the analysis of Eucalyptus clones for bioenergy and charcoal production. Therefore, multivariate canonical correlation analysis may be used to determine the inter-correlations that exist between the wood and charcoal characteristics and with the depth of the pin penetration of the pilodyn. The canonical correlation is a multivariate statistical procedure which allows verifying the existent correlations between two groups or variable sets (X and Y).

This work aimed to use the canonical correlation analysis to verify the existent associations between the group formed by wood characteristics and the group formed by plant charcoals of Eucalyptus clones. 7 Eucalyptus clones were used and 24 sample observations were performed. The multivariate test Lambda Wilds was used to evaluate the significance of the canonical roots together.

Only the first canonical function was significant and presented high canonical R2. This result shows the possibility of using this multivariate technical analysis for making inferences about the quality of Eucalyptus charcoal. As deeper the depth of the penetration of the pilodyn pin, the lower the basic density, lignin content, total extractives content and gravimetric yield in charcoal, but the higher the holocellulose content. There is a tendency of high lignin and total extractive contents and low holocellulose content being associated with higher high heating value and basic density. The gravimetric yield in charcoal is negatively related with holocellulose content and positively related to lignin and total extractives contents and basic density of wood.

Keywords: multivariate analysis; clones; bioenergy; biomass

OP184

Small-scale bioenergy production as an incentive for forest fire prevention: case of Portugal

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Abstract

Forest fuel is one of the main components determining forest fire behaviour and is the only one that can be managed efficiently to reduce forest fire risk. Fuel management strategy involves the application of different fuel treatment methods (fuel load and/or forest density reduction), resulting in significant economic costs. This, together with the predominance of small-parcel private ownership (97%), makes the problem of fuel management in Portugal extremely complex. Renewable energy policies have increased the economic value of forest biomass, creating incentives for fuel management and favorable conditions for efficient forest fire risk management. However, the adoption in Portugal of large-scale bioenergy production (thermoelectric power stations with a capacity of 10 to 30 MW), based mainly on the use of residual biomass, is still not sufficient in terms of forest fire risk management.

This research explores the concept of small-scale bioenergy production, which involves the installation of small (around 1MW) heating or combined heat and power plants in settlements and municipalities. Shrubland fuel, composed mainly of Chamaespartium tridentatum (40.35%) and Erica sp. (37.09%), and biomass from fuel treatment operations in stands where Eucalyptus Globulus and Pinus Pinaster are the predominant species, were considered as the main fuel for this bioenergy production system. The gross and net calorific values of these species, the annual accumulation of biomass, fuel harvesting costs and technology of bioenergy production from forest biomass were assessed and analyzed in order to evaluate the profitability of the small-scale bioenergy production system.

Keywords: bioenergy production, forest fire risk management, fuel management strategy, cost-benefit analysis

OP185

Phenolic compounds in the bark of species of *Eucalyptus spp*

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Phenolic compounds are originated from the secondary metabolism of plants and are essential for growth and reproduction, are also formed in conditions of stress, example of these components are tannins, which are produced by different organs of the plant, being found in greater quantities in the bark, which may constitute 20-40% of the dry mass of the bark of many tree species, which their extraction can be a viable alternative by promoting increased value added to the residue bark.

Aiming at a better use of waste, mostly in the form of bark and in view of that species of the genus Eucalyptus are of great importance for the economy, as it is widely planted,it was aimed to determine the yield of phenolic composite components in the shells of the genus Eucalyptus species.

It was used the bark of Eucalyptus grandis, Eucalyptus saligna, Eucalyptus dunni, Eucalyptus maculata, Eucalyptus cloeziana e Eucalyptus pilulares collected in the Universidade Federal de Lavras (UFLA), Brazil. Shells were collected from two trees per species. The trees belong to an experimental planting located on the UFLA campus. The shells were air dried, ground in Willey mill and its particles standardized in the granulometry of 60 mesh.

In preparation of the extracts, it was used the corresponding to 200 mg of dried and ground bark, which was extracted in 10mL of methanol at 50% in cold decoction and constant agitation for a period of 4 hours.

The dosing of total phenols was conducted according to the methodology Folin & Denis (1912) modified. The dosing of tannins was conducted by the method radial diffusion of Hagerman (1987) and the dosing of flavonoids was conducted in accordance with the procedure described by Stahl and Schild (1981) modified.

Following the order of the species described above the mean values of total phenols were: 0.53, 1.10, 5.25, 6.98, 8.04 and 0.89%; flavonoids were: 0.069, 0.180, 0.390, 0.216 , 0.189 and 0.097%. Only the species E. dunni, E. maculata e E. cloeziana, it was met tannins with average values of 3.83, 6.27 and 7.44%.

Keywords: Eucalyptus spp; phenols, flavonoids and tannins.

OP186

Flavonoid supplementation reduces extractives content on Eucalyptus urograndis trees

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Wood is the main source of terrestrial biomass production, and is expected to play a significant role in the future as a renewable and environmentally cost effective alternative feedstock to biofuel, fibers and solid wood products, as well as a major sink for excess atmospheric CO2. It is also the major feedstock for pulp and paper processing. In Brazil, pulp and paper industries have been efficiently fed by eucalyptus forests due to its rapid growth, adaptability and wood quality. In view of pulp and pa-

per production, elite trees can be defined as trees in which the wood has low lignin and extractives content and high polysaccharide (especially high cellulose) content. Wood extractives are undesirable in pulping processes due to its negative influence in the pulp yield and may be transformed into contaminants of products and equipments. They are polyphenolic groups, waxes, fatty acids, resins, soluble carbohydrates, etc. All of them combine to form a very little known soup, which affects not only the pulping process and the quality of products and processes, as some of them have even an environmental impact on effluents and aquatic life. Many experiments to produce better trees for pulp and paper production have been attempted either by breeding, genetic manipulation or nutritional management, such as flavonoid supplementation. The flavonoids are intermediates in phenylpropanoid metabolism in plants and its supplementation has been reported to have influence on lignification and growth on a large number of species by affecting the lignin pathway and metabolic processes.

Here we report results for flavonoid supplementation on young Eucalyptus urograndis trees. Samples were successively extracted with ethanol and water in a Soxhlet apparatus. Groups treated with direct flavonoid supplementation presented a significant reduction on extractives content when compared to control groups. This is an indication of the potential of flavonoid supplementation as a nutritional complement for forest industries regarding pulp and paper production.

Keywords: Flavonoid; extractives; Eucalyptus.

OP187

Potential Biomass Volumes from and uses for Beetle Killed Lodgepole Pine (*Pinus contorta* (Dougl. Ex. Loud.) from Colorado and Wyoming in the western United States

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The outbreak of mountain pine beetles in the western United States has left extensive areas of dead lodgepole pine, creating hazards to human health and property particularly along roads and within the Wildland Urban Interface (WUI). This situation has lead to calls for the government to take action. We estimated the amount and cost of biomass potentially generated by a hazard abatement program. Over the coming 10 years as much as 5.1 to 7.6 million oven-dry metric tons of dead lodgepole pine could become available. Total harvesting costs could exceed $US200 million. Given the length of time much of the material has already been dead, the rate at which treatments can be implemented, and the lack of sufficient primary processing infrastructure (sawmills or veneer mills) use of this material for higher value wood products is unlikely. Co-firing of coal fired power plants or other energy uses holds the potential to dispose of large amounts this material but the costs could be high. Chipping and hauling the material to an energy facility would add an additional $US135 to $US425 million depending on the location of the dead stand. So even though there is enough material to co-fire 5 typical power plants for 11 to 17 years the annual cost for each plant could range from $1.8 million to $7.2 million per year and this could be more than the cost of coal. This presentation examines the potential to include higher value wood product options as a way to reduce overall costs.

Keywords: Wood to energy, dead timber, wood utilization.

OP188

Study of the use of organosolv lignin as bio-preservative of wood

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The service life of wood depends on the species, use and environmental conditions of exposure. The treatment of wood protect it against degradation by xylophagous agents, enhancing the durability of material up to 10 times, and reducing the deforestation around 12.5%. In this way, the use of treatments is necessary because increases the service life of material and protect against xylophagous agents who degrade the wood. The study and development of new preservative products for wood are necessary in order to substitute heavy metals-based preservatives, such as CCA (Chromated Cooper Arsenate) that entails environmental risks.

Lignin is considered as a residue in pulp and paper production processes, being mainly used as fuel in the recovery boiler for energy generation. However, more valuable uses of lignin could be developed for several interesting applications such as bio-preservative activity.

In this context, the present study aimed to evaluate the properties of eucalyptus organosolv lignin, obtained by using 60% (v/v) ethanol/water solution, in a solid/liquid ratio of 1:10, at 180 C for 90 min. The resulting lignin samples were characterized by different analytical techniques such as FTIR, GPC, DSC and TGA. Furthermore, the antioxidant potential of lignin by ABTS and DPPH methods and the fungicide potential by ASTM D 2017 – 81 were analyzed.

The analyzed lignin showed neutralization and inhibition activities (antioxidant capacity). These characteristics demonstrated that lignin could be an excellent wood bio-preservative obtained from renewable sources.

Keywords: wood treatment, wood preservation, wood quality.

OP189

First Report on the Termiticidal Activity of Extracts of Annona squamosa (Annonaceae) Seeds and on its Active Constituent Squamocins.

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Termites inflict severe damage on wood and impede usage of several forest species. The biological metabolites could potentially replace synthetic termiticidal products which are becoming more restricted to use. Annona squamosa is well known for its edible fruits - tropical custard apple. Annonaceous tetrahydrofuran acetogenins have attracted much interest due to their broad range of biological activities, and seeds containing them are reported to show insecticidal and abortifacient properties.

Under the course our exploratory investigation of non food valuable products from less known forest species (here from Benin), the fractions obtained from defatted cake of Annona squamosa seeds with solvents covering a broad range of polarity, revealed a significant termiticidal activity, when applied at 5 - 10 mg/cm^2 (non-polar solvent) and 1.2 - 5 mg/cm^2 (case of a more polar solvent).

Based on the result (0: no attack) from the standard procedure EN 118, these extracts could be used for preserving wood under class of use number 1. A derivatization step with Kedde reagents A and B, elemental analysis C,H,O, HPLC/MS and proton NMR showed the presence of squamocin type acetogenins (MW 594 and 622 g/mole: C35H62O7 and C37H66O7) as main components of the most active fraction (100% mortality within 7 days for a sample applied at 2 mg/cm^2).

Additional work will be undertaken to confirm the structure of most active compounds in the extracts, and to check whether some Annona squamosa seed extracts (non timber products of sustainable management of native forest) could show even higher activity to protect wood under more adverse conditions and be alternative active natural products to synthetic compounds.

Keywords: Annona squamosa, acetogenins, termiticidal activity, wood preservation, Benin.

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OP190

Linseed oil based waterborne UV/air dual cured wood coatings

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In this study, the effect four kinds of curing process including UV irradiation, UV irradiation + air curing, air curing + UV irradiation, and air curing on the films properties of the linseed oil (LO) based waterborne dual cured wood coatings were examined. Modified linseed oil (MLO) was prepared by transesterification of glycerol(GL) and LO with the mole ratio of 1.0. The waterborne resin was synthesized from MLO, dimethylol propionic acid (DMPA) and isophorone diisocyanate (IPDI), hexamethylene diisocyanate (HDI) and hydroxyethyl methacrylate (HEMA) by acetone process for providing a resin with C=C bonds of acrylic acid and fatty acid, respectively. And then the resin was neutralized by triethylamine (TEA) and dispersed into water. After vacuum distillation to remove acetone, the waterborne resin was obtained. Raman and fourier transform infrared spectrometer (FTIR) were used to identify the formed products, and fundamental properties such as solid content, NCO content, molecular weight, viscosity, pH and particle size of the resin were also tested. The result showed that the waterborne resin was a pseudoplastic fluid and possessed reactive double bonds. The waterborne dual cured coatings were formulated by mixed the waterborne resin with photoinitiator Darocur 2959 and different Co, Zr and Ca metal dryer, respectively , for different curing processes. The waterborne dual cured coatings were cured through 4 kinds curing processes as mention above and the cured film properties were characterized. The results showed that the films properties such as hardness, tensile strength and heat resistance of the dual cured coating obtained from UV irradiation + air curing were equal to those of obtained from air curing. Furthermore, the elongation at break, bending resistance, gloss and weight retention of films from UV irradiation + air curing were better than those of air drying. The poor adhesion of traditional UV cured coating films could be improved by using the UV/Air dual cured coatings. As a conclusion, the linseed oil based waterborne UV/Air dual cured coating has a potential for using as a high efficiency, excellent performance and environmental protection wood coating.

Keywords: Dual cured; UV irradiation; Air drying; Wood coatings; Waterborne resin

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OP191

Wood-leather panels – A biological, fire retardant building material

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Facing increasing problems with raw materials supply for wood based panels recent developments in this field aim to diversify the material supply. Many attempts have been made to incorporate ligno-cellulosic materials such as straw (Han et al. 2001), rice husk (Leiva et al. 2007), bamboo or bagasse (Lee et al. 2006). The presented project focuses on a new way using waste residues from leather production for the development of a completely bio-based building material with improved material characteristics e.g. fire resistance.

Regarding the performance of wood -based panels, fire resistance is clearly among the largest issues. For instance, an untreated MDF panel shows a performance of D-s2,d0 according to the standard EN 13986 (M. Kaindl Holzindustrie), which means that the material is burning normally, shows smoking but creates no burning droplets. Comparatively new materials like fire-retardant MDF's are capable of showing a performance of B-s2,d0 which means that the material is fire retardant, shows smoking but creates no burning droplets (Finsa 2006). This performance is usually carried out by impregnation with inflammable salts such as borax.

Beside the price of such a material these materials always represent a mixture of natural and artificial resources which means merging a

biosphere material with a technosphere material according to the Cradle to Cradle principle defined by Braungart and MacDonough (McDonough und Braungart 2002).

For the development of the wood-leather panels the leather material used is originated from the trimming of tanned wet blue and wet white hides. Annually a remarkable amount of 0,2 mio tons of these residues is generated in Europe. At current this material can only be disposed in landfills as it is non-burning. For the production of the wood-leather panels, the leather particles were mixed with standard MDF fibres using a laboratory ploughshare mixer and panels were produced using an automated hot press.

The performance of the wood-leather panels was evaluated by benchmarking with a fire-retardant MDF B1by M. Kaindl Holzindustrie, Wals, Austria in a furnace with flame treatment according to the standard temperature curve. The wood-leather panel showed an optimum fire resistance of 27 min with a mixture of 50% wood and 50% leather. In comparison, the MDF B1 by Finsa, Spain showed only a resistance of 12 minutes. Higher leather content showed a slightly (23 min) weaker performance for 75% and a strongly (9 min) weaker performance for 100% . The benchmarked fire-retardant MDF showed a performance of 19 min. The presented wood-leather material thus enables to solve this problem by incorporating natural resources such as leather and wood.

The conducted experiments showed that a production of panels which can withstand fire like a fire-retardant MDF B1 is possible. They even showed the same performance of B-s2,d0 by using only the before-mentioned raw-materials. Additionally it was shown that the leather particles increased the mechanical properties such as internal bond and modulus of rupture.

Bearing in mind the-availability and the low price of the leather residues, the developed material shows the potential to create fire-retardant structures according to the principles of Cradle to Cradle with a remarkable price advantage.

For the building industry this new material could enable fire retardant constructions, dependant on material-thickness of (R)EI 30/60 etc with an eco-effective building material.

Keywords: wood, leather, wood-based panel, fire protection, flame retardant

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OP192

SWORFISH: Superb Wood Surface Finishing

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The main goal of the SWORFISH project is to establish the scientific and practical feasibility of creating novel technology for mechanical, thermal and chemical modification of wooden materials and manufacturing process to create superb wood-based materials and products. Such materials themselves will have selected physical and mechanical properties needed to satisfy certain end-use demands (e.g. extra-durability against insects, elevated abrasion resistance, fire self-extinguishing characteristics, antibacteria feature, self-cleaning, self-deodorizing, accumulation of emissions/particles/pollutants or attractive outlook with pleasant touch).

A real technological progress would be possible if benefit is taken of advanced material/process modelling and simulation techniques; not yet extensively used in manufacturing of wood products. Several state-of-the-art technologies are investigated including thermo-hydro-mechanical wood modification, optimized wood machining, innovative coating and surface treatments, among others. The experimental data acquired are collected and will be implemented in to numerical modes. On the other hand, by knowing appriori both; the surface characteristics (evaluated from wood by scanning techniques, like near-infrared spectroscopy) and expected surface performance, it could be possible to individualize the surface treatments by means of models developed within the SWORFISH project.

In parallel to modelling tasks, several experimental activities have been performed. An innovative surface characterization laboratory was established at IVALSA/CNR. Several unique devices were designed and assembled, including surface roughness scanners, gloss scanners, dedicated spectrometers and tension meters. Finally, an original artificial weathering machine simulating the real changes of climate such as seasons, day/nigh, rain, solar radiation and freezing the surface was constructed

Keywords: wood surface finishing, durability, wood modification

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OP193

Effect of preservative treatment on mechanical performance of round and square poles made of small diameter Scots pine

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The volume, annual growth and annual harvesting removal of Scots pine (Pinus sylvestris L.) timber in Finland are 1098, 45, and 23 million m3, respectively. A growing proportion of harvested timber originates from the first or second commercial thinning stands, which means that the average volume of logs gets smaller than is the case in conventional final felling stands. There is a need to find economically viable and high quality wood products that can be manufactured from this raw material. Small log volume means not only demands of increased efficiency for material handling in logistics and manufacturing processes, but also challenging wood properties such as high proportion of juvenile wood and sapwood. Due to these facts, products made of small diameter logs are prone to twist and check, and have poor durability against weather. These shortcomings can be improved by a number of preservation meth-

ods. In this study, we concentrated in pressure impregnation with copper based preservative, and pine oil impregnation. The objective of the study was to define the modulus of elasticity (MOE) and modulus of rupture (MOR) of non-treated, pressure impregnated and pine oil treated fencing poles in static bending.

The material originated from five stands in south-eastern Finland. We prepared two diameters of round poles (80 and 120 mm), and two square-sawn dimensions (50 x 50 mm and 100 x 100 mm). The material of 317 specimens was divided into three treatments. Treatment 1 was not impregnated, treatment 2 was impregnated into AB-class with copper-based preservative in commercial process, and treatment 3 was impregnated with pine oil using the process of Ekopine Ltd. After the impregnation, the specimens were further divided into two groups. The first one headed straight to the bending tests, and the other group was subjected to a relatively mild 14-day-long weather exposure test in a weather chamber. After the weather exposure test, also these specimens were tested in bending. The bending tests were done according to EN 408.

Unlike expected, both MOE and MOR of square sawn poles were clearly higher than those of round poles. The AB class pressure impregnated specimens had, on average, slightly lower strength than the other treatments. This was also the case with stiffness of round poles, whereas the square-shaped AB impregnated specimens had almost equal stiffness compared to the non treated and pine oil impregnated specimens. The analysis of the material tested in weather chamber is still in progress.

Keywords: pine oil impregnation, Pinus sylvestris, pressure impregnation, stiffness, strength

OP194

Tool Wear Mechanisms during the Cutting of Particleboards

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Tool wear and its associated costs during the machining of wood and wood-products is a primary concern for both manufacturers and tool suppliers. Although, tool wear has been extensively studied, reports on the wear characteristics of newer materials such as rubberwood and oil palm fiber-based products are limited. Therefore, a series of experiments were carried to determine tool wear, tool edge profile and tool edge temperature when cutting rubberwood and oil palm-based particleboards.

The experiments were carried out using a specially designed high speed lathe with cemented tungsten carbide tools, which machined a rotating disc of the experimental materials. Tool wear was interpolated from the measurement of cutting forces using a piezoelectric load cell, while the cutting temperature was recorded through thermocouples, specially attached to the knife inserts.

The results showed that the increase in principal cutting forces had a similar pattern with the wear of the tool edge as well as temperature increase at the tool edge, implying a direct relationship between cutting forces, tool wear and tool temperature. The cutting temperatures of 386°C for oil palm particleboard and 307°C for the rubberwood particleboard, suggests that the oil palm particleboard is harsher on the cutting tool compared to the rubberwood particleboard. However, the recorded tool temperatures are lower than the prevalent temperatures at the cutting zone in the workpiece, suggesting that high temperature wear phenomenon, such as oxidation, apart from mechanical wear are the predominant wear mechanisms when cutting particleboards. Further, the study also reveals that the use of specially designed cutting tools is necessary to counter the higher costs associated with the machining of oil palm particleboards.

Keywords: tool wear, rubberwood particleboard, oil palm-based particleboard, cemented tungsten carbide tool

OP195

Wear Characteristics Of High Speed Steel And Tungsten Caused By Extractive And Abrasive Material In Some Wood-Based Composites

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Tropical woods and wood-based materials are processed in large and increasing quantities in many countries for building constructions and decorative purposes. In the secondary wood manufacturing industry, where wood and wood-based materials are machined extensively, tool wear becomes an important economic parameter. Therefore, investigating their machining characteristics will lead to making better choices of cutting tool materials used to cut them. For many wood cutting processes, the interest of high speed tool steels and tungsten carbides remains very important because of their good tool edge accuracy and easy grinding. This paper presents the wear characteristics of SKH51 high speed steel and K10 tungsten carbide caused by extractive and abrasive materials present in wood-based composite of particle board, MDF, hardboard, wood-chip cement board, and oriented strand board (OSB). Experimental results showed that wearing of the cutting tools tested was determined by extractive and silica contained in the wood composites. OSB contained extractive which was the most corrosive to the cutting tools. Wood-chip cement board, which is high in silica content, caused severe damages of the cutting edge of the SKH51 high speed steel. However, K10 tungsten carbide tool retained high wear resistance in cutting the tested wood-composites.

Keywords: wear resistance, high speed steel, tungsten carbide, silica, extractive, wood-composite

OP196

Burr Formation Characteristics in Side Milling with a Computerized Numerically Controlled Router

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Computerized numerically controlled (CNC) routers have been used under hard processing conditions with the aim of raising productivity. Therefore, tool wear progresses rapidly, and the burr formation occurs on surface of wood and wood based-material frequently. Because this burr formation greatly influences product quality and productivity, the investigation on the characteristics of burr formed by tool wear in processing is requested.

In this study, to obtain basic knowledge on burr formation, the side milling of wood with a CNC router by using wear bits and non-cutting bit were conducted under various side milling conditions, and the shape, area of burr were measured, respectively. In addition, the vibration during side milling was measured, and the correspondence between burr formation and vibration was examined.

The main results are summarized as follows: the differences of burr shapes were recognized with each side milling condition, and these shapes were classified into three types (string type, vertical type, and curl type). The burr area became larger with increasing bit wear regardless depth of groove. The high correlation was recognized between the vibration amplitudes and the burr area. From this result, it was suggested that the vibration of the work material in side milling is closely related to the burr formed by the progress of bit wear.

Keywords: CNC router; side milling, burr formation, bit wear

OP197

Wear of modified tools during peeling of MDF

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The aims of this study the improvement of tool wear resistance during peeling of MDF. The modifications of the active cutting surfaces by applying hard coatings (CrAlN, CrSiN) have already given promising results in routing of MDF. The limiting factor of applying these coatings was their adhesion to the carbide tools. To enhance it, a duplex treatment (nitriding + hard coating) were developed.

Nitriding treatments have been performed inside a low vacuum furnace equipped with an impulsive current generator. The CrAlN coating was carried out by a dual magnetron sputtering system.

The CrSiN films were deposited using DC/RF dual magnetron sputtering system. In order to study the effect of Si content on the CrSiN properties, two targets (50.8 mm of diameter) of Cr (99.99%) and Si (99.99%) were used. ADC and RF (13.56 MHz) generator were used to polarize the Cr and Si targets, respectively. The Cr target/substrate distance was 80mm while the Si target/substrate distance was only 70mm.

Wood machining tests were performed using a laboratory micro-lathe which permits to simulate the peeling process.

CrSiN coating showed an improvement in the wear resistance of the tools and resulted in unequivocally smoother surfaces as compared with other modifies tools.

Keywords: Peeling, Wear, Sputtering, Nitriding, MDF, Wood machining.

OP198

A novel approach to determination of cutting power while sawing of wood with circular saw blades

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In the classical approach, energetic effects (cutting forces and cutting power) of wood sawing process are generally calculated on the basis of the specific cutting resistance, which is in the case of wood cutting the function of more or less important factors. On the other hand, cutting forces (power) could be considered from a point of view of modern fracture mechanics. Cutting forces may be employed to determine not only toughness but also shear yield strength, which are then applied in the models. Analyses of changes in cutting resistance predicted by the cutting models derived from fracture mechanics, which include work of separation in addition to plasticity and friction, allowed us to explain the reasons for the increase in cutting pressure for small values of feed per tooth ('size effect'). Furthermore, forecasting of the shear plane angle for the cutting models, which include fracture toughness in addition to plasticity and friction, broaden possibilities of energetic effects modeling of the sawing process even for small values of the uncut chip.

Mentioned models are useful for estimation of energetic effects of sawing of every kinematics, as it was proved in the earlier our works. Nevertheless, for band saws and circular sawing machines the chip acceleration power variation as a function of mass flow and tool velocity ought to be included in analysis of sawing at larger cutting speeds. In this paper the forecasting method for determination of cutting power for sawing with circular saw blades is going to be described.

Keywords: Energetic effects, cutting power, wood sawing process, circular saw blade, fracture mechanics, fracture toughness

OP199

Analysis of chips production by slabber

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Wood chips are principally used in paper mill. Before fibre separation, logs must be cut into wood chips by slabbers so as to properly enter in the pulping process. To make the chipping process more efficient, one has to study carefully the coupling between the process parameters and chips quality. The main chips quality requirement is its geometry. It appears that many processes and materials parameters strongly influence the chip geometry. Although there is no slabbers' cutting model available yet. Particularly, the chip thickness could not be predicted.

The aims of this study are setting the parameters of the cutting environment geometry, filming the chip formation with a high speed camera. First, discussions with industrials gave information to set properly the geometry. A CAD software was used to set the parameters of the cutting environment. A layout was obtained. In a second step, a laboratory apparatus (Chardin's Pendulum) able to set cutting speed close to 7 m/s was in used. The cutting energy was also estimated to characterise the state of the cut. Finally a film was recorded on an industrial slabber.

Keywords: Chip, Slabber, High speed camera, Cutting forces, Fracture process

OP200

Mechanical properties of structural composite lumbers made from Aspen slash wood or bamboo

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The disposal of forest thinning residue, especially with diameter less than 100 mm, is one of major problems for sustainable forest management. There are a number of impediments to utilizing such small diameter woody biomass for value-added forest products. This study investigated the technical possibility of manufacturing composite lumbers from Aspen slash wood with diameter between 10 mm to 76 mm or bamboo culms for structural applications. The aspen slash and bamboo culms were crashed along their natural fiber orientation through the wood scirmber process. After drying, the crashed strand-like elements were soaked in the phenol formaldehyde resin for one minute. The resonated elements were then dried to moisture content of 7%, formed in a forming box with the elements oriented in their longitudinal direction, and hot pressed to a panel with 172.00 cm in length, 43.00 cm in width, and 3.81cm in thickness. For bamboo composite lumber, the crashed bamboo elements were also pretreated with mild Na2CO3 solution to remove its wax layer to improve the resin penetration. Due to the limited raw materials, the final size of bamboo composite is only 61.00 cm in length, 48.00 cm in width and 2.60 cm in thickness. Bending specimens were cut from the lumbers and evaluated for their mechanical performance in accordance with American standard test methods (ASTM D-198).

The results showed the edgewise modulus of elasticity (MOE), flatwise MOE and Modulus of Rupture (MOR) of Aspen slash wood structural lumber was 4.99 GPa, 5.24 GPa and 19.51 MPa respectively, when the average specimen density was 0.63 g/cm3. These corresponding properties would be improved to 6.58 GPa, 7.15 GPa and 28.71 MPa when the average density increased to 0.73 g/cm3. Bamboo composite lumber with higher average density of 1.02 g/cm3 showed much higher mechanical properties with average MOE of 12.58 GPa and MOR of 90.1 MPa. The Na2CO3 pretreatment of bamboo was found irrelevant in improving the overall performances of bamboo composite lumber. It was also noticed that the mechanical performance of the aspen slash composite lumber met the minimum requirements of structural sawn lumbers and could potentially provide an alternative for efficient forest management.

Keywords: Slash wood; bamboo; forest management; structural composite lumber; value-added.

OP201

Manufacturing of flat bamboo boards from half tubular bamboo culms

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To maximize the utilization of bamboo and to overcome a constraint due to its shape, an attempt was made to produce a flat bamboo board from a tubular bamboo culm (Dendrocalamus asper Backer). The half tubular bamboo specimen (3mm in thickness and 150 in length) was pressed under a constant load of 15N while being immersed in hot linseed oil at various temperatures (80°C to 180°C). Specimen height, used to calculate the degree of flatness, was measured as a function of time. Effects of initial moisture content and volume fraction of fiber of bamboo specimens on the flattening behavior were also examined. The flattened bamboo boards were later hot-pressed at temperatures between 180°C and 260°C under pressure of 650 kPa for up to 10 minutes. Springback of the fixed bamboo boards in an ambient air (28°C and 75%RH) was then assessed. It was shown that the water-saturated half tubular bamboo culms with an average fiber volume fraction of 55±5% were successfully flattened in hot linseed oil at temperature above 120°C without an immediate springback after load removal. However, an acceptable final degree of flatness of more than 90% could only be achieved at the linseed oil temperature of greater than 160°C. Without an additional fixation at high temperature, the flattened bamboo board continuously sprung back up to about 40% of its initial height prior to flattening. This level of springback could be reduced to below 5% by hot-pressed of the flattened bamboo boards at 260°C for 10 minutes.

Keywords: bamboo (Dendrocalamus asper Backer); flat bamboo board; linseed oil; fixation, springback.

OP202

Scavengers to reduce formaldehyde emission from wood-based panels

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Wood is a privileged way to stock CO2 in nature. During growth, carbon dioxide (CO2) is removed from the environment and incorporated in wood structure. The use of wood as biofuel would release carbon stoked during years. Stimulating the recycling of wood for the production of wood-based panels, will prevent this carbon of being released contributing for the carbon sequestration. Nowadays, particleboard industry uses 50 to 100 % of recycled wood; using wood-based products contributes to the global goal of greenhouse gases emission reduction.

Urea-formaldehyde resins are still the most commonly used adhesive to produce wood-based panels due to their high reactivity, low cost and excellent adhesion to wood. Nevertheless, their main disadvantage is the low resistance towards water and moisture, especially at high temperature, thus promoting hydrolysis of aminomethylene links and causing continuous formaldehyde released from the panel. Due to the recent classification of formaldehyde by the International Agency for research on Cancer (IARC) as "carcinogenic to humans (Group 1)", companies are compelled to produce low formaldehyde emission panels. Up to the present the reduction of formaldehyde to urea molar ratio was the common approach used but the minimum usable limit has been already reached. Other approaches were also applied with success as incorporating melamine in resin polymeric structure. Another approach to reduce formaldehyde emissions is using scavengers, but normally this approach is normally linked with the reduction of the physical properties of the panels. However, old panels presents itself formaldehyde from adhesive used that will contribute to formaldehyde emission of the new panels, reinforcing the used of formaldehyde scavengers.

The selection of chemical scavengers and process application are variables with critical impact in the reduction of formaldehyde emissions. The application of scavenger mixed with adhesive is the simplest approach, but the premature reaction of scavenger with formaldehyde penalises the cure reaction and therefore the physico-mechanical properties. Is this work, different procedures for the application of chemical scavengers are studied in order to understand the relevant reactions and mechanisms that occur during the hot-pressing. The main goal of this work is to find suitable systems for producing wood-based panels using formaldehyde based resins, with formaldehyde emissions at the same level as natural wood.

Keywords: Wood-based panels, formaldehyde emissions, formaldehyde scavengers, formaldehyde based resins

OP204

Eucalypt coppice management for multiple-use in South Africa

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Eucalypts were introduced into South Africa late in the 19th century, initially as a source of timber for the mining industry, but by the late 1980's they were most commonly planted for pulp. Due to the types of buds found in eucalypts (epicormic buds and/or lignotubers), most have the ability to regenerate coppice shoots after felling. Dependent on a number of criteria, the stepwise and selective thinning of these coppice shoots can be used for the re-establishment of commercial plantations. As such, all the past coppice management research in South Africa was exclusively focused on maximizing timber volume production alone.

To supplement the quantity of timber required by the larger companies for their pulp mills and/or chipping plants, additional timber supplies have been obtained from rurally based, small-scale timber growers that belong to various timber growing schemes. Although the average size of each of their planted areas is small (1.5 ha), collectively the large number of growers participating in these schemes provides an important source of timber to the commercial companies. Besides supplying timber to the commercial companies, the eucalypt coppice shoots/stems are also used by these small-scale timber growers for fencing (droppers and poles), building (laths or poles), or as a source of firewood. Thus, the management of these stands is varied, with no consensus amongst the different growers as to the best management practices for any specific product. It is therefore critical to determine the most effective manner in which coppice regrowth can be managed for multiple-use (fuel wood, droppers, building material, wood for pulp, etc.) rather than focusing on maximizing volume production alone.

In 2005, a trial was initiated in the sub-tropical region of Zululand, South Africa, on a recently felled Eucalyptus grandis x E. camaldulensis stand. Twelve different multiple-use management scenarios were tested against a commercial control over the subsequent 6 years. The most appropriate coppice systems are highlighted that include product-specific, as well as multiple-product options.

Keywords: building material; coppice; Eucalyptus; fencing material; rural communities

OP205

The Recovery Rate and Lumber Quality of Two Lesser Utilized Species (LUS) in Ghana: Essential Technical Measures to promote LUS

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With the dwindling volumes of the primary species and the 'acceptable' lesser used timber species due to overexploitation, there is scarcity of timber supply for both domestic in Ghana and international

market, thus reducing forest revenue to the economy. It has become necessary to promote Lesser Utilized timber in Ghana forest to replace those species that are being overexploited and threatened of being endangered. In this study, trees of two lesser utilized species: Cola gigantean and Ficus sur were extracted from dry semi-deciduous forest type in Ashanti region,Ghana. The recovery rate for both species were computed and the quality of produced assessed. Results revealed average recovery of four trees 44-84% for Ficus species whilst Cola gigantean recorded values 53-85% using both cant and live sawing patterns. The volume of log used were between 0.11m3 and Though with higher recovery The cola tree were difficult to saw and lumber produced were knotty with a proportion of decay.

OP207

Wood Properties of Acacia Hybrid and Second-Generation *Acacia mangium*

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In Malaysia Acacia mangium is the main plantation tree species as it has the desired qualities of timbers among fast growing tree species. However it has serious problem of diseases mainly heartrot and the tendency to produce an undesirable tree form. Currently new planting material of A. mangium has been introduced and planted in Sarawak that acquire many desirable properties such as faster growth, straighter bole, less tapering and resistant to heart-rot. The new breeds are known as Acacia hybrid (Acacia mangium x Acacia auriculiformis), which is meant to produce wood, and second-generation Acacia mangiun planted for fibre production to be used especially for making medium density fibreboard. Since they are new, little is known about their basic characteristics that determine the wood quality. The objectives of this paper were to examine physical and mechanical properties, fibre morphology and natural durability of Acacia hybrid and second-generation Acacia mangium planted in Sarawak, Malaysia. Five acacia trees of seven years-old were studied and sampled by cutting at DBH, 50%, 70% and 90% height of the clear bole. Results showed that basic density of Acacia hybrid and second-generation Acacia mangium was 472 kg/m3 and 336 kg/m3, respectively. The strength properties of second-generation Acacia mangium were significantly low compared to Acacia hybrid. The average fibre length and fibre wall thickness in the hybrid were 962 µm and 2.21 µm, respectively and were found to be greater than in second-generation Acacia mangium (901 µm and 1.88 µm). Fibre diameter (17.16 µm) and fibre lumen diameter (12.75 µm) in Acacia hybrid were smaller than that of second-generation Acacia mangium. The Runkel ratio of Acacia hybrid and second-generation Acacia mangium were 0.35 and 0.22, respectively. Acacia hybrid was more resistance to Coptotermes sp. attack than second-generation Acacia mangium. Laboratory soil block test showed that Acacia hybrid and second-generation Acacia mangium were moderately durable timbers. This study indicated that marked differences in wood properties and qualities between Acacia hybrid and second-generation Acacia mangium. Further study is required to accurately assess the wood properties of both Acacias because of variation effects due to locations, growth characteristics and silvicultural practices.

Keywords: Acacia hybrid; second-generation Acacia mangium; wood quality; plantation species

OP209

Radial variation of wood density and wood anatomical features from pith to bark in two clones and two different planting densities of Rubber tree (*Hevea brasiliensis*)

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The variability in wood cells sizes and distribution of the elements in the radial direction has engaged the attention of researchers for decades. Radial variations (pith to bark) of wood density and wood cells characteristics of two different clones of rubber tree [RRIM 2020(I), RRIM2025 (II)] and two planting densities [500 trees per hectare (I) and 2000 trees per hectare (II)] were investigated in a pilot plantation in Terengganu, Malaysia. Wood air-dry density was calculated by water displacement method and wood cell features were measured by image analysis on transverse microsections cut from radial strips sampled at 1.30 m tree height.

Air-dry density radially increased; 7% and 10% in clone I; 12% and 14% increase in clone II of respective planting densities. The fiber length showed 16% to 39% increase in clone I; 18% to 19% growth in clone II; fiber diameter values ranged from 26.33 to 32.54µm (23% increase) and 28.18 to 32.42µm (15% increase) in clone I; from 26.55 to 31.71µm (19% increase) and 27.78 to 34.70 (25% increase) for clone II; fiber lumen diameter ranged from 17.32 to 23.25µm (26% increase) and 17.01 to 24.09µm (42% increase) in clone I; and, in clone II, from 16.43 to 20.94µm (25% increase) and 20.01 to 26.56µm (33% increase), respectively. Fiber wall thickness also shows an increasing trend for both clones and planting densities. It ranged from 4.63 to 5.16µm (11% increase) and 4.08 to 4.63µm (14% increase) for clone I; and from 4.26 to 5.39µm (27% increase) and 3.89 to 4.10µm (5% increase) for clone II. Vessel frequencies and vessel areas radially showed a descending trend, whereas an ascending trend documented for vessel diameter. High values of vessel frequencies and areas were limited to the zone adjacent to the pith and therefore to the juvenile wood zone of stem cross-sections. The Ray count, height and width showed an increasing trend radially in both clones and planting densities. Intensive planting density negatively affects ray number.

Significant variation from pith to bark and between planting densities revealed the effect of cambial age and growth rate on wood element dimensions. Knowing the wood density and wood cell features gradient in radial direction help to differentiate the juvenile, transitional and mature wood. Identification of this zones are necessary in order to assess both the efficiency of procedures aimed at biological development of trees and the effect of cultivation measures on the quality of wood. Consequently, knowledge of the differentiation line between juvenile and mature wood in the stem cross section is important for both foresters and wood technologists.

Keywords: Radial variation; wood density; wood anatomy; rubber clone

OP211

Developmental Nano-Mecahnical Properties of Bamboo Fiber Cell Wall

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Bamboo is a traditional, second world crop after wood that is poised to be introduced as a new annually renewable source of industrial purpose in the so-called developed economies. As one of biomaterial, bamboo is the best raw material for structure in plant, because of its high strength, good elasticity, stable properties and low density. The comparing strength and comparing hardness of bamboo are higher than both of wood and common steel, and it is widely used in construction. The particular tissue of bamboo culms is the base of excellent mechanical properties of bamboo. Bamboo fiber cell is thick-wall cell, which is to compose vascular bundle, plays the main role to determine the mechanical properties of bamboo.

Nanoindentation has been used to characterize plant cell wall development, the effect of anisotropy, microfibril angle, and pyrolysis on mechanical properties, since it is firstly used to determine the hardness and Young's modulus of wood cell wall. In this paper, an in-situ imaging nanoindentation technique was used to investigate the mechanical characteristics and its radial changes of S2 wall, cell corner and cell middle lamella in bamboo Phyllostachys pubescens fiber development from 17 days to 6 years. Longitudinal MOE and hardness of S2 wall and cell corner was found to be highest in 4-year-old fiber. In micro-morphological regions of cell wall, longitudinal MOE and hardness of S2 wall was the highest with value of 22.25 GPa and 0.553 GPa in outer part of bamboo, and 21.05 GPa and 0.563 GPa in inner part of bamboo, respectively. Furthermore, the measured longitudinal MOE and hardness of cell corner and middle lamella were approximately 30%, 50% and 15%, 10% lower than S2 wall in the same age level, respectively. In matured bamboo, the longitudinal MOE of S2 wall and middle lamella decreased from the outer part to inner part of bamboo culms, while hardness of S2 wall and cell corner showed an alternative change tendency.

Keywords: Nanoindentation, bamboo, longitudinal elestic modulus, hardness, secondary wall, middle lamella, cell corner, mechanical property

OP212

Variability in Wood Properties: Implications for Processing and Utilisation

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Over the past 50 years there has been a trend of switching from old-growth forests to intensively managed plantations as a source of wood fibre. Nowadays there is a global trend towards managing these planted forests on increasingly shorter rotations due to the desire to achieve an earlier financial return from the investment made in growing these forests. At the same time there is an increasing demand from end-users of wood products in terms of product performance. In the case of solid timber, key performance characteristics include: strength; stiffness; dimensional stability; density; appearance; and workability. These performance characteristics are in turn affected by wood properties, such as microfibril angle, grain angle, tracheid length, cell wall thickness and chemical composition.

Radial and longitudinal variation in these wood properties has a major impact on wood utilisation, particularly wood from conifer forests grown on relatively short rotations. These forests contain trees with an increased proportion of juvenile wood, which generally yields timber with inferior properties. In the case of structural timber, material cut from the juvenile core has a higher likelihood of failing to meet the requirements for a particular strength class or grade. There is also considerable variation in wood properties between individual trees within stands and between stands. In order to best utilise the available forest resource, ensure the profitability of sawmills and meet customer expectations around product performance, better information is needed on the sources and extent of variation in timber mechanical properties and other quality measures. In addition, the ability to identify material that is unsuitable for producing structural timber at an early stage in the forest-to-mill supply chain would be beneficial to the forestry industry. This would allow forest growers to better understand the impacts that their management decisions have on end-product quality and it would also enable the industry to identify those trees or stands that are likely to yield poorer quality material.

This paper discusses the sources and extent of variation in selected wood properties and their implications for wood utilisation. The primary focus is on strength, stiffness and distortion of structural timber and how this is affected by variation in wood properties within and between trees. Approaches to material segregation at different points in the supply chain are also presented and discussed.

Keywords: Structural timber; segregation; wood properties; stiffness; strength; distortion

OP213

What non-destructive testing can tell us about genetic and phenotypic variability in wood quality

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Wood quality is influenced by a wide range of wood properties, with specific properties assuming greater importance depending on the product. Regardless of the product several specific wood properties are generally involved in determining product performance, hence a matrix of different wood properties is required to fully assess and understand how the wood of a given species will perform. Unfortunately many potentially important wood properties are difficult and time consuming to measure which often hinders our ability to understand wood variability and responses of wood properties to genetic and silvicultural manipulation. Fortunately several techniques (SilviScan, near infrared spectroscopy (NIR) and acoustics) are now available that facilitate the rapid, non-destructive assessment of wood properties that collectively have the potential to greatly improve our understanding, and knowledge of, wood property variation. Each technique has its advantages and disadvantages, for example, if detailed knowledge of radial variation is required,

then SilviScan presents the most suitable option. Alternatively if the number of trees requiring examination is in the low thousands and knowledge of radial variation is still required, albeit at lower resolution, then NIR spectroscopy or ultrasonics would be a better option. The various techniques are also complementary, for example SilviScan can provide wood property data at relatively low cost that can be used to calibrate an NIR spectrometer. Examples of how the techniques have been used to better understand genotypic and phenotypic variability in wood properties will also be described.

OP214

Variation of Wood Quality in Half-sib Families of *Picea jezoensis*

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Picea species is one of the important plantation species in subarctic regions. Picea jezoensis Carr. is naturally distributed in Hokkaido, northern part of Japan. The wood has been used for construction lumber, pulp, and instrumental materials. However, there are only a few researches on wood quality of this species from plantation. In addition, compared to other Picea species planted in northern Europe and Canada, tree breeding for wood quality of P. jezoensis has not been evaluated. Hence, it is important to clarify the basic wood properties and their genetic variation in P. jezoensis. The main objectives of the present study are 1) estimation of wood quality in P. jezoensis plantation trees and 2) clarifying genetic variation of half-sib families to apply the tree breeding programs for wood quality. Seeds from open-pollinated trees of P. jezoensis were collected from 4 different natural forests in Hokkaido. Sub-progeny test site was established at Chitose, Hokkaido, Japan (42°47´N and 141°28´E) in 1966 by using these seeds. A total of 254 trees from 10 plus-tree families were thinned in 2010. Before cutting down, stem diameter at 1.3 m above the ground was measured from each tree. Logs were collected from 1.3 to 2.3 m above the ground to measure dynamic Young's modulus of logs. Two disks were collected from these logs to measure annual ring width and basic density. Boards were also collected from the logs (from 1.3 to 1.75 m above the ground) to measure dynamic Young's modulus and static bending properties. Mean values of stem diameter, basic density, and dynamic Young's modulus of logs were 17.2 ± 4.8 cm, 0.33 ± 0.02 g/cm3, and 9.56 ± 1.24 GPa, respectively. Almost the same radial variation of dynamic Young's modulus was observed among families: it increased up to 15 rings from the pith and then became almost constant value. Dynamic Young's modulus (10.5 GPa) showed almost the same as those of other Picea species. Significant difference among families was found in dynamic Young's modulus of logs, indicating this species could also apply to the tree breeding for wood quality as same other Picea species.

Keywords: Picea jezoensis; tree breeding; genetic variation; mechanical property

OP215

New Approach of Chemical Distribution in a Frozen-Hydrated Wood Sample Using the Cryo-TOF-SIMS/SEM System

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Time-of-flight secondary ion mass spectrometry (TOF-SIMS) is a powerful tool for analyzing chemical distribution in plant tissue. We applied TOF-SIMS to the study analyzing the distribution of wood chemicals. In these studies, we used dried wood samples. However, during drying as part of the sample preparation, some artifacts could occur, due to the fact that water soluble chemicals could be moved, drained or changed at that time. In order to understand the function of chemicals in living trees, it is a key to accurately reveal chemical distribution in planta.

We developed the new Cryo-TOF-SIMS/SEM system to analyze the chemical distribution of frozen-hydrated samples. This new system consists of a glove box (GB), a cryo-scanning electron microscope (Cryo-SEM), and a TOF-SIMS with a cryo-stage, which were interconnected by a Cryo-vacuum-shuttle. After sample preparation in GB, the frozen-hydrated sample was kept in frozen state until all analysis with Cryo-TOF-SIMS and Cryo-SEM was finished.

Using this new system, we examined the detection of water with chemicals, and tried to obtain chemical distribution in frozen-hydrated Cryptomeria japonica wood. We analyzed potassium and ferruginol distribution in the heartwood of C. japonica, since potassium is a key element for vital plant activity, while ferruginol is known to be a major wood chemical of C. japonica and known to be contained in the heartwood. We succeeded in detecting water and these chemicals simultaneously in frozen-hydrated wood sample. The water was mainly distributed in cell lumina and a little in the cell wall. Potassium was distributed in the cell wall and in the axial parenchyma cells. Ferruginol was distributed in the cell walls of some tracheids.

These results indicated that potassium and ferruginol were not uniformly distributed in the C. japonica wood in planta. This new approach will be powerful tool to understanding the function of chemicals in living trees.

Keywords: TOF-SIMS; SEM; cryo; frozen-hydrated; wood

OP216

Plant Biorefinery for "Green" chemicals and biofuel

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By-products from agro-industrial activitie, invasive and energy dedicated crops offer a great opportunity for the development of environmentally friendly production of biofuels, green chemicals and biodegradable materials. However, in the plant cell wall the main components (lignin, cellulose and hemicelluloses) are strongly linked and this association limits the extent by which lignocellulosics can be used in industrial processes. To achieve the effective utilization of biomass, it's necessary to use pretreatment technologies to separate the main components. One of the major goals of optimizing a pretreatment process is the full recovery of the feedstock through optimum utilization of all components as marketable products.

In this presentation, we will describe the application of different pretreatment processes to three different plant resources: Miscanthus x giganteus, empty palm fruit bunches and Typha grass. The importance of the lignins structure and lignins recondensation during the pretreatment on the efficiency of subsequent delignification processes will be addressed. The resulting cellulose-rich material was evaluated by enzymatic hydrolysis and the lignin was characterized and used as lignin-based wood adhesives for the manufacture of wood particleboard.

OP217

High value chemicals from Eucalyptus Biomass Residues from Agro-forest and Pulping Industry

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Agro-forest and industrial exploitation of Eucalyptus species for pulp production is a very important sector in some country's economies. This sector generates considerable amounts of biomass residues, which are in large extent exploited for energy and power production in pulp mills. However, some of these residues contain high value chemicals in their compositions whose exploitation may be an important contribution to the up-grade of forest resources, within the concept of biorefinery integrated in the pulp and paper industry, without considerably disturbing their current application as energy sources.

Eucalyptus species are the dominant wood sources for pulp and paper production in south-western Europe (Portugal and Spain), South America (Brazil and Chile), South Africa, Japan and other countries.

Some years ago we reported that the lipophilic extractives of E. globulus bark are very rich in triterpenic acids, such as betulinic, ursolic and oleanolic acids, along with β-sitosterol and β-amyrin [1]. These triterpenoids, specially the triterpenic acids with ursane, oleanane and lupane skeletons, have shown promising nutraceutical and biological activities pointing to future practical applications [2, 3]. This finding prompted us to start a research program aiming to evaluate the potential of barks from other eucalyptus species, namely E. grandis and E. urograndis (E. grandis x E. urophylla) cultivated in Brazil, and E. maidenni, cultivated in Portugal, as sources of triterpenic acids [2-4]. The employment of environmentally friendly extraction and purification processes on its exploitation(e.g. based on supercritical CO2 extraction) were also evaluated.

A global overview of the main results obtained from the characterization of these biomass resources and on the extraction and purification methodologies under development will be presented in this communication.

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Keywords: Eucalyptus, bark, biomass residues, lipophilic extractives, triterpenic acids

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OP218

Lignin-Carbohydrate Complexes in Woody Biomass: Isolation, Characterization, Qualification and Their Impact on Enzymatic Hydrolysis of Polysaccharides for the Production of Bioethanol

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Woody biomass is a natural and renewable resource critical to the development of a sustainable global economy. In this respect, lignocellulosics have been considered as an alternative feedstock to producing biofuels. The main obstacle to producing biofuel from woody biomass is the recalcitrance of the biomass to releasing sugars in the cell wall. These structures create a significant hurdle in the efficient enzyme conversion of the feedstock. Among various physico-chemical recalcitrant structures proposed, lignin-carbohydrate complexes (LCC) are probably the least studied due to the difficulty in their characterization and quantification. A protocol for the identification and quantification of various LCC linkages in isolated lignin samples has been developed based on Nuclear magnetic resonance (NMR) techniques including a combination of 13C and 2D heteronuclear single quantum correlation (1H-13C HSQC).

Milled wood lignin (MWLc), cellulolytic enzyme lignin (CEL) and LCC-AcOH preparation were isolated from loblolly pine and sweetgum as a representative of softwood and hardwood, respectively. Three types of LCC linkages have been identified, namely phenyl glycoside, gamma-ester, and benzyl ether linkages. The amounts of these linkages in MWLc, CEL and LCC-AcOH are determined. While similar amount of benzyl ether linkage was found in both CEL and

MWLc of both woods, MWLc has higher amount of phenyl glycoside and gamma ester linkages the CEL. This is presumably due to the fact that all cellulolytic enzymes contains β-glycosidases and esterases. Loblolly pine has higher amounts of total LCC linkages, especially the benzyl ether linkage than sweet gum. Chips of loblolly pine and sweet gum were also pretreated with green liquor, a pretreatment process developed in our laboratory for woody plants. CEL was isolated from the pretreated pulps. While phenyl glycoside and gamma ester linkage are cleaved during the pretreatment, the benzyl ether linkages are preserved to some extent in both woods. Again, loblolly pine has higher amount of benzyl ether linkage than sweet gum. Correlations between LCC linkages and enzymatic hydrolysis will also be presented.

OP219

Influence of the pyrolysis temperature on the end-products obtained during the carbonization of *Eucalyptus* wood

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Charcoal Production and consumption from planted forests of Eucalyptus for manufacture of steel in Brazil has increased significantly in recent years. The charcoal quality is related to different factors such as the raw material nature and its carbonization process parameters. Carbonization process parameters considering the heating rate, final pyrolysis temperature and also pyrolyiss pressure used in the process.The final temperature of carbonization interferes significantly in the carbonization products and sub products, as well as in quality of charcoal. With the increased production of charcoal from planted forests of Eucalyptus the studies of the effect of temperature in the carbonization products are important. Thus, this study aimed to asses the influence of final temperature of carbonization on the end-products yields.Standardized samples were removed from four trees of Eucalyptus sp. The carbonization was conducted in experimental electric furnace adapted with water-cooled condenser and collection flask volatile condensable materials. The peak pyrolysis temperatures were equal to 500, 600, 700 and 800 °C. The gravimetric yields of charcoal, pyroligneous liquor and non-condensable gases were determined.The pyroligneous liquor yield, ie tar yield and non-condensable gases yield showed a significant difference only at higher temperatures of 700 °C and 800 °C. The charcoal yield varies between 27% and 34%, tending to decrease with increasing temperature. The average pyroligneous liquor yield is 45% and a non-condensable gas is 24.5%, both with variable behavior in relation to the carbonization temperature. The yields are consistent with those reported in the literature. Temperature of 500 ° C showed the optiumum result in trem of charcoal yield, but more investigation on charcoal quality at different pyrolysis temperatures are needed to define the best process parameters to bedefined for charcoal requirement in steelmaking.

Keywords: Gravimetric Yield, Pyroligneous liquor, Non Condensable, Charcoal.

OP220

Hydrodeoxygenation of Bio-oil in the Presence of Pd/C in Supercritical Ethanol

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Liquid pyrolytic products (bio-oil) produced by fast pyrolysis technology from yellow poplar wood was subjected to hydrodeoxygenation reaction to overcome disadvantages such as high water content and low heating value. Hydrodeoxygenation (HDO) of bio-oil was performed in supercritical ethanol under hydrogen atmosphere by using Pd/C catalyst at different temperatures (250-370°C), reaction time (40-120 min) and catalyst loading (0-6 wt%). After completion of the reaction, gas, char and liquid were obtained. In case of liquid phase two immiscible separations occurred (upper layer: light oil and lower layer: heavy oil).

The distribution of these products was heavily influenced by temperature, reaction time and catalyst loading. The upgraded oils were less acidic and contained less water than the raw bio-oil. Water content of the light oils and heavy oils at different conditions was 48.5 - 62.4 wt% and 0.4 - 1.9 wt%, respectively. The higher heating values of heavy oil were estimated to be between 28.7 MJ/kg and 37.4 MJ/kg, which were about twice the value of raw bio-oil. Elemental analysis of the liquid products showed that the heavy oil had lower O/C ratio which ranged from 0.17 to 0.36 than original bio-oil (0.71). The H/C ratio of heavy oil decreased from 1.50 (250°C) to 1.32 (370°C) with increasing of temperature and slightly increased from 1.26 (40 min) to 1.42 (90 min) for longer reaction time.

The highest yield of heavy oil was approximately 48.4 wt% (wet basis of starting bio-oil weight), with the reaction conditions of 250°C, 60 min of reaction time and 4 wt% of catalyst. But in this condition, the degree of deoxygenation was estimated to relatively low, which should be the reason for low calorific value (28.7 MJ/kg).

Keywords: Bio-oil; yellow poplar; upgrading; hydrodeoxygenetion; Pd/C catalyst oil

OP221

Microwave-treatment of frozen Wood Packaging Material

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Wood Packaging Materials (WPM) are known as preferential vectors of exotic forest pests and pathogens, which are nowadays major threats to the biodiversity and productivity of forest ecosystems.

As a preventing tool against biological invasions, ISPM15 (FAO, 2009) regulates the phytosanitary treatments that must be applied to WPM.

Two treatments are at present approved in ISPM15: Methyl Bromide fumigation and Heat Treatment. However, since the former is being phased out, the latter will be soon the only remaining method for WPM producers, which is an uncomfortable situation.

Fortunately, the ISPM15 Appendix 1 (currently under consultation by the IPPC signatory countries) is on the verge to approve the Dielectric Heating (DH) for the phytosanitation of WPM.

DH consists in irradiating wood with radio-frequencies (RF) or microwaves (MW), which generate the vibration of polar molecules (mainly water) contained in the material.

In the framework of the DH, 60°C must be achieved during at least 60s throughout the profile of the wood (i.e. 60°C/60s) in order to comply with the requirements of ISPM15 Appendix 1.

Due to the volumetric heating generated by RF and MW, as well as to the thermo-insulating properties of wood, it is generally considered that, when applying DH, the temperature inside the wood is higher than on its surface. This hypothesis makes possible the monitoring of the DH simply through the measurement of surface temperatures.

In our opinion however, the influence of wood properties on the relationship between surface and internal temperatures of DH-treated wood still requires investigations.

In particular, because ice and liquid water exhibit contrasting properties towards RF and MW, the heating pattern of frozen wood may be different as the one of thawed wood: This could have important implication on the efficiency and monitoring of DH when performed on frozen wood.

In this context, wood pieces were irradiated in a 28.8 kW oven, at 2.45 GHz (MW), and the impact of their cross-section, initial temperature and moisture content is discussed.

Keywords: wood packaging material; dielectric treatment; microwaves; ISPM15; frozen wood.

OP222

Wood for food packaging: state-of-the-art of the European regulations and ongoing research in France

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The European regulation n° 1935/2004 of the 27th of October 2004 indicates that materials meant for food contact must not interact with foodstuffs. In France, a ministerial order, issued on 15th of November 1945, lists the wood species that can be used in contact with foodstuffs, but without specifying how to demonstrate their suitability for that purpose.

Microbiological analysis of packaging or surfaces made of plastic or paper can be currently achieved because different sampling methods exist. However, no standard have been developed so far for wood, and there is a real lack of a recognized method for the microbiological analysis of this material. Many quantitative microbiological methods exist, such as agar-contact plates, swabbing analyse, or stomacher and ultrasonic sound methods. However, most of them only allow analysing the microbiological contamination of the surface of wood. One of the main challenges of the French Consortium EMABOIS is to develop new methods for microbiological analysis of the surface and/or the inner part of untreated wood used in contact with foodstuffs, allowing to remove microorganisms without endangering their viability, and to increase the yield of removed microorganisms compared to current test methods. The most promising analytical method aims to become a basis for developing specific European standards for assessing the sanitary quality of wood packaging.

A recognised method would help the wooden packaging manufacturers to guarantee the quality of their products in contact with foodstuffs and to promote the use of renewable and natural materials such as wood.

Keywords: wood, food packaging, quality control, microbiological methods

OP223

Detection of the Pinewood Nematode, *Bursaphelenchus xylophilus*: A challenge

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The pinewood nematode (PWN), Bursaphelenchus xylophilus, one of the most serious pathogens of pine trees, Pinus spp., is the causal agent of the pine wilt disease (PWD) and has been causing severe losses to pine forestry worldwide and economic damage. The transmission of the nematode from one tree to another is carried out by insects mainly of the genus Monochamus but the long-range spread of PWN occurs as a result of human activity in wood transport. The early detection of PWN in wood samples and in the insect vector is of primary importance not only to enable rapid actions but also to prevent the spread and introduction of this nematode into new areas and this can only be achieved by an efficient sampling and PWN reliable detection methods. Sampling procedures must focus on PWN and insect life cycles, PWN vertical distribution within the host tree and developmental stage of PWD. The detection methods usually used to identify and differentiate B. xylophilus from other species have been based on morphological and/or molecular markers, after nematodes extraction, from wood or insect samples, involving time consuming steps and requiring a high level of expertise on Bursaphelenchus taxonomy. Furthermore, the use of morphological characters offers limitations due to the intra-specific variability and morphological similarity with other Bursaphelenchus species. The majority of the molecular methods also require the nematode extraction from wood or insect samples, followed by the extraction of nematode DNA and amplification of PWN-specific genomic regions. Only a few have been described without the preliminary steps of nematodes extraction. In our laboratory, a new methodology was developed for the rapid and accurate detection of a single nematode directly from P. pinaster wood samples and from one entire insect vector, without nematode extraction, constituting an useful assay for the PWN detection, fundamental to define aspects of its control and management.

Keywords: Insect vector; Monochamus Pine wilt disease; molecular detection; pine wood

OP224

Coniferous bark heat treatment for the elimination of the pinewood nematode

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The pinewood nematode (PWN), Bursaphelenchus xylophilus, the causal agent of the pine wilt disease, is considered a quarantine organism by the European and Mediterranean Plant Protection Organization. The FAO/IPCC standard ISPM 15 defines the general requirements for PWN elimination from wood products by heat treatment with a minimum wood core temperature of 56ºC for 30 continuous minutes. Several studies have confirmed that natural heat treatment throughout a bark heap can provide temperatures above 60ºC. Therefore, the Portuguese authorities for agriculture and forest products (DGADR) defined specific technical requirements based on the natural heat treatment of coniferous bark for PWN elimination. Bark heaps are constituted with a minimum of 500 m3 and overturned three times, corresponding to four heating cycles, moving the exterior and bottom bark to the interior of the sequence heap. During the treatment, the heat is produced by specific bacteria and the temperature is controlled and monitored by minimum six temperature probes distributed throughout the heap. The temperature should be 60ºC in all probes during six hours, except in the last heating cycle where the minimum duration is three hours. After the treatment, the bark is screened for the presence of PWN and calibrated to remove woody debris. Calibrated bark of different sizes are collected and packaged. In order to validate this process, several experiments are being undertaken by a multidisciplinary research team in collaboration with the Portuguese industry and DGADR. The main objectives of this research are to investigate the phytosanitary risks of Pinus pinaster bark for PWN dissemination and to validate the natural heat treatment as process to eliminate the PWN. Furthermore, an industrial prototype is being constructed and tested as an alternative or a complement to the natural heat treatment which allows artificial heat treatment of bark based on steam. Results of this multidisciplinary research will be presented and discussed.

Keywords: Bark; Bursaphelenchus xylophilus; heat treatment; pinewood nematode, Pinus pinaster.

OP225

Termite resistance of wood impregnated with phenol-formaldehyde (PF) modified boron compounds

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In order to investigate the effect of phenol-formaldehyde (PF) modified boron compounds on termite resistance of two main plantation-grown wood species, namely, Masson pine (Pinus massoniana Lamb.) and Chinese fir (Cunninghamia lanceolata (Lamb.) Hook.), laboratory termite tests and field tests were carried out according to AWPA standard E1-97 and AWPC protocols/2007. Different concentrations of boric acid (BA), borax (BX), and disodium octaborate tetrahydrate (DOT) mixed with 20% aqueous solution of PF were used to impregnate the sapwood of both wood species. Formosan termite (Coptotermes formosanus Shiraki.) was used as the test termite in laboratory termite tests, while the field tests were carried out in Guangzhou, China. The results showed that the compound treatments of boron compounds with PF could efficiently improve the termite resistance of both wood species, especially the treatments by using BX. According to the laboratory termite tests, the untreated Masson pine and Chinese fir sapwood rated 5 and 4 (seriously attacked) with average weight losses of 29.3% and 43.7%. After treated with PF modified boron compounds with concentrations of 0.5, 1.0, 1.5, and 2.0%, the average weight losses were reduced to lower than 5.9, 5.1, 2.3, 1.2% for Masson pine and 7.6, 5.0, 1.8, 1.1% for Chinese fir, respectively. The performance of Masson pine in field test was much worse than Chinese fir by showing complete digestion by the termites. BX-PF treatment showed the best results in field test by reducing the average weight loss of Masson pine samples from 100% to lower than 6.1% or Chinese fir from 25.6% to lower than 8.6% at a BX concentration lower than 1.0%.

Keywords: wood; PF resin; boron compounds; termite resistance

OP226

Effect Of Chlorpyrifos As Fumigant On Wood Degrading Agencies: A Laboratory Test

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This paper intends to contribute to the efforts aimed at achieving sustainable environmentally benign of conventional synthetic wood preservatives. One alternative of these conventional preservatives is fumigant. Fumigants have been used around the world to reduce the threat of pest transmission in raw wood products. Some fumigants have also been successful to kill fungi. For this study, Chlorpyrifos, a well known termiticide, was tested against wood decaying fungi (Trametes versicolor and Oligoporus placentus) and wood destroying insect (Lyctus africanus) larvae under laboratory

conditions. Soft and hard wood blocks of specific size were fumigated with different concentrations of chlorpyrifos to test its fumigant activity. The activity of these fumigated blocks against fungi was evaluated through soil block bioassay test and against Lyctus larvae through larval transfer method. Soil block bioassay results revealed that chlorpyrifos exhibited effectiveness against fungal mycelium. Fungal susceptibility to fumigation varied by species. The results show that the chlorpyrifos is promising as a larvicidal agent against Lyctus africanus larvae. This treatment also prolonged the duration of the larval stage. Results clearly showed that chlorpyrifos could be an alternative for chemical pesticides.

Keywords: Fumigants, Hard wood, Oligoporus placentus, Soft wood, Trametes versicolor, Lyctus africanus

OP227

Wood Culture Education by Utilizing Various Ethnic Wood Musical Instruments in Japanese Elementary School

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Wood education, a Japanese national strategy, attempts to inspire all citizens to appreciate wood, wood products and wood culture. Japanese school education also emphasizes the nurturing of students who can intensify mutual understanding with others of different cultural backgrounds to promote better international interaction. This talk describes a case study in wood culture education which utilizes various ethnic wood musical instruments in a Japanese elementary school. These instruments are divided into four main groups of idiophones, membranophones, chordophones and aerophones. Ten types of small wood musical instrument kits; such as the Brazilian caxixi, the West African talking drum, and the Indian gopichand; were chosen as the educational components. These musical instruments had different wood species, interesting shapes, and diverse acoustics features and motivated the students to learn everything about these instruments. This motivation leads to a high interest in learning wood musical instruments and the regional cultural and religious background associated with these instruments. This activity for students to come in touch with different ethnic wood musical instruments is an effective way to focus both on wood education and inter-cultural understanding.

Keywords: drums, acoustics, students, gopichand, caxixi

OP228

The Wood Culture in Italy: Past, Present and Future

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In the next few years CO2 emission in the atmosphere must be reduced significantly. In the construction industry it will be necessary to build low carbon buildings. To accomplish this we must use renewable and natural materials that require low energy to produce. Also the energy consumed for heating and cooling the buildings needs to be minimized. This management will be easier if the buildings are well insulated and following the principles of bioclimatic architecture. To build in timber construction could be a good constructive and sustainable solution.

A building tradition in wood doesn't exist in the main part of Italy, limited to the Alpine regions, in north Italy, where wood has been always widely used prehistorically for the stilts to hold up buildings and then for the first houses on land. Until recently wooden buildings have been constructed mostly in the rural area and in mountain settlements. Today only 1.5 % of the new buildings in Italy are timber, although the ratio is growing.

The building systems most often used in Italy are "blockbau", "post and beam", "framed load bearing panels" and the "xlam system". The first and the second one evolve from traditional systems used from the Middle Ages in all of Europe. The third one is the evolution of the American "platform frame" in which the panels can also be precast in the factory. The "xlam system" is a new system that was introduced less than 25 years ago from Germany. With this system at moment in Italy houses are being built with two or three stories high quality thermal insulation and, consequentially, with low energy consumption. Recently houses have been built with 5-7 floors. A prototype of this type of building has been tested on vibrating platforms for severe earthquake with good results. Future development will be for buildings with 15-20 floors to solve the problem of social housing.

This spread of this new culture of timber buildings throughout Italy can provide a major contribution to sustainable building and limit the CO2 emission to the atmosphere. These new buildings will sequester 1.06 ton of CO2 for each cubic meter of timber used. Also good thermal behavior can contribute to save energy and consequently to reduce the use of the energy from non renewable sources.

Keywords: wood culture, building systems, sustainability.

OP229

Wood Science in Conservation of Cultural Heritage

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Cultural Heritage is formed by all material and intangible values of the cultural identity of a population and is determined by complex relationships between objects, symbols, personal and group identities. This concept is true for an ancient building or wooden works of art, as well as for a wooden tribal African mask. Wooden Cultural Heritage is also a repository of unspoken and traditional knowledge in which the spread has been interrupted after thousands of years. The preservation of this knowledge and these skills is absolutely necessary for not only preserving a nostalgic and marginalized view of the past, but also promoting creativity and development for the future. The preservation of this heritage has important implications in personal and group identities. Wood science can play a very important role in its continuation in the future.

Conservation of wooden artworks belonging to Cultural Heritage requires a thorough understanding of the material's history, structure, properties, behaviour, and degradation processes. Wood is a natural material of biological origin and features large variability in

the material itself (wood species, provenance, growth conditions, location in the trunk, singularities, etc.), in the processing methods (felling, sawing, axing, seasoning, treating, impregnating, connecting, gluing, painting etc.), in the types of objects manufactured (ranging from load-bearing timber structures to music instruments, from foundation poles to panel paintings, from furniture to weapons, from ships to land or air vehicles, etc.), and in the use and conservation conditions (indoors, outdoors, waterlogged wood, etc).

Studies in the conservation of Wooden Cultural objects apply important knowledge from wood science: examples are the mechano-sorptive behaviour of panel paintings or historical musical instruments, moisture diffusion and its implication to the relationships between environment and objects, or the effect of biological, chemical and physical agents in determining ageing phenomena in material. Work on individual materials is inseparably mixed from work on whole objects, on complex structures, on tangible and intangible values to be conserved.

Keywords: wooden artworks, wood physics, wood mechanics, traditional knowledge, cultural identity

OP230

Wood trade and use in the first Islamic foundation city in Cairo, Egypt

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Approximately 700 objects were analyzed from the IFAO excavations at Fustat – Istabl'Antar, the first Islamic installation in Cairo at the 7th century AD. Most of the objects were used in the daily lives of the local population and show an important aspect of how the new Islamic population organised their lives and how they mixed with the indigenous population. Wood anatomical analyses were carried out to show the continuity of new wood importations and use.

The amount of imported genus studied is a little more than half of the total. The indigenous species we saw at Fustat were various species of Acacia, Capparis, Caroub Tree (Ceratonia), Ficus sycomorus, Willow (Salix), Poplar (Populus), Sebesten (Cordia), Tamarisk and Thorn Tree (Ziziphus). The importance of wood trade at Fustat is verified because a little more than 50% of the objects studied there are made of imported wood. The important presence of Pine (Pinus) and Cedar (Cedrus), coniferous woods, followed by the Box wood (Buxus) and African Ebony (Dalbergia), which are hardwoods, has been noted. But we also found other coniferous woods such as Cypress (Cupressus), Juniper (Juniperus), Yew (Taxus) or Fir (Abies), and a great diversity of hardwoods such as Judas Tree (Cercis siliquastrum), Strawberry Tree (Arbutus), Oak (Quercus), Ebony (Diospyros), Ash (Fraxinus), Beech (Fagus), Walnut (Juglans), Common Hazel (Corylus), Olive Tree (Olea), Elm (Ulmus) or Teak (Tectona).

The Roman Period opened international trade and developed land and maritime trade routes. The Arabs continued this expansion. The silk, incense and cinnamon roads are well known because of the spices and resins trade, but the routes concerning wood are not as evident. The species such as Scots Pine and black pine arrived from the North; Anatolia or Europe. We do not have much evidence of trade with China. The Indian trade appears to be evidenced by the presence of Teak wood, and the east African coast by the different species of African Ebony and Ebony. The Ebony could have been provided by Madagascar, India or the East African Coast.

Keywords: wood anatomy, Islamic Period, wood trade, history, archaeology

OP231

A Special ancient technique in wood Art: Dovetail (Kundekari)

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"Kündekari" or tongue-and-groove joining is the name given to the technique of placing small pieces of wood side by side to form a design. The Ottomans used plain pieces of wood in place of geometric shapes. The Kündekari technique, of which the earliest examples were found in Egypt, Aleppo and Anain the12th century, involves fixing small geometric pieces together with grooves. The Kündekari technique, of which the earliest examples were found in Egypt, Aleppo and Anain the 12th century, involves fixing small geometric pieces together with grooves.

No nails or glues were used. The works of art created with this technique have survived today undamaged by the environment. The grains of individual pieces were placed crosswise, so moisture or heat would not pass from one to another. As a result, works of Kündekari art have remained in good condition, i.e. little swelling and shrinkage and smoothness throughout centuries. The 'Kündekâri' technique is used especially on large surfaces such as doors, shutters, pulpits and wood panelling. Pieces of wood cut in lozenge, star or octagonal shapes are joined together inside regularly hollowed out strips of wood in an interlocking pattern.

Keywords: grooves; dovetail; Ottoman; swelling; shrinkage

OP232

Holly trees in culture and religions of Iranian peoples

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Trees in Iranian culture have always been used with words such as holy tree, life tree and knowledge tree. Evergreen and deciduous trees are respectively symbols of permanent life and the material world that is continuously renewable. Iranian people before immigration of the Arians to Iran (about 4200 B.C.) have built their houses and agricultural equipment with wood. A high regard for trees was the one of main tenets in the Zoroaster religion (an Iranian traditional religion). The building of woody towers and war carts were important factors to success in the wars of the Achaemenidal empire age. The pictures of Palm and Cedar trees were seen on stone cuttings of the Persepolis palace as symbols of fertility and long life respectively. Wood was used in architecture, hunting, and music equipment in the Sassanid empire age.

After the introduction of the Islam religion to the country, the best woody art was seen in the doors, chairs, and woodcuttings describing religious teachings located in the mosque and other holy places. The names of some important trees are mentioned in the Holy Koran book such as Ficus, Olea, Palm, Ziziphus and are always recommend for planting and their conservation. These teachings resulted in many species of long living trees to be conserved as genetic reserves for the future. The secrets and mysteries of trees and wood always have been presented in words of the prophets; teach men and poets so that trees are the symbol of knowledge and wisdom in the world.

Keywords: tree, wood, Iranian culture, religion.

OP233

Wood and Forest Culture in the United States – Importance as Reflected by Art, Literature, Entertainment, and Folklore

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The United States (US) has had a rich history of forestry and forest products use since the settlers from Europe came to North America in the early 1600's. Forest products have been a major strategic asset and are critical to the social, economic, and ecological well being of the US. As the country developed, the importance of wood and forests was again and again reflected in the art, literature, folklore, theater, and movies.

Early popular folklore that helped to shape the popular views about forestry and forest products included stories about George Washington, Johnny Appleseed, and Paul Bunyan. Movies, such as Silent Running, presented philosophical views on the value of trees to our society. This presentation will focus on how "the arts" were influenced by and changed national attitudes towards forestry and forest products.

Keywords: Forest Products, forestry, history, movies, theater

OP234

Effect of Moisture Sorption State on Vibrational Properties of Wood

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Wood material can be schematically described as a two phase composite of elastic fibrils consisting of cellulose and a part of hemicellulose, and a viscoelastic matrix substance consisting of lignin and the remaining part of hemicellulose. Moisture has effect on almost all the physical and mechanical properties of wood. Since environmental conditions never remain stable and ambient relative humidity changes continuously, repeated adsorption and desorption of moisture takes place and moisture content of wood seldom reaches to equilibrium level with surroundings in fact. As wood behaves differently during adsorption and desorption, some of its properties are influenced by the state of sorption.

In this study, vibrational properties of Chinese fir (Cunninghamia lanceolata) wood were investigated as a function of changes in moisture content and grain direction. The dynamic cantilever vibration experiments were performed on specimens. Two anisotropic directions have been considered – parallel and perpendicular to grain. The dynamic modulus of elasticity (dynamic MOE) and log-decrement were examined during moisture adsorption and desorption processes. It was observed that the dynamic MOE and log-decrement in both the grain directions were affected by moisture content (MC). Dynamic MOE presented a maximum at around 8% MC. A continuous decrease of log-decrement was obtained with the increase of moisture content from 0 to 10% and the trend became concave upward. Dynamic MOE was higher during desorption process compared to adsorption process at a given moisture content, while the log-decrement showed an opposite trend. The vibrational properties were lower during moisture changing process compared to those measured at similar moisture content in a stable state. The parallel to grain direction showed a higher dynamic MOE and a lower log-decrement compared to those of perpendicular to grain direction. This vibrational anisotropy of wood may be attributed to the microscopic, macroscopic molecular as well as chemical constituents of wood.

Keywords: changing process of moisture, dynamic modulus of elasticity, log-decrement, anisotropic characteristics

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OP235

Assessing Quality of Wood by Spatial Variation of Transverse Elastic Properties of Wood Within the Stem

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Maritime pine (Pinus pinaster Ait.) wood accounts for about 30% of the forestland in Portugal (around 885x103 ha) corresponding to a total volume of raw material available of about 86x106 m3. This species has been used as firewood, pulpwood, pallet wood, and for boat building, construction, fencing and furniture making. However, despite its relative abundance and variety of applications, this important natural resource has not been efficiently used because there are still wood quality assessment problems. Namely, there is a lack of forestry programs in the majority of plantations which mostly belongs to smallholders and absence of quality grading parameters.

Wood quality is defined in terms of attributes that make it valuable for a given end use.

Density has been considered a suitable parameter to define wood quality. However for some end uses it does not represent the quality grades. For instance, for structural applications, it is more adequate to have a grade of wood quality based in terms of strength and stiffness.

In this work, both density and stiffness were proposed as indices for assessing wood quality of maritime pine for structural timber. The transverse elastic properties of both early and latewood and their spatial variability were determined in 750 specimens taken from five trees, aged from 60 to 68 year-old, harvested in Portugal central region.

X-ray microdensitometry measurements were carried out to assess the local density of wood, as well as the respective dimensions and fractions of the earlywood and the latewood layers within the growth rings.

Tensile tests at the growth ring scale were carried out. Specimens with nominal dimensions of 50(R)x5(T)x2(L) (mm) were tested on an Instron 5848 Microtester machine under a displacement rate of 0.2 mm/min. These tests were coupled with digital image correlation technique for assessing strain fields across the region of interest. Images were recorded by means of an 8-bit Baumer Optronic FWX20 camera (1624x1236 pixels, pixel size of 4.4 µm) coupled with a telecentric lens TC 2309.

With this study, it is intended to develop methodologies for quantifying the variability of maritime pine wood within the stem. Assessing this spatial information can be of major importance for wood modelling and end-user applications.

Keywords: Wood quality, density, transverse elastic properties; earlywood; latewood; variability; maritime pine.

OP236

Inter- / Inside-tree Variations of Reference Wood Characteristics of High Value-Added Central African Timber Species

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The Central African wood sector is characterised by a steady but sometime short-lived commercialisation of new timber species on the local market as well as for regional or international trading. Wood manufacturers must identify the most suited species according to their own processing constraints in relationship with the specific wood properties of the selected species. According to these operators, wood variations quite only correspond to differences between species.

However, important variations of physical and mechanical properties are observed on sawn timber, leading to bitter technological problems during processing. Some reference characteristics currently used to qualify technological behaviour of tropical species have been determined according to international standards or specific CIRAD's standard sampling procedure.

The analysis of the variations of some of these properties (shrinkages, fibre saturation point, hardness, Young's modulus) brought out the respective effect of several factors: basically, type of botanical species, but also differences between trees (linked to any diameter and age effect, even if very often, trees age is not known), and variations inside trees.

Inter-species variations are frequently very high, but for some Central African timbers (i.e. Cylicodiscus gabunensis / OKAN, Pterocarpus soyauxii / PADOUK, Staudtia stipitata / NIOVE), intra-species variations can be higher. In particular, it is usually considered that intra-trees variations have not to be taken into account for timber from natural forest, and only concern plantations species. However, high variations inside trees have been observed for some species explaining some technological problems occurring during processing.

These results shown that the study procedures to qualify tropical woods from plantations in one hand, and tropical woods from natural forests in the other hand, can be quite similar in some cases. Intra-species wood variations of timber from natural forest must be taken into account to improve appropriateness between their quality and their potential utilisation.

Keywords: Tropical wood; Central Africa; Wood Variability; Shrinkages; Fibre Saturation Point, Hardness, Young's modulus

OP237

Efficiency of pruning and thinning for three different eucalypt species managed for high value wood production

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Partially future demand of valuable hardwoods can be covered by plantation grown hardwoods with management dedicated to high quality sawlog production. Due to specific self-pruning of the genus Eucalyptus, high quality in short rotation plantations with relatively low target diameter can only be reached by implementing intense pruning strategies. The quality of wood products based on eucalypts at the world market is promising and might be judged as to be similar or superior to hardwood species. In a specific sawlog management regime an effective pruning system is essential for high value wood production. Short rotations and rather low target diameters make it absolutely necessary to concentrate the inner knotty core to a very small region around the pith.

In southern Brazil a considerable area of eucalypt plantations are managed for high value sawlog production. Wider initial spacing, frequent thinnings and several pruning regimes are applied to guarantee high value wood production. The tree growers wanted to know the size of the knotty core that can be expected for the different genetic materials when a standardized management system is applied.

From these areas 3 genetic materials have been selected. E.grandis and E.dunnii from seeds as well as a cloned hybrid of E.saligna x E.grandis, all managed after the same system:

- spacing: 2,8 x 5m

- pruning with 20 and 36 month up to 3m and 6m

- thinning at 24 and 60 month to 600 trees/ha and 333 trees/ha

For detailed analysis of the dimension of the knotty core 49 month old, pruned trees were cut, stem taper measured as well as proportion of wood and bark determined by an image analysis system. Cicatrisation has been analysed by cutting occluded pruned branches which were cut from the felled trees. The data were used to model knotty core of the 3 different genetic materials treated with 2 pruning lifts. The knotty core then was used to simulate the recovery rate of different sawing systems assuming several target diameters. The results are used to make economic analysis of the applied management system.

Keywords: wood properties, stem taper, pruning, knotty core, Eucalyptus, sawlog simulation

OP238

Forest Sustainability in Developing Countries

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World's forests cover about 40 million square kilometres, 30% of the total world's land area. The topical region (South America and Caribbean, West and Central Africa, South East Asia) contains 45% of the world's forest.

Mostly all of the countries in this region can be considered less developed or developing countries, where forests provide important resources for the livelihoods. The forest situation in less developed countries presents enormous challenges reflecting, the larger constraints of low income, weak policies and inadequately developed institutions.

The Sustainable Management of the Forest (SFM) is a general issue. Forest loss is taking place at annual rate within 0.5 and 2% depending from the country (ITTO2005) and the growing population and rising prices of food and energy might even exacerbate the situation. Illegal logging is still a relevant portion of the total wood harvested. Between 1990 and 2005 only in Ghana indiscriminate exploitation of the forest areas led to a 26% loss (2 million hectares) of the total initial surface with an annual change rate equal to -2 % one of the highest in African continent and even the whole world (FAO2009).

Forests, in particular rainforests, play a key role in climate regulation. Deforestation results in 5.8 billion tonnes of CO2 equivalent being released into the atmosphere each year, accounting for up to 18% of greenhouse gas emissions globally.

Forests are the only proven method for removing significant amount of greenhouse gas from the atmosphere, with rainforests having the highest rates of sequestration. Approximately 96% of the emissions from deforestation are emitted by the developing nations of the tropics.

Nevertheless it is important to bear in mind that forests are essential to the wellbeing of the world's poorest societies. More than 1.6 billion people depend to varying degrees on forests for their livelihoods, such as for fuel, medicinal plants and food. Poverty is one of the major drivers of deforestation.

How all this issues can be integrated with specific examples of the current situation but also some ideas on how we can all contribute to achieve sustainable forests in developing countries are addressed in this lecture.

OP239

Possibilities and challenges of sustainable use of larch wood resources in the changing needs of homebuilding sectors and community in northern Japan

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Japanese larch (Larix kaempferi) is one of the major tree species in the artificial forests in northern Japan. In Hokkaido region, the northern most island of Japan with the land area of 8.3 million ha and the population of 5.5 million, larch plantations cover almost 30 % of the total area of artificial stands. The total amount of growing stock of this species in the region is ca. 93 million m3, of which 51 % is stocked in the mature stands over 40 years old. The annual log production of larch has increased during this decade, exceeding 2 million m3 in 2007 for the first time.

Currently, however, most of the uses of larch woods are limited to low-value-added products, such as transport materials (packaging, pallets etc.) and paper pulp. Less than 10 % of the larch logs are sawn for house and building construction in this region. Increase of larch wood supply to homebuilding sectors is desired, based on the recent technological advances of wood processing and innovation of timber distribution systems.

On the other hand, the required performance of contemporary houses has been raising year to year in terms of energy-efficiency, long-term durability or earthquake-proof safety etc. To meet the current and future required levels of housing performance, the quality and applicability of wooden structural members, larch timbers in this case, have to be re-evaluated.

Furthermore, in the coming aging society with fewer children, the quantitative demand of housing is expected to be diminished and the desired plans of a house will be also changed. Future prospects of housing demand in quantity and quality is indispensable for effective and sustainable supply of woods to homebuilding sectors.

To meet the above-mentioned various technical and social needs related to the sustainable use of larch woods in the housing sectors, we launched a collaborative research project in 2010. In this paper, we will present the background, overview, current progresses and future direction of the project.

Keywords: Larch; resource management; wood processing, housing performance, aging society

OP240

Fire and Carbon Dynamics of miombo woodlands in Niassa National Reserve, northern Mozambique

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Miombo woodlands are the most widespread forest type in southern Africa, covering approximately 3.2 million km2 and hosting ca. 100 million people, mostly rural dwellers depending on this ecosystem to meet their primary food, health and housing needs. Besides its social importance, miombo contributes to formal economies (providing valuable sources of wood) and plays an important role in energy, water and carbon balances.

Located in northern Mozambique, the Niassa National Reserve (NNR) extends over 42,000 km2 and embodies the largest and most pristine conservation area of Africa's deciduous miombo woodlands. It was established in the 1950's to protect important populations of wildlife species. With a low density of people and a high density of elephants and fires, NNR represents a key area to monitor the relationships between vegetation and environmental drivers, a crucial question in miombo woodlands.

As part of the Biodiversity Conservation Program of NNR, we have initiated a comprehensive interdisciplinary study, aiming at understanding miombo responses to land cover changes and associated disturbances. Using MODerate Resolution Imaging Spectroradiometer (MODIS) daily active fire and daily land-surface reflectance data, we have quantified the fire regime in NNR. The observed pattern of fire frequency distribution was a decreasing gradient from the east to west side, accompanied by a definite pattern of biomass dynamics that varies with the fire return interval. At the structural level, there was an inverse relationship between woody parameters and fire frequency. At the compositional level, typical miombo species [Julbernardia globiflora (Benth.) Troupin and Brachystegia spp.] may be replaced by Combretum spp., Terminalia sericea Burch. ex DC and Diplorhynchus condylocarpon (Muell. Arg.) Pichon. In spite of that, carbon stock analysis indicated that NNR is still a stable ecosystem. This is further supported by preliminary genetic diversity studies of some priority species. During the presentation, the main implications of this study will be addressed.

Keywords: Biodiversity, Carbon, Fire, Miombo woodlands, Niassa National Reserve

OP241

Invasions threatening eucalyptus and pine ecosystems in Portugal: role of disturbances and of native species

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Invasive Alien Species (IAS) are organisms non-native to an ecosystem which may cause economic and/or environmental harm, while also constituting a significant component of global environmental change.

In parallel with the global trend, invasions of forest ecosystems in Portugal by IAS, have sharply risen over the past decades and threaten both mixed woods and monospecific plantations. We analyse the present situation regarding invasiveness of two of the three most important production forest types: plantations of Eucalyptus sp. (mostly E. globulus), an exotic genus in Portugal, and of Pinus spp, mostly P. pinaster and P. pinea.

Over the past three decades, eucalyptus have been attacked by an increasing number of pests and diseases, causing economic impacts to productivity and requiring the adoption of complex measures of control, some of which based upon the use of exotic natural enemies. Regarding pine stands, although attacks by a few new pests and diseases have occurred, a major threat is posed by plant invasions, mainly by a sequence of species of Acacia, which easily reach the phases of establishment and spread.

Within this context, we analyse the role of disturbances, as well as of some native or previously naturalized species, which have successfully integrated the new food webs, like pollinators and seed dispersers, as facilitators of IAS success. Although the implementation of mitigation measures is not straightforward, we compare some forest management regimes which can contribute to contain the problem.

Keywords: invasive exotic species, eucalyptus plantations, pine plantations, management regimes

OP242

Life Cycle Inventory of Softwood Production in the Portuguese Forest

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The aim of this work is to generate generic life cycle inventory data for Portuguese softwood as material and as fuel.

The ecoinvent database was used where the principal assumptions were changed to include the Portuguese situation. New economic allocation and correction factors to include mass, energy, and carbon dioxide uptake from nature were calculated forming the new

inventory tables for round, industrial, and residual wood (Portuguese softwood). The Ecoindicator99 method was chosen to assess the environmental impact and to check the influence of the data adaptation on the life cycle impact assessment (LCIA) final results.

The study shows that differences exist between ecoinvent and Portuguese data for the softwood production in relation to tree species, yield of forest and time from planting trees to final harvesting, length and width of forest roads or total area and land use. The life cycle impact assessment results are completely different for all sorts of softwood: Portuguese round wood is better than ecoinvent round wood; and Portuguese industrial and residual wood are worse than ecoinvent industrial and residual wood.

Keywords: Portuguese softwood; wooden products; ecoinvent database; life cycle impact assessment (LCIA).

OP243

Entomophaga maimaiga – new biological agent in the integrated forest protection in Serbia

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The integral protection of forest implies the continuous application of the protective measures in the aim of the undisturbed growth and increment of trees, as well as the creation of the wood volume of the best possible quality, which implies the inclusive and maximum protection from the harmful effect of various abiotic and biotic factors.

In Serbia, where the forest complexes cover an area of 2.4 million hectares, with the wood volume which is 235 million square meters, gypsy moth is the main economically harmful outbreaking insect species. During the outbreak, the gypsy moth frequently spreads in the broadleaf forests which cover an area of several hundred thousand hectares. The defoliation caused by the caterpillar feeding led to the decrease in the increment, absence of seed production, physiological decay and desiccation of trees, as well as to the creation of conditions which were favourable to the attack of the phytopathogenic microorganisms, fungi and xylophageous insects.

Naturally occuring enthomopathogens are important regulatory factors in insect population. Entomopathogenic organisms, various types of viruses, microsporidia, bacteria, protozoa, fungi, nematodes, which can under the favourable conditions cause the massive insect mortality and are of great breeding capacity, normally live in nature. Epizootics caused by naturally occurring viral and fungal pathogens are often responsible for spectacular crashes of insect pest populations.

The entomopathogenic fungus Entomophaga maimaiga Hamber, Shimauzu & Soper (Entomophtorales: Entomophtoraceae) was isolated and described as the natural enemy of the gypsy moth in Japan, where it causes the periodical epizootias. It is also spread in some parts of China and the Russian Far East. E. maimaiga was introduced in North America in 1910-1911. Today it is very significant pathogen of gypsy moth in North America and in Canada. Bulgaria has been the third country in the world and the first one in Europe in which E. maimaiga was introduced successfully. The first epizootia of it occurred in 2005, and the latest ones were reported in the very vicinity of the Bulgarian borders with Serbia, Greece and Turkey.

In 2010, the higher mortality rate of the older gypsy moth larval instars was reported in the some forest complexes, in the culmination phase of the new outbreak of the gypsy moth in Serbia. By the field and laboratory studies of the causes of their death, the presence of conidia and resting spores of the entomopathogenic fungus E. maimaiga was reported in the dead caterpillars. It has been the first discovery of this kind in Serbia, i.e. Serbia is the third European country in which this fungus has been reported. It proved to be a powerful reducer of the population size of the gypsy moth, and in all cases it caused the collapse of the outbreak in 2011.

Keywords: Entomophaga maimaiga, epizootic in Serbia, gypsy moth

OP244

Tree social status influences tree-ring formation in a mature silver fir plantation

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Our knowledge about the influences of environmental factors on tree growth is principally based on the study of dominant trees. However, tree social status may influence tree growth, leading to differential responses to environmental conditions. Indeed, we have shown in a previous study that, in a closed conifer forest, stem diameter variations resulted from differences in the rate of xylem cell production more than in its duration. We have also shown that tree size interacts with environmental factors to control the timings, duration, and rate of cambial activity through functional processes involving source–sink relationships principally, but also hormonal controls. In this paper we aimed to determine whether the huge within-stand differences in growth rates and durations observed between trees belonging to different crown classes resulted in well-marked anatomical structures of the formed tree rings and distinct climate sensitivities.

Cambial activity and wood formation were monitored weekly from 2006 to 2008 for three crown classes (five dominant, five intermediate and five suppressed trees) in a 40-year-old silver fir (Abies alba Mill.) plantation near Nancy (France) using microcores. A meteorological station located close to the stand in an open field provided daily meteorological data.

Preliminary results confirmed distinct sensitivities to the climate between the three crown classes. On the other hand, densitometric and anatomic profiles were very similar between the three crown classes, the only significant differences being a lower value of the minimal density in dominant trees due to larger earlywood cells.

So, despite huge differences in growth rate, growth durations and climate sensitivities, trees from different crown classes showed very similar tree-ring structure, suggesting strong internal regulations of the concerned physiological processes. Further works are needed to show in details these regulations, to describe their mechanisms and to understand their importance in forest ecology.

Keywords: Cambial activity; forest-stand structure; silver fir (Abies alba); tree-ring formation: tree-to-tree competition; social status; wood anatomy; xylem cell differentiation; cliamate

OP245

Can the age of baldcypress (*Taxodium distichum*) trees be estimated?

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Baldcypress (Taxodium distichum Rich.) occurs in the southeastern United States and grows in various plant communities in dry or flooded soil. The trees can live for more than 2000 years but ageing them may be difficult because older trees are often hollow, and false growth rings and missing rings are common. Since the growth rate may change as the tree grows, one cannot use simple diameter to calculate the age of baldcypress trees. Brown and Montz cored between 2000 and 3000 baldcypress trees and developed a method to calculate the age of baldcypress in Louisiana, based on a variable growth rate. Trees <12 in (30.5 cm) must be cored because the growth rate is so changeable.

The system is as follows: a tree with a diameter of 12-16 in (30.5-40.6 cm) has 8 rings per inch of radius (RPI). A tree with a diameter of 17-24 in (43.2-60.9 cm) has 10 RPI, etc. The system can be used for trees up to 60 in (152.4 cm) in diameter. In this method, a tree with a diameter of 14 in (35.6 cm) would have a radius of 7 in x 8 RPI = 56 years. A tree with a diameter of 24 in (60.9 cm) would have a radius of 12 in x 10 RPI = 120 years.

Some of the trees Brown and Montz cored grew on the shore of Catahoula Lake in south Louisiana. We also cored baldcypress trees around Catahoula Lake, crossdated the cores, measured rings and aged the cores. We compared our results to those of Brown and Montz to assess the accuracy of their method.

OP246

Dendrochronological dating of Portuguese-Flemish paintings from the National Museum of Ancient Art

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The study is part of a recently approved research project PTDC/HIS-ARQ/117099/2010: "Development of long master tree-ring chronologies in Portugal - a tool for dating archeological findings and art pieces" funded by the Portuguese National Science Foundation. The project aims at starting to establish the first long master-dendrochronology(ies) in Portugal. Once established, these chronologies can be used as dating references for archeological findings and art pieces as well as for any other undated wood material.

The objective of the present work is to date, using dendrochronological methods, and to identify the wood species used in a set of Portuguese-Flemish paintings on wood panels, presumably dating from the 15th-16th centuries, from the collection of the National Museum of Ancient Art, in Lisbon, Portugal. Dendrochronology is a method for absolute dating of tree rings, with a high level of precision, allowing the dating of wooden artifacts.

The importance of Flemish painting in Portugal is a result of strong commercial and cultural relationships that were established in the 15th-16th centuries between Portugal and Flanders. There is evidence of the presence of Flemish painters, in the early 16th century, in shipyards and workshops in many cities of the Portuguese kingdom, especially in Lisbon, where the Court was based most of the year.

Master tree rings chronologies from the Baltic region will be used as a reference to date the paintings for two main reasons: the shipbuilding industry in the Portuguese Discoveries Period led to the importation of wood from abroad, particularly from Flanders and the Baltic region, thus allowing the use of this raw material for other purposes, notably in works of art, including painting; on the other hand, the existence of Portuguese trading posts in Flanders and Bruges, through the active role of economic and diplomats agents, encouraged the acquisition of many paintings by the Church and the Portuguese Court.

Keywords: dendrochronology, painting, Baltic, Flanders

OP247

Analysis of the tree-ring development along one cycle of cambial activity

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The growing awareness concerning the influence of environmental factors on tree´s growth, particularly under the threat of climate changes, fostered the design of a new method to study cambial activity and xylogenesis along the growing season, under the influence of Mediterranean climate. Unlike the currently used methods, that extract samples from the stem, this method is based on the collection of twigs from the crown, with the purpose of overcoming the disadvantages associated to other methods, such as the impact on tree, the associated cost, the lack of simplicity and of applicability to softwood and hardwood species.

The study includes seven hardwood and three softwood species. After microtome sectioning and staining (safranin and astrablue) techniques, the sections were photographed and analyzed, aiming at monitoring the ring development and defining the period of cambial activity.

The twigs revealed great differences in the radial growth, which might be associated to their particular position in the tree (proximity of leaves, source of photoassimilates) and/or to the effect of the different microclimates created in the crown. Also, difficulties arose when identifying the limits of the rings of most species, related to several factors such as presence of reaction wood, formation of false rings and of more than one ring per year. The method showed effectiveness in the study of cambial activity, revealing, however, limitations on the study of ring development, due to the impossibility of establishing a parallel between samples.

Keywords: vascular cambium, xylem, Mediterranean, twigs, growth-ring.

OP248

Microdensitometry of tropical wood using helical X-ray tomography: a proxy for dendroclimatology and forest management

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Nanowood is the latest multi-resolution X-ray tomography setup developed at UGCT, the Ghent University Centre for X-ray Tomography. It consists of an 8-axis motorized stage combined with two X-ray tubes and two X-ray detectors, specifically designed to obtain very high resolution scans as well as scans of larger objects. The system offers a large range of operation freedom, all combined in versatile acquisition routines (standard or fast scanning, tiling, helix, etc). It has a generic in-house developed CT scanner control software platform (Dierick et al. 2010) that allows full control of the scanner hardware. Reconstruction of the scans is performed with Octopus, a tomography reconstruction package for parallel and cone-beam geometry (Vlassenbroeck et al. 2007). The latest development includes GPU-based helix reconstruction, as such the scanner is suited for scanning elongated objects such as small sticks and drill cores in order to obtain 3D information on the growth rings and density from pith to bark. Since some time 2D microdensitometry is a known methodology, yet its 3D equivalent has only recently been explored. Especially in the field of tropical dendrochronology, with often difficult growth ring demarcation, the concept of microdensitometry in 3D can contribute to the study of growth cycles and the influence of the climate on wood formation. This approach can also assist in improved demarcation of growth rings for temperate wood species and visualization / quantification of wood anatomical traits such as vessels. The technique enables to compile and archive dendrochronological series, microdensitometrical profiles and in some cases vessel chronologies. Examples on limba (Terminalia superba), teak (Tectona grandis) and afrormosia (Pericopsis elata) illustrate the potential of the microdensitmetrical profiling while oak (Quercus spp.) is used to illustrate the potential of vessel quantification.

Keywords: Tropical wood; helical X-ray tomography; microdensitometry; dendrochronology; vessel quantification

OP249

A dendroecological approach for evaluating growth and production models in Stone pine in the south of Spain

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The impacts of climatic conditions in Stone pine growth rate in drought-prone areas and their relationship with cone production have not been properly evaluated in the rear edge taking into account the differential responses to climate change of local sites, time, stands and tree conditions. In this work these responses are evaluated assessing the changes in radial growth and production of plantations of Stone pine (Pinus pinea) in Sierra Morena (Andalusia).

Dendrochronological methods and General Linear Models (GLM) of basal area increment are used to study the responses of trees to site, stand and climatic conditions. In the study area, a minimum temperature rise and a decrease in spring and fall precipitation have led to drier conditions during the late twentieth century which culminated with a sequence of severe droughts (1994, 1995, 1999 and 2005) affecting directly to Stone pine growth and production. The Principal Compound Analysis (PCA) and Pearson Correlation showed three main components in order of importance (climate, structure and physiography) related with growth and production, respectively. Comparisons with the climatic records showed that the radial growth and cone production were influenced positively by spring precipitation in the current year and the previous autumnal precipitation; and negatively by winter minimum temperature in the current year.

High growth rate was associated with tree size (dbh), competition (low density), site conditions (north aspect) and climatic conditions (high fall precipitation and winter minimum temperature). The production model showed positive relationship with crown diameter, fall-winter precipitation, and minimum winter temperature; and negative with stand density, north aspect and slope. The annual variation in production could be explained largely by the climatic conditions during the three previous years before of the collected year. The relationship between growth and climate in the three previous years could be implicated in the mature process of cones.

The growth rate and cone production of Stone pine plantations in Sierra Morena could improve their future knowledge with the study of moving correlation between climate, stand structure and fixed factors like physiographic conditions

Keywords: basal area increment, dendrochronology, Mediterranean climate, mixed models, Pinus pinea, plantation, production.

Type of submission: Poster

Theme: Modelling growth and production Topic 11 Non wood forest products

Name of presenter: Cristina Prades

OP250

Mould growth on wood-based materials – a simulated in-service study

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Ten different wood-based materials - preservative-treated wood, fire retardant-treated wood, modified wood, WPCs and untreated references of pine sapwood and spruce were placed in three different environments; a cold pitched roof and two crawl spaces for periods of more than two years. The mould growth was analysed at five to seven month intervals in an effort to map the growth development. Simultaneously the relative humidity and temperature were logged. In the crawl spaces the thermally treated wood was the most susceptible to mould and had well developed growth after 6 months. None of the materials was able to withstand mould growth in the crawl spaces after 26 months exposure, though the preservative-treated WPC board only had the least amount of growth.

Keywords: mould, crawl space, modified wood, WPC

OP251

Serviceability of wooden guardrail members in the end-use condition

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The UV of sunlight and rain, snow and pollutants affect the wood exposed outdoor and above ground. Especially, UV and moisture is significant factor for wood weathering.

Generally, wooden element will decay at an expected life at 10 years. However, it is difficult to expect when the wooden rail element lose their serviceability in end-use condition exactly. The objectives of the study were to investigate the influence of treatment to the serviceability in end-use conditions from an above-ground exposure experiment as a potential inhibitor of weathering.

The test species was Pitch pine (Pinus rigida Mill). Two types of specimen used in this study, half-circle and circular hollow section (CHS) timber beams. The specimen size of half-circle timber beams were 140 and 160mm. And those of CHS timber were outer diameter 140 and 160 mm and inner diameter 85 and 105 mm. All specimens were 2,400 mm long. Timber specimens treated with ACQ and CB-HDO. The outdoor exposure test was located in the Korea for 2 years from 2009. Exposed specimens fixed on the post using the bolt with a 90˚to the south as the actual guardrail installation state. The guardrail consisted of 3 beams, steel post and connection block. The heights of hanging specimen were 300mm – lower part and 1, 100mm most higher parts from the above the ground surface to the bottom of the specimens. All specimens were measured each 3 months. The test methods to evaluate serviceability used visual inspection, weight loss, and static bending test.

Check of the end of the wood beam was observed and recorded during the weathering. A number of checks of the treated wood beams were lower than the untreated wood relatively. Regardless of the treatment type, wood treatment inhibited the check production. Also, weaker erosion of sapwood on the surface of the wood was observed. The UV and moisture caused a colour change of wood surface. The value ΔE for the untreated control was about 80, after then decreased 50, a clear indication of colour change after 2 years weathering. Both of the treated wood gave of a ΔE of 50, indicating that treatment slowed wood colour change. The surface MC was shown the little differences because of the weather, rain, snow etc. However, surface MC was not risen above fibre saturation point regardless of treatment. Because all specimens was not contact the ground directly, it has been installed after drying. The MOR and MOE obtained static bending test were not significant changes that the treatment had little or no meaningful effect on the mechanical behaviour before the outdoor exposures regardless of treatment and non-treatment.

Keywords: wood preservative, serviceability, ACQ, CB-HDO, pitch pine, CHS timber beam

OP252

In-Service Quality Assessment of Micronized Copper and Other Preservative Treated Wood Posts

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An in-service quality assessment was conducted on 1,820 southern pine posts treated with MCQ, ACQ, CA-B or CCA wood preservative in agricultural and residential applications. The inspections took place in seven Southeastern U.S. states in AWPA Deterioration Zones 4 and 5 during the spring of 2009 and 2010. Average time in service ranged from about two to four years for the MCQ and ACQ, to five and 15 years for the CA-B and CCA, respectively. Evidence of decay activity was found with each treatment: 3% of the MCQ, 9.7% of the ACQ, 5.5% of the CA-B treated posts. Data clearly show that performance of the MCQ treated posts in service for four to five years is at least comparable to ACQ treated posts, demonstrating MCQ to be an effective and viable micronized copper wood preservative system.

OP253

Effectiveness of CCA-C and CCB preservatives after a 30 years stake test

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The objective of this experiment was to assess the durability of four pine species treated with waterborne preservatives. In order to determinate this, a stake field test, following the IUFRO (International Union of Forestry Research Organizations) recommendations, was installed at Experimental Station of Luis Antonio (21º 32' S and 47º 42'W), State of São Paulo, Brazil.

Species under test were Slash Pine (Pinus elliottii var elliottii), Caribbean Pine (Pinus caribaea var hondurensis), Oocarpa Pine (Pinus oocarpa) and Benguet Pine (Pinus kesiya), as untreated (witness) as well treated with the preservatives CCA type C and CCB, in five retention levels (from 4.1 to 12.8 kg/m^3).

These material were inspected to evaluate the degree of attack by fungi and termites; after 8, 21 and 30 years of exposure. The results were plotted as decay index over time for all conditions (wood species and retention levels) in order to determine the mean service lives.

Differences observed among preservatives, retentions and wood species are discussed, demonstrating as main conclusions: a) the decay index presented a direct relationship to the level of retention; b) the lowest decay index (longer durability expectation) correspond to treatments with CCA-C in retentions above 8.0 kg/m^3; c) the CCB preservative showed a lower performance comparing to the CCA-C preservative.

Keywords: wood preservation; Pinus spp; CCA; CCB; field test; durability; service life.

OP254

Some Properties of Chemically Modified Sesenduk (*Endospermum malaccense*) Wood Exposed to Weathering

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The study presents the evaluation of some important properties of sesenduk (Endospermummalaccense) wood treated with propionic anhydride and exposed to outdoor conditions for up to one year. Defect free samples of sesenduk were extracted with a 3:1:1 (v/v) mixture of toluene, ethanol and acetone for 3 hours at temperature of 100°C. The samples were then modified at the same temperature for another 3 hours using propionic anhydride and 10% sodium formatsas catalyst before they were conditioned to an equilibrium moisture content of 12%. Modulus of elasticity (MOE), modulus of rupture (MOR) and compression strength parallel-to-grain orientation of the samples exposed to weathering were tested. Chemical treatment reduced the MOE but slightly increased the MOR and compression parallel-to-grain compared to those untreated samples. However, treated samples had higher strength properties than those of untreated ones i.e., a result of weathering. Modulus of elasticity, modulus of rupture and compression strength parallel-to-grain of treated samples at radial orientation were 20%, 31% and 62% higher than those of untreated at the end of one year outdoor expose, respectively. Weathering adversely influenced surface quality of the specimens for all exposure time. Results of statistical analysis showed that no significant difference was found in bending characteristics of the samples from tangential and radial grain orientations.

Keywords: Chemical modification, weathering, Endospermummalaccense, propionic anhydride

OP255

The effect on moisture content of water trapped in wood joints

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To predict the service life of a structure, a model where the exposure of a structure is compared to its resistance can be used. Which exposure and resistance parameters that are relevant depend on which materials the structure consist of. This approach, with an exposure and a resistance parameter, is similar to the one used in structural engineering where a load (exposure) is compared to the bearing capacity (resistance) of a structural element.

For wood outdoors the relevant exposure parameter is a combination of wood moisture content and temperature and the resistance parameter is the ability to withstand decay by rot fungi. This study concerns the exposure parameter of wood outdoors above ground. To predict moisture and temperature conditions in the wood from climate data, the macro climate (precipitation, temperature, RH etc.) needs to be transformed into a micro climate, i.e., the climate at the wood surface. The moisture and temperature conditions in the wood can then be calculated using heat and mass transfer models with the micro climate as boundary condition.

The micro climate is influenced by the design of a structure. If water is trapped in joints and stays on wood surfaces, the time during which water is absorbed by the wood increases as well as the risk for decay. The aim of this work is to provide information about the relationship between micro climate and wood moisture content. The study concerns structures exposed to liquid water where high moisture contents are reached. Three different types of joints were exposed to artificial rain in the laboratory. Three different gap sizes between the boards were tested for each joint type to create different micro climates at the wood surfaces. Both the micro climate (the duration of water on surfaces and in gaps) and moisture content profiles were monitored during wetting and drying. The measurements were performed using small glued resistance electrodes.

Keywords: durability; service life; duration; surface moisture; moisture content measurements; joints; wood; exposure

OP256

Toward sustainable bleaching of cellulosic pulps

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More than 100 millions tonnes of cellulosic pulps are bleached every year in the world by processes which use chlorine dioxide as the main bleaching agent and which then release chlorinated organics. Whether or not this practice has a negative effect on the environment and quality of the final products has been a matter of debate for more than 20 years. This presentation shows that the progress in the understanding of the bleaching chemistry makes it possible to soon design new and cheaper processes which will be exclusively based on oxygenated reagents issued from air as raw material, not contributing to any formation of chlorinated organics, and making easier the combustion of the organic materials dissolved during bleaching. The demonstration is based on the following findings:

-in the present industrial practice the quantity of applied bleaching chemicals is twice the theoretical quantity needed to destroy the coloured residual lignin.

-oxygen bleaching, which is today commonly performed before the application of chlorine dioxide, can be made more efficient by an appropriate change of the operating conditions.

-chlorine dioxide is very reluctant to destroy the coloured quinonic groups present in the cellulosic pulps before bleaching. Moreover it creates new quinones. As a result a large excess of chlorine dioxide is required to achieve a good bleaching.

-ozone, which is superior to chlorine dioxide in many aspects, should be involved in the process. Not only, on a weight basis, its delignification power is better, but also it destroys quinones and does not create new ones when it reacts with lignin.

-part of the lignin is retained in the pulp by covalent bonding to the carbohydrates, which contributes to the over-consumption of bleaching chemicals. New acidolysis treatments can cleave these bonds and then facilitate the subsequent bleaching process.

As a result of these findings, bleaching processes involving the combined use of acidolysis, oxygen, peroxide and ozone delignification are proposed which should have the quality required to replace the present chlorine dioxide-based processes and to contribute to the better sustainability of the cellulose producing industry.

Keywords: Cellulosic pulps, bleaching process, bleaching chemistry, chlorine dioxide, oxygen, ozone

OP257

Optical, mechanical and effluent characteristics of Hydrogen peroxide bleaching of Chemi-Mechanical Pulp by Using Magnesium Hydroxide at medium consistency

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Traditionally, sodium hydroxide has been used as an alkali for hydrogen peroxide bleaching. But as a strong base, sodium hydroxide can cause carbohydrate dissolving particularly hemicelluloses, which leads to the formation of anionic trash, which is carried on to the wet- end of the paper machine. This can have negative consequences on papermaking operations, such as increased polymer/additive cost, reduced drainage and low product quality.

This research was done to determine substitution possibility of sodium hydroxide and sodium silicate by magnesium hydroxide as a weak source of alkali for hydrogen peroxide bleaching of CMP. Unbleached mixed hardwood CMP pulp was provided from Mazandaran Wood and Paper Industry. Bleaching was carried out by QP sequence. Pretreatment with DTPA was done as a chelating agent before bleaching stage on pulps. Bleaching were done at two levels of hydrogen peroxide(2,3%) and five levels of magnesium hydroxide (0.5, 1, 1.5, 2, 2.5). Control samples were bleached by using of 3% sodium silicate, 1.6, 2.1% sodium hydroxide and 2 , 3% hydrogen peroxide respectively. All pulps were bleached at 10% consistency and 70˚C for 150min. Results from optical, physical and strength properties in different levels of magnesium hydroxide and their comparisons with control samples show that Higher brightness was gained at 1.5% magnesium hydroxide by 3% hydrogen peroxide. In all levels of bleaching based on magnesium hydroxide, opacity had increased than control. In optimized treatment of bleaching system by Mg(OH)2, density of handsheet papers is decreased. Also strength properties had a less decrease than control. Also, chemical oxygen demand (COD) and Total Solid (T.S.) for Mg(OH)2 based bleaching had a striking decrease than control. Generally, results show that Mg(OH)2 can be effective replacement for sodium hydroxide and sodium silicate in hydrogen peroxide bleaching.

Keywords: Bleaching, Hydrogen Peroxide, Magnesium Hydroxide, Optical Properties, Chemical Oxygen Demand (COD).

OP258

The Effect of Hot Dispersion on the Physical Properties of Deinked Pulp

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A hot-dispersion facility peels away hornified outer fiber layers through the high temperature and the kneading force exerted by refiner disks to enhance the bonding potential and disintegrate residual shives, and eventually affecting the physical properties of the paper formed. The study used 100% deinked computer form paper and examined the effects of a mill hot-dispersion unit with temperature of 90~115°C and pulp consistency of 19~36% on the development of pulp properties. For the pulp properties, freeness, tensile, tear, bursting index and stiffness were examined. The results indicated that for the tensile and stiffness gain, a dispersion temperature of 100°C was optimal, while 90°C was the best for the bursting index and tear. And a screw-press consistency of 32% was the most suitable.

Keywords: deinked pulp bleaqching, disperser, sodium dithionite, formamidine sulfinic acid (FAS).

OP259

Spectroscopic techniques for evaluation of paper biodegradation rate

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Two types of pulps: cellulose and waste paper/recycled paper are principally used in modern paper production. As a result of re-pulping recovered fibres have poorer mechanical properties. Therefore, it is commonly accepted that fibres can be utilized only five to seven times before these becomes too short. Some additives (such as fresh fibbers or fillers) are necessary to enrich pulp and increase mechanical properties. Recently 90% of paper pulp is made of wood, however due to economic reasons wood pulp is currently complemented with other (than wood) fibrous materials.

Traditional analysis of chemical composition of ligno-cellulose materials are time consuming and costly. Besides, they belong to destructive methods what makes them considerably limited. Spectroscopic methods (FT-NIR and FT-IR-ATR) might be an alternative since there are non-destructive, relatively quick and not expensive.

Presented study reports investigation of various pulp additives (bran, starch and resinous glue) for determination biodegradation rate of different paper products. Laboratory handsheets were prepared on Rapid-Kötchen apparatus using tree types of pulps: deciduous, coniferous and recycled. Chaetomium globosum, and a mixture containing fungi Aspergillus niger, Penicillium funiculosum, Trichoderma viride were selected for mycological tests. The fungi growth rate has been visually estimated on 4, 7, 10, 14, and 21 days according to the four points scale. Determination of paper resistance (breaking length - relative humidity of papers sample: 7 ± 1%), was performed according to standard PN-EN ISO 1924-1:1992. Samples were additionally measured by means of FT-NIR and FT-IR-ATR spectroscopy.

The aim of this work was to examine additives influence for different types of pulp exposed for biodegradation. Estimation of degradation intensity were evaluated by near infrared and mid infrared spectroscopy and compared with two independent methods (standard method – using indexation for the fungi overgrowth degree, and measurement of resistance towards self-breaking of the examined paper products). Spectral analysis allowed band assignments to be made that showed which functional groups were affected by the microfungi and proved its potential in the characterisation of biodegradation processes for ligno-cellulosic materials.

Keywords: biodegradation, paper samples, microfungi, FT-NIR spectroscopy, FT-IR-ATR spectroscopy

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OP260

Comparative End-use Characterisation of Eucalypt Wood

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With the increasing global demand for energy and the declining reserves of fossil fuel there is considerable interest and investment in sustainably renewable resources to meet this demand. Although it has been suggested there is not enough available land to completely replace oil consumption with biofuels, the production of biofuels has increased considerably since 1980. The increase in production of wood pellets shows the interest in developing sustainable fuel supplies and wood remains central to this. During the lifetime of a forest plantation, waste thinning occurs to remove poor performing individual trees and to promote the growth of larger trees through less competition. Traditionally the residues from thinning had little use and ended up as waste. However the potential exists for the thinnings to be used for biofuel production, which would add value to plantations.

Eucalypts however are not grown for biofuel production as the true value lies in their solid wood or pulp wood end use. Intrinsic wood properties such as basic density, Kraft pulp yield, microfibril angle and modulus of elasticity result in particular end use being suited to individual species. To date this is well established for pulp and solid wood applications with some species better suited to one end use rather than the other. In order to determine the optimum end-use potential it is necessary to rapidly and non-destructively characterise the variety of eucalypt species for a number of end uses.

Several species of lesser-known Eucalypts were assessed via NIR spectroscopy to predict a number of physic-chemical properties (density, MFA, stiffness) and including new calibrations for calorific value and chemical composition. Using these predicted values the species were ranked for their potential end-use in three broad classes: solid wood, pulp wood or biofuel. In particular E. benthamii, which is currently being assessed as a potential biofuel feedstock in several regions of the world, had the highest calorific value and lowest pulp yield of the species measured.

Keywords: lignin, cellulose, MFA, stiffness, density, calorific value, NIR

OP261

Wood charcoal quality from forest harvesting residues of *Quercus sideroxyla* produced in Brazilian beehive ovens

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Charcoal is a solid fuel used worldwide and its main use is for cooking and industrial purposes. The production techniques, processes and sources of material used are important factors to consider as

they may determine quality of the charcoal obtained. Therefore, the use efficient production methods are required in order to compete with international markets and to improve life quality of rural producers. This study determined the quality of wood charcoal produced from Quercus sideroxyla wood branches and firewood in Brazilian beehive ovens. Two ovens were randomly selected each was loaded with a different kind of wood residue. At the end of the carbonization process, six samples of charcoal from the bottom, middle and upper of the oven were selected. Samples were placed in plastic bags to prevent moisture absorption during transport to the laboratory. Charcoal quality such as: percentage of moisture, volatile matter, ash and fixed carbon were determined according to the International Standard ASTM D 1762 to 1784.

Statistical analysis of results was carried out after transforming percentage values into the function of arcsine square root of each variable. A 2x3 factorial design was performed and the multiple average comparisons in Tukey were developed. Moisture results showed no significant differences between kinds of residues and oven levels, and percentages ranged from 3.2% to 3.8%, which is acceptable for international markets. The content of volatile materials showed highly significant differences ($p = 0.0008$) between kind of residues and levels of the oven. The highest content of volatile was obtained from branches at all three levels of the oven, the values ranged from 23.0% to 27.1%, which is considered high. In contrast, firewood charcoal presented acceptable values of 12.5%. The ash content showed no significant difference between residues and levels of the oven, the values ranged from 3.7% to 6.7%, they are also acceptable for the market. The fixed carbon showed highly significant differences between kinds of residues and levels of the oven. Most fixed carbon was obtained at the top of the oven by firewood with 78.8%, which is acceptable. Firewood charcoal produced in the middle and bottom of the oven was 70.1% and 72.2%, the lowest amount was obtained from branches with values ranging from 63.2% to 66.8%, which are low. The conclusions of this research are that charcoal from firewood produced in the upper part of the oven qualifies for international markets, while charcoal produced from the branches is rather heterogeneous and not good enough for the international market.

Keywords: charcoal quality, dendroenergy, forest residues, pirolisis.

OP262

Technological properties of canker-resistant cypress clones for timber production

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Mediterranean cypress (Cupressus sempervirens L.) has been widely cultivated for centuries throughout the Mediterranean region as a multipurpose tree and still plays a major role in the Italian landscape. Mainly used as ornamental, it has been also widely used for protective purposes due to its high plasticity and adaptability to poor soils and environments. At the same time, it is capable of considerable growths, achieving a high productivity. Moreover, cypress wood is also characterized by technological properties greatly appreciated as the fine texture, high natural durability and good mechanical and aesthetic qualities.

The extensive damages caused by cypress canker epidemics have limited the use of this tree during the last five decades and currently there is no a real market of cypress wood, mainly because of the short supply. Hence, the need of a new assessment of cypress for a productive forestry. The large availability of cypress genotypes selected for resistance to Seiridium cardinale canker, has provided the material for the further technological characterization of those clones potentially more suitable to be cultivated for timber production.

Totally, ten C. sempervirens var. horizontalis clones were sampled in two stands with different environmental conditions. Both growth, morphological and wood technological traits were measured to evaluate the performance showed by the selected genotypes in the two sites.

Generally, all the evaluated clones have proved suitable for timber production. They were characterized by an adequate growth rate, especially in the more favourable site. The fast growing was closely linked to the pedoclimatic conditions of the site, while the branch size and the development of the crown should be controlled appropriately by specific cultural practices.

The wood properties were rather stable across the sites, although higher growth rates were associated with lower wood density, but also with lower shrinkages.

The establishment of cypress plantation for timber production seems entirely possible, due to the availability of canker-resistant genotypes with high productive potential and suitable technological properties of cypress wood.

Keywords: Cupressus sempervirens; plantation; bark canker; wood material science

OP263

Wood and bark characteristics of *Acacia melanoxylon* grown in Portugal

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In Portugal, Acacia melanoxylon was introduced as an ornamental in the XIX century but its adaptation characteristics led to consider this species as an invasive.

The objective of this study is to evaluate some of the anatomical, physical and chemical features of A. melanoxylon wood to promote different uses.

The study was made on 20 trees with a 40 cm DBH class harvested from four sites (five trees in each site) in Portugal. Stem discs were taken at the base and at 5%, 15%, 35%, 50%, 65%, 75%, 85% and 90% of total tree height.

Wood and bark anatomy were studied using microtome sectioning and light microscopy observations. Fibre biometry of bark and wood were measured in macerated samples. Ring width and wood density were determined by microdensitometry.

Heartwood development along the stem was studied bay measuring cross sectional area and heartwood area by image analysis. The extractive content of heartwood and sapwood were determined at 5% (DBH) of total tree height by sequential solvent extraction.

Wood and bark structure of A. melanoxylon were described and illustrated by photomicrographs. Fibre length, diameter and wall thickness of bark and wood were 1.42/0.94mm, 18.07 /18.8µm, 5.2 /3.7µm, respectively. The average ring width was 5.27 mm and the ring density 0.656 g/cm3. The heartwood attained 81% of total tree height and at 5% height level heartwood represented 69% of the wood cross-sectional area. Sapwood and heartwood extractives were 4.2% and 7.9% respectively.

The results of density and fibre biometry suggested that A. melanoxylon should be considered as a valuable commercial timber species in Portugal namely for quality furniture and for the pulp industry.

Keywords: fibre biometry; heartwood; microdensitometry; extractive content.

OP264

Lignocellulosic biomass as potential raw material for wood composite manufacture

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There are many types of Lignocellulosic biomass (e.g. kenaf, bamboo, rice straw, oil palm,etc.). However if we consider their utilization to the wood industry, we do not know whether they can be used as raw material for wood composite manufacture or not.

Therefore, in this study, a new production process for wood composite such as binderless boards and their powder as a natural binder for plywood are introduced.

Bindeless boards have attracted great interest as environmental-friendly products, because they can be manufactured from fragments of lignocellulosic biomasses by hot pressing, without the addition of any adhesives. However there are few studies on manufacturing wood –based materials that consist of large element such as plywood and laminated lumber without adhesives, because the self-bonding capacity of lignocellulosic biomasses is still limited to the manufacture of binderless board, extraction, molding materials, and vibration welding. Although the research on binderless board is still in progress, these results have suggested that lignocellulosic biomasses can be used as a natural binder. Hence lignocellulosic biomasses powder was used as a binder to manufacture plywood.

As the results of experimental works, i.e. kenaf core, it was found that the kenaf core binderless boards showed higher mechanical and water resistant properties than urea-melamine formaldehyde resin bonded particleboards. Their bond durability was comparable to MDF for structural use.

Furthermore, mechanical and physical properties of binderless board manufactured from bamboo, rice straw, oil palm exceeded the minimum requirement of grade 15 type MDF by JIS A 5905.

For plywood, three –ply plywood that manufactured from sugi heartwood veneer bonded with powder of heartwood as binder met the requirements for the second grade of JAS for plywood.

It appears that manufacture of composite panels including particleboard, fiberboard and plywood from lignocellulosic biomass would be viable approach. Various studies were carried out to produce binderless panels and plywood from several lignocellulosic biomasses. This presentation will review some of the findings of experimental works carried out related to value added panel manufacture from several lignocellulosic biomasses.

Keywords: lignocellulosic biomass, composite panels, binderless, natural binder

OP266

Wood and forest culture in Brazil: *Caesalpinia echinata*, Brazilian wood, a connection with the history of the country

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Wood and forest culture represent a strong connection with the history of Brazil, whose name is derived from a traditional Brazilian tree species, Caesalpinia echinata, heavily exploited by the early settlers. When Portuguese navigators discovered Brazil, on April 22, 1500; they observed that brazilwood trees were abundant along the coast and the rivers of the new country. Brazilwood constituted a better source of a brilliant red dye at that time replacing the tropical Asian tree sappanwood (Caesalpinia sappan) native to India, Malaya and Sri Lanka, and imported into Europe in limited quantities from medieval times. In the following years, under a monopoly established by a Portuguese royal family, the first, intensive and organized operation for felling and shipping the brazilwood logs to Europe was established with the participation of the indigenous population. According to the historical documents this rich commerce stimulated other nations to harvest and illegally transport brazilwood out of Brazil and the corsairs to attack Portuguese ships to steal the brazilwood. In 1555, a French expedition invaded the colony for economic exploitation of brazilwood.

Brazilwood was first mentioned in the botanical literature in 1623, by Caspar Bauhim, a Swiss botanist, who published a long list of Brazilian plants in the early 17th century. In 1789, the French naturalist Lamarck described the main characteristics and named the tree species Caesalpinia echinata, which is still used today. The botanical specimen used for the first description is deposited in the Natural History Museum of Paris. This plant is also cited in the famous book Flora Brasiliensis by Carl Friedrich Philipp von Martius. However in the 18th century the excessive exploitation of brazilwood trees resulted in the cessation of brazilwood activity. Presently, the species is listed as an endangered species by the IUCN and also included in the official list of endangered flora of Brazil. The heartwood of brazilwood was used to make violin bows for more than two centuries and is known to bow makers and musicians as pernambuco wood. Today, some sites where pernambuco wood occurs naturally are legally protected. Therefore, new reserves must be created and surveys undertaken to locate remnant populations, and evaluate their genetic and diversity mechanisms. The presentation aims to recall the history of Brazilwood and its significance to the forest culture in Brazil.

Keywords: endangered species, pernambuco wood, Brazil, Brazilwood

OP267

The social and religious aspects of wood, development of wood industries in Nigeria and its contributions to sustainable rural livelihood and national development

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In this study, the social, religious and cultural roles of wood among the tribal people of Nigeria and the development of wood based industries in the country were assessed. The contributions of wood to rural and sustainable national development were also discussed. Data on religious and socio-cultural roles and other important utilization patterns were collected through questionnaires, by discussions with key informants, and by observation. The data on the development of wood industries in Nigeria and the roles of wood for sustainable development were collected from government official records, files, annual reports, and the literature.

The results revealed the following: the importance of wood from a religious perspective, trees and national identity, different cultural products from wood, traditional herbal medicine, wood and fetishism, musical instruments from wood, and the aesthetic products of wood. Specific wood species involved in each of the utilization patterns were identified. For other utilization patterns, wood is relied on as the only source of energy for industrial and domestic cooking. Wood is also the only source of lumber, poles, stakes, handles for farm tools, hunting tools, shelter, canoes, and household utensils. On the topic of national development and sustainable future, the study reviewed the development of wood industries in Nigeria, employment and trade in wood and wood products as sources of rural and urban income. It also assessed the present status of the various large and small-scale wood industries in Nigeria and their contributions to national development. Finally, the paper proposes some recommendations on how wood use and sustainable development can be strengthened with the view of promoting higher-value wood use at the local and national levels in Nigeria and sub-Saharan Africa.

Keywords: forest resource base, wood utensils, joinery, sustainable development.

OP268

Wooden frames for the production of hand-made paper: An example from an ancient Italian production plant

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An important production pole of hand-made paper was established between the 15th to the 17th century near and within the town of Pescia (Tuscany, Italy), along the river having the same name. The raw materials for papermaking were rags made of vegetable fibres, such as cotton, hemp or flax. The presence of water was important to produce the power for fibre maceration and to have the pulp, dissolve in the water. The product was a high quality hand-made paper, strong and durable. The new industrial production of wood (or cellulose) based paper slowly reduced the traditional paper industry, which became a niche operation during the 20th century and practically closed in the last two decades.

An old 17th century production plant called "Le carte" (Papers) was considered as a core to establish a museum on local paper production. The paper factory closed at the beginning of the nineties, preserving within its walls the whole production process and the accompanying machinery. Among them, there is a rich collection of wooden frames containing the screen molds used for the fibre felt deposition and leaf forming with their watermark, made of approximately 450 artefacts.

This paper describes the research project aimed at characterizing the wooden frames from a technological point of view. The different parts of the frame construction were described, the wood species identified, and biotic and mechanical decay measured. The results were divided into two principal sources of artefacts. Most of the frames were local, principally made of cypress (Cupressus sempervirens L.) wood and dovetail connections jointed with heather (Erica sp.) wood nails. A second group was from a British source, made of mahogany (Swietenia sp.), with a large use of brass bands, which simultaneously protected and connected the elements. The principal biotic and abiotic degrading factors of the frames will also be described. The results will form the basis for the design of the restoration, exhibition, and maintenance of the artefacts in the future Museum of Paper (Museo della Carta).

Keywords: Wood culture; paper production; wooden screen molds; Museum of Paper; wood species.

OP269

Probe into Forests Cultural Ecology Protection in China

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Cultural ecology protection is mainly used for protection of urban construction planning, refers to the protection of the architectural layout led to a certain architectural style for the tone, then a comprehensive reflection of "the beautiful order "in the urban civilization environment. Forests have economic, ecological, social and cultural functions. In recent years, forest ecological protection has made great progress in China, but there is also paid insufficient attention to the forest cultural ecology protection, and which the related development lagging behind and so on. This paper studied that China's society and economic development has promoted to mature and consumption phase, forest cultural ecology protection is the key to the future development of forestry, especially with the higher level of urbanization, urban forest is focus of the cultural ecology protection. The study suggested that forest cultural ecology protection should be taken into forest legislation and management, and should strengthen forestry development planning, highlight the physical wealth and spiritual wealth of integration, and promote forest cultural ecology protection and green cultural development in China.

Keywords: Forest; cultural ecology protection; green culture; legislation; management

Biography: Dr. Zhang Ying is a professor of natural resources economics in School of Economics and Management, Beijing Forestry University. He got a PhD from this University in 1999, and studied as a post-doc. in Korea University in 2000. In 2007-2008, he was a Fulbright visiting professor in Yale University. His major is forest economics, and over 110 papers and 18 books by sole author and co-authors have been published in this field and 4 state awards of China have been earned from 1999 to 2010.

OP270

Identification of timber species in the largest Italian collection of wooden statues at the National Museum of the Palazzo di Venezia in Rome

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The Palace of Venice was built in the 15th century by the Venetian Cardinal Pietro Barbo, who later became Pope under the name of Paul II. One century later the Palace was donated to the "Serenissima", the Republic of Venice. The name of the Palace is derived from its designation as the Embassy of the Republic in Rome. In 1797 the Palace became the property of the Austrian Empire, as Austrian Embassy. The Palace was acquired by the Italian State in 1916 with the intention of hosting a National Museum. The most important and largest (over one hundred and seventy pieces) collection of wooden sculptures present in Italy, having various origin and production from Italy and other European countries, is now kept in this museum.

From one hundred artefacts, partly exhibited in the museum and partly preserved in the deposits, 137 samples were drawn to identify the wood species, following the guide-lines for sampling and identification of species contained within the UNI 11118 : 2004 (Cultural heritage - wooden artefacts - criteria for identification of wood species). The results of this analysis provided art historians an important set of data in the complex task of identifying the exact origin of the "unknown origin" artefacts, by combining the technological and scientific results obtained with historical-artistic information; the wood species are related indeed to very specific growing habitats, often related to the cultural areas of artistic production. A total of 13 different timber were identified: 60% of those identified correspond to lime (Tilia sp.) and poplar (Populus sp.), whereas out of the total, lime is 43%. Other timbers occurred infrequently, but among them more significant were Swiss pine (Pinus cembra), European walnut (Juglans regia), sweet chestnut (Castanea sativa) and deciduous European oak (Quercus sp.).

Keywords: Wood culture; Palace of Venice; wooden sculpture; wood species identification.

OP271

The Poplar wood (*Populus alba* L.) physical and mechanical behaviour across the grain

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In central Italy the Renaissance period was very productive. The arts and science went through a highly creative time. Machiavelli, Battista Alberti, Ghiberti, Michelangelo, Leonardo Da Vinci, Beato Angelico were some of the artists who strongly contributed to developments in science, literature, architecture, painting and sculpture. As for the paintings, many artists painted on wooden support structures during the Renaissance. Specialized craftsmen made the wooden supports, according to the needs of artists.

The wooden supports could have various shapes and dimensions depending on their purpose, such as for impressive crosses, altar pieces, large polyptychs, or small portraits. Several different technical features were used, however in central Italy a common factor was the wood species used. Nearly 90% of the paintings were painted on Poplar wood (Populus alba L.) mainly because of its large distribution in the region, its light color, and ease of processing. Today we deal with the conservation of these panel paintings. Optimal conservation requires thorough knowledge not only of the paint layers, but also of the wooden support as well. To better understand reasons for present breakages and deformations and to analyze and anticipate responses of wooden supports to environmental variations and to restoration interventions, a deep knowledge of the mechanical and rheological parameters of the species is needed.

In the framework at DEISTAF we have carried out various physical and mechanical tests on Poplar wood (Populus alba L). This research work began 6 years ago and is still ongoing. Tests have been carried out mostly on wood extracted from recently felled trees, because of its greater availability. However, some tests and comparisons have also been made on "ancient" wood. Tests have been mostly carried out on the properties across the grain, which are the most involved in panel painting conservation. Here we present the methods used and the most important results related to:

- swelling/shrinkage coefficients along the three main directions (longitudinal, radial and tangential);
- adsorption/desorption isotherms;
- strength and MOE across the grain (short term loading tests);
- visco-elastic behaviour across the grain (long term loading tests).

Keywords: poplar wood, mechanical and physical properties, wood science for cultural heritage conservation

OP272

Wood Aging: Characteristics of aged Hinoki wood from Japanese historical buildings

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Wood has always played a major role in Japanese traditional culture. More than 90% of buildings listed as a national property or a nationally important cultural property of Japan are constructed with wood. In the ancient capitals Kyoto and Nara, many traditional wooden buildings were included in the World Cultural Heritage listings of UNESCO. The most famous and the world's oldest wooden construction still standing is the Horyu-ji Temple from the latter half of the seventh century. Wood is present in many cultural heritage objects thanks to wood's capacity to resist degradation over a long period of time. However, the evolution of wood's properties in regular use is not sufficiently known. The present study on the effect of wood aging takes advantage of the Japanese framework of building traditions which have been maintained for more than 1600 years.

A major difficulty for the research on "aging of wood" is the gathering of suitable samples with well-defined origin and certified dating and permission of publication by conservation administration. The Japanese framework offers a unique opportunity to address the question of wood aging. Since 2004, the wood samples from various temples and other historical buildings were being gathered by the Research Institute for Sustainable Humanosphere, Kyoto University, Japan. Another typical obstacle is matching specimens from different origins.. Wood is a variable material due to genetic variations and dependency on growing conditions of the trees. A recent reference point is required to discuss property changes due to aging. However, it is difficult to obtain recent wood that closely matches a given old wood sample. To overcome the difficulty, thermally treated wood to simulate accelerated aging can be used to produce corrections for comparing data from slightly mismatched samples. Thermally treatments were performed at 90, 120, 150, and 180°C for various periods on new hinoki wood from the Kiso area.

This paper deals with mechanical characteristics of aged hinoki (Chamaecyparis obtuse Endl.) wood from Japanese historical buildings and thermally treated hinoki wood, especially their Young's modulus, rapture energy and hygroscopicity. This study will benefit not only for the basic science study on aging of wood by using unique and indigenous Japanese hinoki wood, but also the commonality and universality of worldwide wooden cultural assets. This research will have a positive role on preservation and conservation of wooden cultural properties in the world.

Keywords: wood aging; mechanical properties; Japanese historical buildings; hinoki (Chamaecyparis obtusa)

OP273

Wooden construction and decoration components of historic private houses in the Old City of Damascus – construction principles, damages, and conservation methods

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The Old City of Damascus, a UNESCO World Heritage site since 1979, still retains a large proportion of the thousands of historic private houses, built in the 18th and early 19th century. The main construction and decoration components of these houses are produced from wood: the timberwork of the walls, wooden beam ceilings, doors, window shutters, partly floor pavement, and painted and metal leafed wall paneling. Due to the high value placed on hospitality in the Arab society, the richest rooms of these houses are the reception rooms for guests, which are furnished by elaborately adorned wooden paneling. Very little research has been done related to these construction issues.

The paper will provide an overview of the construction principles, wood types used, and decoration techniques as well as information about the weather conditions, damages, insect infestation, and conservation problems. During 10 years of practical conservation and research on the Damascene wooden interiors, an array of conservation methods have been developed. For various types of damages specifically adopted treatment methods have been used, such as paper bulb, hemp fibers, Japanese paper application, and support systems for unstable ceiling beams.

Keywords: timberwork, wooden paneling, ceiling beams

OP274

Studies for the conservation of the wooden poles of the pile dwelling in Fiavè (north east Italy): the use of wood species

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The archaeological area of Fiavè, in the alpine Trentino region in Italy, at 646 m above sea level and 10 km north of Garda lake, was developed as a result of the industrial exploitation of the peat that filled the original "Carera" basin, a small glacial lake that has almost completely disappeared. During the period from 1969 to 1975 systematic excavations directed by Renato Perini found light pile dwellings related to various periods dating back to 4000 to 2000 B.C. After the excavations, the wooden poles remained at the site, but the preservation conditions were completely changed, because the poles were not partially or completely covered by water. The evolution of the decay of the wooden artefacts from the excavation up to present times was measured. For this purpose during summer of 2010, several samples, including many from the inner portions

of material, were drawn from a large number of poles. The general aim was to determine how long the artefacts would survive in the present environmental conditions.

The paper will describe the sampling methodologies and the principal results of the decay measurements, made following a specific protocol, according to the Italian standard UNI 11205: anatomical micro-morphological analyses, physical analyses (to determine MWC and densities) and chemical analyses through gravimetric and spectrometric methodologies. The main species found were larch (Larix decidua M.), spruce (Picea abies K.) and fir (Abies alba M.). This analysis led to interesting hypotheses about the use of wood species in different parts of the excavation.

Keywords: piles, decay, Pressler corer, spruce, larch.

OP275

New uses and improvements of the Deformometric Kit to support study and conservation of panel paintings

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The Deformometric Kit (DK) is a measurement system able to give continuously and real time quantitative information on the deformational dynamic response of panel paintings and other cultural wooden objects when they are subjected to environmental hygrothermal fluctuations. Using two parallel transducers linking a pair of axes fixed to the back of a panel, both the linear extension and the mean curvature of a studied zone can be monitored. To date many applications on actual panel paintings have been performed both in churches and in museums. We have monitored crosses, altarpieces, triptychs, placed in their usual display locations. As result of these experiences, new questions arise also of concern related to curators and restorers needs. The presentation will focus on the most challenging measurement needs under current investigation:

- Monitoring strains/stresses during handling and transportation, requiring a particular use of the DK. Some data have been collected during various panel paintings transportations and the results will be presented.
- Developing the fixation system to make it as minimally invasive as possible. Presently the connection between the wooden support and the DK is ensured by screws that fasten the connection in a stable way and represent a safe system for the support and the painted layers too. However we know that the screws system is not always usable, because of conservation issues, or because of the general condition of the wooden support. So we need to design and develop alternative fixation systems, to be optimized according to individual situations.
- Studying the use of DK for evaluating the strains imposed on the paint layer by the deformation of the wooden support. Due to ring curvature shear deformations are induced across the thickness as a result of the hygromechanical loading and of the wood anisotropy. Consequently, the extrapolation to the front (i.e. painted) face of the measurements made on the back is not straightforward and requires some calibration.

The DK is a new powerful method for studying the deformational response of panel paintings and other cultural wooden objects. This presentation reports about new improvements, which will better support knowledge and decisions about conservation of Cultural Heritage, and also provide reference data for calibrating and validating numerical models.

Keywords: deformation, cupping, in-situ monitoring, environment-induced distortion, wood anisotropy

OP276

X-ray computed tomography of wooden dolls of Master IP from the 16th Century

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Wooden link dolls of master IP are situated in museums in Leipzig, Berlin, Hamburg, Innsbruck and Madrid. The aim of the investigations is to check macroscopic observations of male and female dolls related to the workmanship techniques and cultural aspects. For comparison reasons and to clarify hidden phenomena as well as for restoration purposes, we used x-ray computed tomography (CT). 3D-animations and 2D-sections of the doll from the Grassi Museum are used as an example for wood anatomy and dating by yearly rings. The wood shows shrinkage, working, and traces of wear. The nipples are made of harder wood so they will not be damaged by haptic use. The stabilizing catgut sinews are partly dislocated and knotted within the head using wooden toggles. To check the range of the hinge motion non-destructively, we applied blender-software using CT-data leading to virtual 3D-animations. The high resolved CT data are also used to get information on carving and working techniques, possible former restorations and iconographic aspects. Additionally imaging problems are discussed.

Keywords: wooden link dolls, x-ray computed tomography, 3D-animation

OP277

Recommendations for handling mold infestation of wooden artifacts

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The presentation gives an overview of the handling of wooden artifacts with mold infestation. The causes of mold deterioration are demonstrated by investigations in a church, a historic library, and a monastery in Germany. Infested wooden artifacts were altars, sculptures, picture frames and sarcophagi. Important investigation methods including indoor climate measurement, material and air sampling, microscopy, lab investigations, and determination of

the mold species are described. The most typical mold species are discussed. Whereas various species of Penicillium are typical fungi found after water injuries (condensation, leakage, flood), these fungi were not often found in wooden artifacts. Instead, for example, Trichoderma sp. and Aureobasidium sp. were frequently detected on the materials and caused discoloration. Contemporary measures for disinfection and protection of both wooden artifacts and the health of the restorers are shown by examples. Problems are discussed and possibilities for cleaning molds and material preservation by chemicals are shown.

Keywords: discoloration, disinfection, protection

OP278

Wood Properties of Uneven-aged Norway Spruce: a Case Study in Southern Finland

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In Finland and the other Nordic countries, wood raw material for industrial utilisation is currently produced mainly in even-aged forests. Interest in the management of uneven-aged forests with their less drastic disturbances has been gaining more attention recently. Clearly alternative forest management methods need to be developed. However, knowledge on the quality of wood produced in uneven-aged forests in Nordic countries is lacking. Yield and wood studies have been almost exclusively conducted in even-aged forests. Due to their complex stand structures and dynamics, variation in the interactive tree-level factors influencing wood production and quality generally tends to be greater in uneven-aged stands.

We studied wood properties on 5 experimental plots in uneven-aged Norway spruce stands in southern Finland. The plots had been established in the 1990s on three locations. Prior to that, the stands had been managed with selection harvests for several decades. Four of the plots represented one stand density level each, whereas one plot was composed of eight subplots each with one density level. Twenty-four trees in each diameter class (0-9.99 cm, 10-19.99 cm, 20-29.99 cm and 30- cm) were sampled, felled and measured, adding up to a total of 96 sample trees. The samples were taken at the height of 0.6 m. A radial strip of wood from the pith to the cambium was sawn and annual ring width, latewood proportion, wood density, and tracheid dimensions were analysed by SilviScan instrument and by microscope with ImagePro after maceration. The data were analyzed with linear mixed models.

The annual ring width increased according to size classes showing a typical trend for uneven-aged trees. Even-aged trees usually show a maximum at the second size class (DBH 10-19.99 cm). Very narrow annual rings having wood density values close to cell wall density (over 1000 kgm-3) were detected due to suppressed position in the canopy structure during juvenile wood development. Narrow annual rings with high wood density and large microfibril angle close to pith can cause deformation of sawn goods and other defects. Such large differences in annual ring width and wood density have a negative effect on wood quality.

Keywords: Picea abies; wood quality; fibre properties; softwood; wood anatomy

OP279

Wood stiffness in black spruce from regular and irregular stands in eastern Canada

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Mean fire return intervals in the boreal forest are key determinants of stand age structure and species composition, which in turn may have an impact on wood quality. Forests in areas with long fire return intervals tend to be dominated by shade-tolerant species, mainly black spruce (Picea mariana (Mill.) BSP) and balsam fir (Abies balsamea (L.) Mill.), and tend towards a more uneven-aged structure. In the boreal forest of eastern Canada, there is a west-to-east gradient of increasing fire return intervals, which offers an opportunity to compare wood quality between the different growing conditions found in regular and irregular stands. For structural applications, modulus of elasticity (MOE) and modulus of rupture (MOR) are key determinants of end-use potential and therefore value.

Nonlinear mixed-effects models were developed to characterise the radial trends in MOE and MOR in 60 black spruce trees from 6 regular and 6 irregular stands in Québec, Canada. Separate models were fitted to the data from even-aged and uneven-aged stands, and in each case the dependent variables were modelled as exponential functions of cambial age.

Results indicate that in addition to the expected large tree-to-tree differences, there was substantial between-site variability in mechanical properties. However, both MOE and MOR were generally lower in the irregular stands – by approximately 20% for MOE and 10% for MOR – than in the regular stands. This may be related to a decline in site quality as stands become more irregular, as a result of the combined effects of paludification and lower soil temperatures. These effects are associated with reduced site fertility and restricted growth, which in turn affect wood properties.

We have extended this study in order to confirm the magnitude of the observed site effect. Sample material was taken from a further 40 sites across a verified chronosequence of time since last fire. The final wood properties models are intended to be integrated, along with region-specific growth models, into a wood quality simulation system, which will be linked with a sawing simulator in order to optimise value recovery.

Keywords: Wood quality, MOE, MOR, black spruce, irregular stands, boreal forest, mixed-effects models

OP280

Wood density and MOE for aspen and white spruce in complex, multi-species stands in the western Canadian boreal forest

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Within Canada's western boreal forest, stands available for harvest are largely dominated by complex mixtures of trembling aspen (Populus tremuloides [Michx.]) and white spruce (Picea glauca [Moench] Voss). Silvicultural objectives have mainly focused on increasing volume growth (through site preparation, vegetation management, and stand density control). Additionally, many areas that were previously mixtures of aspen and white spruce are being regenerated as monocultures, resulting in neighbourhood competition dynamics that differ from those seen in mixed-species stands.

The effects of changes in neighbourhood competition dynamics on wood quality are largely unknown at present. To begin to comprehend the potential effects, this study examined linkages between stand structure and wood quality characteristics from natural unmanaged stands. Stands selected for the study varied in age, stocking density (i.e., trees per hectare and basal area per hectare; at the neighbourhood and stand-level) and species composition.

The objectives of this study were 1) to develop profiles of wood density and MOE (modulus of elasticity; derived from small clears) along the main stem of aspen and white spruce trees from the selected stands, and 2) to test the profiles against tree-, tree neighbourhood, and stand-level variables, including slenderness (Height/diameter at breast height (DBH)), crown size, growth rate and various indices of stocking density. In addition to using specific gravity and MOE at various points along the main stem, earlywood and latewood density and their proportions within annual rings were also be examined.

Preliminary results indicate that variations in wood density and MOE along the main stem of aspen and white spruce trees can be explained through the use of the ratio of tree height to DBH; however, the degree to which this ratio influences wood quality is at least partially controlled by neighbourhood species composition and the social position of the tree within the stand. This presentation will examine in further detail the inter-relationships between wood density, MOE, tree form, and stand dynamics with a focus on the identification of easily measureable variables that can be used by silviculturalists to manage stands for general wood quality traits.

Keywords: Complex mixed-species forests; wood density and MOE; neighbourhood and stand-level dynamics

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OP281

Lumber value of dead standing trees in irregular boreal forests of northeastern Canada

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The north-eastern Canadian boreal forests are subjected to a cold and humid climate that lengthens the fire return intervals and promotes the occurrence of small-scale tree mortality and uneven-aged stands. To preserve this irregular stand structure, partial cuttings could be applied by selecting primarily large dead standing trees, but this raises the question of lumber value from such potentially degraded trees. Hence, the objective of this study was to compare the lumber visual grade yield and value from live and recently dead merchantable trees in three different states of wood decomposition.

A total of 162 black spruce trees (Picea mariana (Mill.) BSP) comprising three different states of wood decomposition and three diameter classes were sampled from 3 sites. The state of decomposition of each standing tree was categorized following Hunter's classification (decay stages 1&2, 3 and 4). The sample trees were then felled and transported to a modern sawmill where they were converted into lumber of different dimensions according to an optimized sawing pattern.

Our results indicate that large trees (> 20 cm) of the Hunter 4 class are of lower value due to inferior wood quality and reduced volume recovery. Considering the current economic difficulties facing the forestry industry and the requirements of ecosystem-based management, we recommend leaving in the forest trees that have reached such a state of deterioration. However, from a strictly financial perspective, trees of the Hunter 3 class could still be harvested because product volume recovery from this class approaches that of live trees.

Keywords: recently dead trees, lumber value, product recovery, volume recovery, wood degradation, irregular forests

OP282

Tree vigour and wood quality in selection cuttings applied to the uneven-aged hardwood forests of Canada

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In north-eastern North America, hardwood forest dynamics are influenced mainly by tree- or gap-level disturbances, which tend to produce stands of irregular structure. With the advent of ecosystem-based management in the province of Québec (Canada), forest managers aim to emulate natural disturbance regimes through the application of selection cuttings. In order to avoid high-grading, a new tree marking system has been developed based on tree vigour. An important problem associated with the application of this new system is that it does not directly consider the quality of standing trees, hence introducing uncertainty into the wood supply chain. We studied the interactions between tree vigour and stem quality for the three most important hardwood species in this region: sugar maple (Acer saccharum), yellow birch (Betula alleghaniensis) and American beech (Fagus grandifolia).

In one study, 96 trees were visually inspected before being harvested and processed. Defects were identified and grouped into 10 categories according to the new provincial tree marking system. Tree value was calculated as the sum of the values of all boards produced under the NHLA classification system plus the value of pulp logs. When normalized by unit volume, value was significantly affected by the presence of fungi, cracks, injuries and evidence of rot. Conversely, results showed that other low vigour trees containing non-rot cankers, branching defects or crown anomalies had a higher value, and should be prioritized for harvesting.

A second study looked at the variation in vigour and quality at the provincial scale using bivariate logistic regression. More than

100,000 stems, measured as part of Québec's temporary sample plot network, were included in this analysis. Results showed that the joint probability of an American beech stem being in the lowest vigour class (i.e. those prioritized for harvest) and still containing at least one sawlog peaked just above 40% for trees with a DBH between 35 and 45 cm, but decreased above this diameter range. Yellow birch and sugar maple followed a different pattern, where the joint probability peaked at DBH values between 50 and 70 cm. This suggests that the current silvicultural strategy to produce large sawlogs in a selection cutting system should be revised in stands containing American beech. American beech stems should be harvested earlier and the smaller logs processed on an appropriately equipped production line.

Keywords: hardwood quality, selection cutting, uneven-aged forests, bivariate logistic regression

OP283

Wood properties of Sitka spruce (*Picea sitchensis*) from a forest undergoing transformation to an irregular structure

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Forest cover in the UK now extends to some 3 million hectares, 12% of the total land area. This major expansion of forestry from only 5% land cover 100 years ago has largely been achieved through successful establishment of conifer plantations, composed principally of even-aged stands of single species planted between 1950 and 1990. There is an increasing move to transform these broadly uniform plantations to more diverse and irregular stand structures, to help deliver a wider range of benefits in addition to timber production. However, there has been little research to date on the consequences of transformation to and management of irregular forest structures on timber quality and wood properties.

The Glentress Trial Area was established in the south of Scotland in 1952 with the objective of examining the transformation of even-aged plantations to a permanently irregular structure using group selection. Recently, the opportunity arose to assess the timber quality and wood properties of 20 Sitka spruce (Picea sitchensis) trees growing in this trial area. Here we present the results of this study, which included measurements of tree growth and competition, stem form, stress-wave velocity in standing trees and logs, and wood density, clearwood modulus of rupture (MOR) and modulus of elasticity (MOE) in bending on samples from 1.3m height and at crown base. Results of these assessments are compared with data from even aged stands of Sitka spruce and with previous timber property model simulations. The influence of stand structure, competition and individual tree growth on key wood properties is examined with a view to improving future predictions of wood quality from these types of stands.

Keywords: Transformation; irregular stand structure; wood properties; timber quality; Picea sitchensis.

OP284

Competences and Careers – Outcomes of Study Programmes in Wood Science and Technology

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The most important outcomes of a study programme show in the competences and careers of their graduates – do professors really think much about this, or do they only have their subject specific content in mind?

What do our students learn? What should they learn? Do they learn, what they will need later? What would our graduates make successful in their careers, in the labour market? Finally: Do university exams assess what professors intend to teach, what students want to learn, what the labour market needs?

Concepts, methods and instruments to give answers to these questions are expected learning outcomes (ELO) and graduate analyses. The paper will deal will these concepts, based on examples from study programmes of wood science and technology as well as wood science and technology courses in forest sciences programmes.

OP285

Enhancing Students Interest in Forest Product Education Through Student Organization Initiative

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Now days environment have been put as the center of the worldwide attention. Including forest, this big part of environmental is currently facing global the conservation issues. The booming of conservation paths due to global environmental crisis in other side negatively changes the views of image of forest product utilization. The need of forest product for human live againts the need to conserve forest as natural resources. Thus, forester with wide knowledge on forest product utilization has important role to connect between forest product utilization and the global conservation issue. Here, the role of Faculty of forestry is important as part of institution of education to attract many students as preparation of young professional forester with expertness in forest product utilization in the future.

In contrary the department of forest product technology under forestry Faculty in Universitas Gadjah Mada, Indonesia recently has been experiencing the small amount of student applicant compared to other department such as forest management, forest conservation and Silviculture. Realizing this situation encouraged and fostered student of forest product and technology department to act their idea to address this important case. Through student organization called FORESTECH, students initiated several programs in order to stimulate others student interest in forest product sector. There were three major programs conducted to open students' views, gain awareness, and accommodate curiosity regarding forest product future prospect. The three majors programs are Industrial

Visit, Forest product Exhibition and Lecture by figure. This writing will analyze the effectiveness and effects of this student initiative affects student interest in forest product education.

Keywords: Students, Student interest, student organization, Forest product department, Education.

OP287

Development of low-emission Particle Boards by using different kinds of Bark

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The Faculty of Forest Sciences and Forest Ecology, as one of a few of study locations to do research in forest/wood sciences in Germany (e.g. Munich, Dresden, Rosenheim), offers its students a diverse education in a multitude of topics, like national/international forestry, biological/technical wood processing, ecosystems analysis, etc.

Beside two BS programs with a current total of 450 students, the faculty provides one MS program in "Forest Sciences & Forest Ecology" which is divided into five key areas, each of which leads to a M.Sc. degree within two years. "Wood Biology & Wood Technology", as one of the study focuses (with 30 students at present), covers the procurement of basic knowledge and detailed expertise in the field of wood sciences and processing, biotechnology etc. The Faculty additionally offers the only existing three-year Ph.D. program in Wood Technology in Germany with a current total of 29 students.

A current field of research deals with the development of particle boards containing different kinds of tree bark with low formaldehyde release.

Rising costs and a politically promoted use of renewable energies have resulted in increasing competition of renewable raw material. This also directly affects the wood panel industry that is consequently in search of a solution to counteract the price increase, as well as to save its competitiveness, e.g. through an investigation of new resources for its intentions.

Beyond that the industry keeps itself busy with the required reduction of the formaldehyde release of particle boards bonded with urea-formaldehyde resin. To achieve this objective, the wood panel industry is working intensively on new approaches to the production of low-emission wood panel products.

Against this background, GAUG determines to what extent the partial use of bark as a renewable raw material is eligible to substitute and save common wood materials and – as a synergistic effect – how bark can be applied as a formaldehyde scavenger in particle boards for reducing post-production emissions. According to the relevant literature different types of tree bark contain constituents that are reactive towards formaldehyde.

Keywords: forest sciences, wood, particle boards, bark, formaldehyde, scavenger

OP288

Wood Property Variation Of *Pinus Patula* Planted In Malawi, Africa

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Pinus patula is one of the major exotic species grown in Malawi mainly for saw-timber. It is native to Mexico. Wood properties of Pinus patula were studied in detail, in order to provide a basis for utilizing this resource. The vertical and radial variations of tracheid length, mechanical properties and growth characteristics were investigated in stems of 30-year-old Pinus patula planted at a spacing of 2.74 m x 2.74 m. Specimens were cut from 1, 3, 5, 7 and 9 m above the ground. The pattern of ring width with cambial aging was broadly similar at all stem heights: large to the 4th growth rings, decreasing gradually up to the 10th ring and then very narrow towards the bark. The minimum tracheid length was 2mm with rapid increase of tracheid length up to ring number 10 and then a stable pattern towards the bark. There were significant correlations between air-density vs. MOE, air-dry density vs. MOR, and MOE vs. MOR at 1% level. At 12% moisture content, the tested five Pinus patula families have average MOR and MOE of 105.17 MPa and 10.93 GPa, respectively.

Keywords: Pinus patula, growth ring, wood density, MOE, MOR

OP289

Upgrading low density wood by a Viscoelastic thermal compression process

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Viscoelastic thermal compression (VTC) is a process for compressing wood, perpendicular to the grain, without damaging the cellular structure. VTC- wood has strength and stiffness that has increased in proportion to the increase of density. As the VTC mechanism is understood, this research focused on optimizing process schedules in regards to hybrid poplar (Populus deltoids x Populus trichcarpa) veneer, composite bond properties and consumption of adhesive. Processing schedules differed in pre-compression conditioning time, compressing time and compression rate (speed). Densified veneers were bonded (different loading rates) with a commercial phenol formaldehyde resin, and bond properties were assessed with a modified form of ASTM D 1037- 99 and ASTM D 905- 98. Shear results show that joint performance is affected by pre-compression conditioning time and compression rate, whereas composite modulus or elasticity and modulus of rupture are unaffected by the different treatments. Results, however, may contain bias as there were some technical problems with the press cooling and venting systems.

OP290

Innovation in the Wood Products Sector: a research group experience at Virginia Tech

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It is commonly accepted that American society perceives wood as a high value among the raw materials used for manufacturing. The annual total consumption of roundwood to be used as raw material for the wood products industry in the United States of America has increased constantly from 12 billion cubic foot by 1965 to approximately 17.2 billion cubic foot by 2005, representing a per capita usage of 255 board feet and also 1.75% of the GDP of the country. Yet still the wood products industry is a large business in the American economy. However, as many other business sectors, wood products has been facing many challenges to maintain itself as a profitable sector. This situation has opened up an opportunity to research for proposals aiming to help this industry to achieve sustainable growth. Innovation seems to be the right path especially for the wood products industry since, according to U.S. economy indicators, this sector shows one of the less innovative performances based on the Research and Development expenditure compared to the company sales in the US.

As part of this search, the Wood Innovation Research Group at Virginia Tech is leading an interdisciplinary effort, where different areas of expertise get together to look for new markets, new products, and improved manufacturing techniques to expand the wood products sector, and also identify what management practices are currently being used in other business sectors that could be applied in the wood products companies to foster innovation as a tool to grow.

Keywords: innovation, manufacturing, interdisciplinary research, wood products

OP291

Pulping characteristics of Acacia melanoxylon wood as an exotic species in Portugal

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Acacia melanoxylon is one of the main wattle species that have disseminated in Portugal since introduction through plantations in the dry and poor sandy soils along the coast in the beginning of the XX century. Blackwood is one important timber tree and the potential as pulpwood of A. melanoxylon grown in Portugal has been recently studied (Santos et al, 2006; Lorenço et al, 2008).

The importance of wood density and pulp yield are key parameters in the evaluation of tree productivity and quality for pulping and their relationships are of high practical importance.

The influence of wood density on pulp yield and other pulp quality parameters using as a case study Acacia melanoxylon and its natural within and between tree variability were investigated. Twenty trees were harvested (five trees in each of four sites in Portugal), and wood discs were taken at different height levels, from the base to the top of the tree, providing 85 wood samples covering the natural variability of wood density ranging 449 kg.m-3 to 649 kg.m-3.

Under the same experimental conditions, pulp yield ranged 47.9-55.6%, kappa number 11.1-16.6, ISO brightness 19.9-45.0, fibre length 0.66-0.82 mm and fibre width 17.2-20.8 µm. The pulp yield and kappa number were not correlated with wood density. Higher pulp yields were associated with lower kappa numbers and alkali consumption, suggesting the important role of chemical composition of wood on kraft cooking.

The results show the pulping quality of Acacia melanoxylon trees grown in Portugal expressed by high pulp yields, low residual lignin and favourable brightness. The influence of sites, trees and within the tress is not significant in the pulp measured parameters. The pulp yield and kappa number were not correlated with wood density. Moreover, the results suggest the possibility for tree selection as both wood density and pulp yield change independently.

Keywords: Acacia melanoxylon; wood density; pulp yield, fibre length and width

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OP292

Influence of Biological Treatment of Eucalyptus globulus Woodchips on Auto-Hydrolysis Performance

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In previous studies, it was shown that the auto-hydrolysis with low severity conditions is an efficient method for extracting material from E. globulus wood, prior to the kraft pulping, without affecting the pulp conditions. However, these conditions have a downside: the low hemicelluloses yield. So, in order to improve this aspect, this study aims at evaluating the impact of two different biological pre-treatments of wood, prior to an auto-hydrolysis stage, on hemicelluloses extraction yield. These biological treatments involve the use of enzymes and fungi. All results from these methods were compared with the ones obtained from the wood without any pre-treatment (reference wood).

In the enzymatic pre-treatment, some preliminary experiments were performed over woodchips. The woodchips were impregnated by vacuum with different sources of commercial enzymatic solutions and incubated at 70ºC, for 0, 2, 6, 10, 15 and 30 days. The pre-treated wood extraction yields at 80ºC and 150ºC were similar to the reference wood.

A second set of commercial enzymes was also used, where the optimal enzyme operating conditions were first selected using an experimental design (full factorial) with 2 variables (T and pH) and with 3 levels. The selected dependant variable was the enzyme activity determined by the Acid Birchwood Xylanase (ABX) Activity essay. In order to eliminate the influence of wood accessibility, the following tests were carried out on E. globulus sawdust. Several enzymatic treatment experiments were performed over sawdust using an optimization experimental design (Box-Behnken) with 3 variables (Liquid/wood ratio, time of treatment, enzyme charge). The pre-treated sawdust was washed and extracted at 150ºC with ultra-pure water. The extraction yield results were compared with the extraction of sawdust without any pre-treatment. These results revealed once again that no significant differences were found between enzymatic pre-treated wood and reference wood.

For the fungal pre-treatment, the woodchips were impregnated with CSL (0,5%) or distillate water, after which they were sterilized, pulverized with the fungal mycelium obtained from the fungus Ceriporiopsis subvermispora and incubated at 27ºC. The study of the fungal pre-treatment was performed based in an experimental design (full factorial) with 2 continuous variables (fungi charge and time of inoculation), plus 2 discrete variables (forced air flow, impregnation with CSL). After the pre-treatment the woodchips were washed, to remove the superficial mycelium, air dried and stored. In order to evaluate the depolymerization of wood components, induced by C. subvermispora during wood decay under solid-state fermentation, the pre-treated wood ships were submitted to an extraction in auto-hydrolysis conditions and the results were compared with the ones for the reference wood. The liquid extract obtained will be chemically analysed and the woodchips will be submitted to kraft pulping.

Keywords: C. subvermispora; biological pre-treatments; enzymes; fungus; hemicelluloses extraction.

OP293

Suitability of Two Indigenous Hardwood Species Growing in Sudan for Pulp and Paper Making

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Sudan is endowed by a great diversity of tree species, nevertheless the utilization of wood resources has traditionally concentrated to a few number of species. Despite the richness of Sudan in most of the basic factors required to establish pulp and paper industry, it is still almost entirely dependent on imports to satisfy its needs of pulp and paper. There is an urgent need to assess the suitability of the local fibrous raw materials for pulp and paper making, this would not only reduce imports, but they would also provide an economic incentive to the forestry and industrial sectors of Sudan.

The present study was carried out to assess the suitability of Acacia seyal var. seyal and Balanities aegyptiaca wood for pulp and paper making. These two species are widely distributed and easily grow on large areas in Sudan; their uses concentrate in charcoal, firewood and fuel wood. The wood materials were collected from different zones in Sudan. Anatomical and physical properties were investigated. In anatomical investigations, fiber length, diameter, lumen diameter as well as double wall thickness were measured from which the Runkel ratio, slenderness ratio and coefficient of Suppleness (or flexibility coefficient) were obtained. Concerning physical investigations, wood basic density was determined and used together with the obtained fibers dimension and their derived values to consider the suitability of the selected tree species for pulp and paper making.

The results showed that the basic density of Acacia seyal is slightly above the range for commercial temperate pulpwood, and that of Balanities aegyptiaca is almost within the range. The fiber lengths of both species are short but within the normal range of hardwood for commercial pulping. These fibers were of good slenderness ratios which makes them suitable for pulp and paper making, nevertheless their Runkel ratio and coefficient of suppleness are not compatible with those described for pulp and paper making. The overall physical and anatomical investigations of the study species indicate their suitability for pulp and paper making by mixing with other species which are already used in pulp and paper making.

Keywords: Acacia seyal var.seyal; Balanities aegyptiaca; fiber properties; Density; pulp and paper making.

OP294

Eucalyptus globulus heartwood and its influence in kinetics of pulp production

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Eucalyptus globulus is the most species used in Peninsula Iberica for pulping, due to its anatomical and chemical characteristics, in particular its low lignin content. In this context the aim of this work was to study the influence of heartwood from E. globulus during the pulping process. For this purpose a tree with 18 years was chosen due to its higher extractives content in heartwood compared to sapwood (9.8 % vs. 3.9 %) and a total lignin content of respectively, 23.5% and 24.3 %. The study was developed using three temperatures (130, 150, 170 ºC) and pulps were produced with several cooking times (1 to 95 min). The liquor was produced in the laboratory with 30 % sulfidity, 20 % alkali active and liquor to wood ratio of 4:1. Pulps were analysed in respect to total yield and residual lignin, and two kinetic models were applied to explain heartwood and sapwood delignification.

During the heating stage of pulping the mass loss was considerable, i.e for heartwood represented from 23.7 to 31.8%, and for sapwood, 15.4 to 23.5%. This mass included removal of lignin, as well as solubilization of wood extractives which are in great amount in heartwood. In fact, the presence of higher extractives enables a faster removal of lignin in heartwood at a given pulping time, but in the end, and in particular to 170ºC, the residual lignin in the heartwood and sapwood pulps were quite similar (2.0 % and 1.1 %). The larger differences between sapwood and heartwood were obtained during delignification at 130ºC with 8% higher final yield for sapwood, but this difference decrease to half in pulps from 150 and 170ºC cooking temperature. The modelling results showed that: i) the kinetics parameters were similar in heartwood and sapwood delignification at all temperatures; ii) both models were quite adequate for the material used, with good correlations (higher than 0.99); iii) heartwood

presence does not influence the kinetic development in relation to delignification since no major differences in the parameters values were noticed.

Keywords: Eucalyptus globulus; heartwood; delignification; kinetics

OP295

Pulping and Papermaking Potential of Six Mangrove Species in Bangladesh

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Scarce information on wood properties of mangrove wood species makes it difficult to use them properly. In this paper physical, morphological and chemical characterizations and pulpability of the six main mangrove species of Bangladesh namely eeora (Sonneratia apetala), Gewa (Excoecaria agallocha), baen (Avicennia alba), sundri (Heritiera fomes), pashur (Xyloccarpous mekongests) and kakra (Bruguiera gymnorhiza)] were carried out.

The wood density of these six mangrove ranged from 0.5 to 0.6 g/m3 , excepting gewa with the density of 0.39 kg/m3. The fiber length of these species varied from 0.74 to 1.2 mm. Sundri has he longest fibres (1.2mm in length) among these six species.

The results of chemical analyses reveal that these species contain high amount of dichloromethane, followed by methanol extractives. Methanol extracts in pashur, sundru and baen exceed 10 %, which indicates a bulk amount of tannins in these species. The high extractives content in pashur, sundry and baen make these woods denser. The total lignin content in these species is more than 25 %, except in gewa (23.6 %) and pashur (21.3 %), which is higher than the normal range in hardwood. The pentosans content in these six species is within the range of 19.4-22.8 %. The α-cellulose content in keora and gewa is acceptable for pulp production , but the others contain lower value than the normal range in hardwood.

The pulping of these six mangrove species was also carried out by kraft process and papermaking properties were also evaluated. Pulp yield was lower and kappa number was higher compared with other tropical hardwoods. The physical strength properties of these species were quite acceptable. Considering pulp yield, kappa number and physical properties, it may be concluded that keora and gewa may be used for packaging grade paper pulp.

Keywords: Mangrove species; Wood density; Fiber length; Chemical characteristics; Pulp yield; Kappa number

OP296

Papermaking Potential of Miraculous berry Stalk for Pulp and Paper Production

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One of the major reasons for the below performance of Nigerian paper mills has been attributed to huge capital investment on importation of long fibre pulp and inability to source for long fibred lignocellulosic materials locally. With Nigerian forest dominated with short-fibred hardwoods, it then became imperative to screen non-wood plants that thrive well in various ecological zones in the country for long fibre production. Among the various plants that thrive well in Nigeria, Thaumatococcus danielli (miraculous berry) stands prominent.

This study therefore centred on an experimental evaluation of the stalks of T. danielli for pulp and paper production in Nigeria. Its fibre characteristics, chemical composition, pulp yield and handsheet properties were determined. The filament from the stalk was macerated in equal volume of 30% hydrogen peroxide and 10% glacial acetic acid for fibre analysis. The stalk was evaluated for total extractive, 1% NaOH , hot and cold water soluble extracts, ash, silica, lignin, holocellulose and alpha-celullose using standard methods. Soda and soda-ethanol pulping methods was used to pulp the stalk and evaluated for basic pulp-sheet properties.

Mean fibre length was 2.68mm with lumen-cell wall ratio of 3:1, flexibility ratio of 59.86% and Runkel ratio of 0.69. Total extractive and 1% NaOH soluble extracts were 8.03% and 22.31%, respectively. Ash, silica and lignin content were 6.44%, 1.93% and 13.18%, respectively, while the holocellulose and alpha-cellulose were 64.57% and 38.02% respectively. Pulp yield of 45.5% was obtained using soda pulping method but increased to 52.75% when soda-ethanol was used. The unbeaten soda pulp had Tear index with a range of 2.44 -3.42mN.m2/g, and 1.96 – 5.22mN.m2/g for soda-ethanol; burst and tensile indices range from 0.74 – 1.96 and 1.85 – 2.56 kPa.m2/g; 22.88 – 39.23 and 30.51 – 51.22Nm/g for soda pulp and soda-ethanol pulps respectively. From quality view point, hand-sheet produced from soda-ethanol pulp had better strength properties compared to soda pulp. The overall results showed that miraculous berry has a promising potential to be used for pulp and paper production.

Keywords: Miraculous berry, fibre characteristics, chemical composition, pulp-sheet properties, chemical pulping methods.

OP297

Improving Sawmilling Recovery in the Malaysian Rubberwood Industry

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Hevea brasiliensis or rubberwood is the most important wood raw material for the large wood processing industry in Malaysia. Although the biomass yield of rubber plantations is 180 m3 per hectare, the sawmilling recovery is relatively low at 30% of this amount. Although the residues are used in wood-based panel manufacturing, the net value of the fibre resource is relatively low. This is impedance for replanting activities by smallholders, who form the majority of the rubber growers. Inevitably, the total area under rubber cultivation in the country has been declining over the years. This study examines the status of the rubberwood industry in Malaysia and evaluates three different processing techniques to improve the sawmilling yield. The techniques were: (i) conventional mobile sawmill with steam heated kiln drying, (ii) saw-dry-rip (SDR) technique with high temperature drying, and (iii) sawing of steamed logs using conventional mobile sawmill with steam heated kiln drying. A total of 150 m3 of rubber logs were used in this study.

The results showed that sawmilling yield improved by 15% through the SDR technique, with a significant improvement in product quality. The incidence of warping and twisting in the sawn rubberwood lumber was also reduced by 8%. The steaming of the logs prior to sawmilling improved yield compared to the sawmilling of untreated logs but was not comparable to the results obtained through the SDR technique. Although the implementation of the SDR technique will incur 12% higher capital investment, the economic returns from the process more than offsets the initial higher investment cost.

Achieving higher sawmilling recovery is an important criterion for sustainable rubberwood production not only in Malaysia but as well as other rubberwood producing countries. The future of the worldwide rubberwood industry depends on the capability of rubber growers to extract as much fibre resource as possible, in order to enhance the economics of rubber cultivation against other competing crops such as oil palm.

Keywords: Rubberwood; sawmill recovery; steam heated kiln drying; saw-dry-rip (SDR) technique

OP298

High-temperature Treatment of Juvenile Rubber Wood

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High- temperature treatment has been used and changed some wood properties. Rubber wood (Hevea Brasiliensis) samples were subjected to different elevated temperatures and different durations of heated temperature at 230 degree Celsius. Six trees of rubber wood were sampled and wood were cut from stem at 50 to 100 centimetres above the ground. Fifteen conditions of treatments were carried out before wood characteristics were measured according to specific standards. Wood density, Physical and mechanical properties of treated wood were investigated and discussed on effect of rates of heating and periods of heat treatment.

Keywords: High-temperature treatment, Rubber wood, wood density, physical and mechanical wood properties, heated wood.

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OP299

Conversion of sugi logs into sawn lumber: Suitable sawing patterns and sawing yields of large diameter logs

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Based on mature sugi (Cryptomeria japonica D. Don) planted forests, the main supply of sugi planted logs is expected to shift from small and medium diameter logs to large diameter logs (30 cm and more in diameter) in the near future. Logs of consistent quality will dominate and high quality logs as part of the supply of large sugi logs will become scarce in the near future, due to the lack of adequate forest operations in most sugi planted forests. Therefore, the effective utilization of large sugi planted logs of consistent quality will be urgently required in Japan in the near future. Since 77 % of sugi logs are now converted into sawn lumber and most of the common quality large diameter sugi planted logs will also be converted into sawn lumber in the near future, it is important to examine suitable sawing patterns of sawing large diameter sugi logs to ensure their effective utilization. In this study, we examined the suitable sawing patterns for large diameter sugi logs and their sawing yields.

OP300

Improving the automated grading by surface appearance of Scots pine sawn timber by a new sensor based on laser-induced fluorescence (LIF)

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Optical systems for timber grading have gained in importance during the last years due to the increased production speed and the nearly fully automated processing of solid wood. The available systems for visual timber grading work to the greatest extend reliable,

but there are different low contrast characteristics that cannot be recognized by these systems. These low contrast features can be mixed up with similar looking features from clean wood and effect a loss of yield. Therefore, systems that are able to evaluate the variations of the chemical wood components are urgently required. The low contrast features are normally associated with the occurrence of different chemicals in the wood structure. These chemical components could be detected with a novel developed sensing method based on laser-induced fluorescence (LIF).

In an application-focused study, different discolorations in Scots pine sawn timber caused by fungi have been examined with the new sensor. These investigations indicated that it is possible to induce a specific two-photon-excited fluorescence in the wood samples which is distinctive for the chemical components of the discolorations. As a result it was pointed out that different discolorations caused by blue stain and red rot can be measured. Furthermore, the results of the investigation showed that it could be possible to evolve this sensor to an online measurement system capable of improving the camera based grading systems. With the possibility to recognize different discolorations by chemical components the yield of high quality products could be achieved. Some existing problems to detect low contrast features could be solved by this new sensor.

Keywords: Laser-induced fluorescence (LIF), sawn timber grading by surface appearance, blue stain, red rot, Scots pine (Pinus sylvestris L.)

OP301

Innovative veneering technology with natural veneers of various shrinkage values

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Veneering technology with using natural materials has not changed since 1940's. The only parameter that undergoes changes is used glue. Asymmetrical veneering is the type of finishing technology that is divided in two groups. First one is one-side veneering. In that technology only one side of panel is veneered, whereas the second is unfinished. Studies presented in this article are concentrated on the second type of asymmetrical veneering in which both sides of samples are veneered, however parallel width surfaces are finished with various sorts of veneers.

The aim of the study was to check warping of both-sidely asymetrical veneered boards. Samples were finished with African mahogany (Entandrophragma cylindricum Sprague), African pterygota (Pterygota bequaertii De Wild.) and European white birch (Betula alba L.) in various combinations. Each board was veneered with using polyisocyanate glue that is elastomer which during crosslinking creates flexible glue-line. Veneering progressed in paramethers 120OC, 180s and 1MPa. All samples had dimensions 900x450x18mm and during studies were conditioned in 22OC and 65% humidity.

Measurements in studies were done on original stand. Their precision amounts 0.02mm. There was also done pull-off test that proved that chosen examined glue fulfil requirements imposed for industrial glues.

Results of studies shows that asymmetrical veneering has influence on geometrical stability of wood-composites. Bending of composites depends on kinds of veneers that were used in process. Moisture evens of composite, that is disturbed in process of varnishing, doesn't have influence on deflection of boards, while glue-line is flexible.

Keywords: asymmetrical veneering, glue-line, crosslinking, geometrical stability

OP302

Development of Fireproof Wall with Fire Retardant Layer Incised by CO2 Laser

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Since the building standard law of Japan was revised in 2000, buildings of more than four-stories in height or 100 m2 in gross floor area in fire area must be one hour fireproof in Japan. This performance is liable for columns, beams, walls and floors of the top four stories of tall buildings according to the law.

Although several types of 1-hour fireproof wooden construction materials have been developed in which 1-hour fireproof Japanese cedar glulam beams and columns by putting fire-retardant-impregnated wood laminas in the flame-die-out layers was developed by our group, we cannot find 1-hour fireproof wall made of Japanese cedar up until today.

Therefore, we tried to develop 1-hour fireproof wall whose structure is the same as 1-hour fireproof glulam. The wall made as a prototype consists of seven layers of which an inner layer, two sets of fire-die-out layers and two outer layers. A set of the fire-die-out layer consists of two layers of lamina incised by CO2 laser and impregnated fire retardant. The inner layer and the outer layers consist of lamina without any treatment.

A fire proof is certified by the minister of land, infrastructure and transportation if the specimen could pass the severe fire test. A specimen is heated for 1 hour according to ISO 834-1 heating schedule under the appropriate load and left in a furnace for more than 3 hours after the end of heating. In case of a flammable specimen the fire test is continued until burning dies out.

The results will be presented by temperature changes in the wall and combustion state of cross section after the fire test.

Keywords: Fireproof wall; laser incising; fire retardant; Japanese cedar

OP303

Regulating agro-forest areas for a sustainable cork harvest

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Portugal is the first cork producer in the world. The national cork oak areas have been slightly increasing since the middle of last century. Nevertheless, cork yield sustainability is not ensured due to increasing loss of stands vitality (only in 40% of the stands no damage was observed). Cork oak (Quercus suber L.) stands have mostly an uneven-aged structure (68%). The existing even-aged stands don't have an age distribution that may promote these areas sustainability: 34% have more than 60 years and 31% are between 20 to 40 years old and only 14% are young stands with less than 10 years. Therefore, efforts should start to be made at the forest management unit level to overcome this constraint.

In this study an agro-forestry area of cork oak partial affected by fire was considered. Even though having a forest management plan, the existing management compartments didn't allow for a sustainable cork annual harvest. To achieve sustainability the area control method for forest regulation was first applied, using a cycle of nine years through a 27 years planning horizon. Later, cork annual yield was also considered in the forest regulation analysis. Cork yield was simulated along the 27 years period using the individual tree growth and yield model Suber. Finally, the proposed management unit compartments were produced as vector layer a GIS and the attribute table organized with all the information available in order to support forest management.

In a fist stage, a medium-long term planning was obtained. As a result, it was proved that a quite stable annual cork harvest could be achieved for the first nine year cycles. After each nine year cycle, planning must be re-evaluated with updated inventory data. Reaching to the end of the 3rd cycle it will be possible to regenerate old stands (age more than 60 years), as young stands were reaching the harvesting diameter (age around 30 years), without cork annual harvest loss. This strategy proved to be possible achieving sustainability for agro-forestry areas of cork oak, while regenerating old stands, using both the area and volume control method combined.

Keywords: Quercus suber L.; cork yield; forest regulation; sustainability

OP304

Application of new technologies at extraction of cork

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Nowadays, cork sector is living a complicated situation. One of the reasons is a lack of specialised manpower, mainly due to the difficulty to use the axe and temporality of this job. Application of new technologies to cork stripping arises as a solution for this problem. Cork cutting machines (IPLA-Morell, Stihl MC200 and COVELESS) and manual tools that complete debarking (cork pincers, Mijuros) have been designed. Four cork stripping systems, using different tools, were tested. To study the viability of these new systems, differences on performance (productivity (kg·h-1·worker-1), cork pieces percentage and production cost (€/t)) was analyzed and were compared with traditional cork stripping performance.

The results evidence that new technologies improve traditional cork stripping performance, increasing productivity and decreasing cork pieces percentage and production cost. Quality of cork stripping was also improved. It was found a minor number of wounds caused in the cork oak, which improve plant health. Other advantage was a more homogeneous dimensions of cork planks and less irregularities. Therefore more cork can be utilized to production of natural cork stoppers.

Workers experience and specialization had less importance in the handle of new technologies. Moreover, the use of new systems at cork stripping will allow increasing debarking legal period to six months, reducing job temporality.

Keywords: Q. suber L, cork stripping, mechanization, performance.

OP305

A ten years analysis of cork oak (*Quercus suber* L.) afforestation projects in the Mediterranean region of centre-eastern of Portugal

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Portuguese forest area has a great expression being around 39%. Since the last centuries the Quercus suber L.(cork oak) areas have increased, reaching to 715 922 ha (23%) according to the last National forest inventory. Afforestation programmes financed by the European Union and the existing protection laws for the species are one of the main reasons for this increase. These efforts are important to promote for these stands a distribution by age class that ensure cork oak forest sustainability (only 14% of the existing even-aged stands are young stands with less than 10 years). In this study, the programme – Afforestation of Agricultural Land – in the region of Beira Interior Sul was analysed, to assess afforestation success during the period of 2001 to 2019.

The information was gathered from 164 projects established which represent an afforestation area of 3363.04 ha. These afforestations were mainly of pure cork oak stands (54.2%) and mixed stands of cork oak with coniferous (23%). Detailed data was collected from field samples in 97 projects to assess if minimum stand density was observed, along with information concerning to previous land cover, stand regeneration, site preparation, species, stand composition, elevation, soil type and depth, individual tree protection, fences, animal damage, among others. Once more, field samples (1640.75 ha) were mainly of pure cork oak stands (47.6%) and mixed stands of cork oak with coniferous (26.6%). The Principal Components Analysis (PCA) was used to find out which variables were the most significant on explaining afforestation success and failure.

Field samples proved that a regular status was found in 71 of the 97 projects analysed. The irregular status, observed in the 27 remained projects, was due to the lack of minimum stand density (73.1%) or to the deficiencies in meeting the management plan goals. When analyzing afforestation success and failure through the PCA technique, both 1st and 2nd principal components explained around 50% of data variability which points out that other parameters must be included.

The results of PCA suggested that afforestation will not succeed in mountain areas (elevation between 700 to 1000 m), in sandy and su-

perficial soils (< 30 cm), using mixed compositions and without any kind of animal damage tree protection. On the other hand, afforestation success seems to be ensured in sites of low elevation (0 to 400 m), previously occupied by olive orchards, in granitic and depth soils (> 60 cm) and when animal damage tree protection is used. These findings are of great help for planning future afforestation in the region. They can also be used as guidelines for other similar Mediterranean regions. Nevertheless, other parameters such as those related to climate and to site should be analyzed in future studies.

Keywords: Quercus suber L.; Afforestation projects; Principal Components Analysis; Afforestation success

OP306

Cork oak wood for flooring as an integrated production within a diversified wood+cork management of cork oak stands

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Diversification of production of cork oak (Quercus suber L.), stands may be implemented through a management aiming at a mixed cork and wood production. Although without competing with the cork production (the main product) the use of the wood component of cork oak stands e.g. from thinning operations, may provide additional market value and opportunities.

Oaks are considered to be a valuable source of timber for construction purposes and they are highly regarded for indoor joinery and furniture due to good mechanical properties and aesthetical value. One of the potential uses of cork oak wood is for flooring products that take advantage of the high density values (0.86 g cm-3 to 0.98 g cm-3), strength and wear and friction resistance of the wood, as well as of the pleasant macroscopic structure and color.

3D modeling and simulation techniques were used to analyse the industrial transformation of cork oak stems into flooring products. The trees for this study were obtained in South-western Portugal in the cork production region of Alentejo, from legally authorized fellings.

Maximization of production yields (54%) was achieved with short logs and small dimension components (parquet and components for multilayer composites). Higher yields were obtained for mature trees when compared with young trees.

Relevant properties for flooring applications (hardness, wear and dimensional stability) were assessed. Cork oak wood was found to be moderately hard with a good wear behavior (average mass loss of 2.8%). In addition, face warping showed little variations in ambient humidity and good stability in contact with liquid water. Thus, the cork oak wood showed good fitness as a noble material for coatings.

Over all the results showed the technological feasibility of cork oak wood for flooring applications (with high traffic uses). Cork oak wood may therefore be a strong alternative to other oak and tropical species.

OP307

Consumer perspectives on perceived environmental and social responsibility of wood products and suppliers in Finnish markets

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Previous literature indicates that today's consumers often perceive an additional benefit associated with responsible business practices and sustainability of purchased products. Regarding wood products, the environmental quality has been found in a previous study to be a part of the total product quality. Despite that over 40% of the production of the Finnish sawmilling industry is consumed domestically, there is still lacking knowledge on consumers' attitudes towards socially and environmentally friendly product attributes. To fill the gap, we address in this paper two questions: first, what does consumers' perceived environmental and social friendliness of wood products consist of, and, second, do identified dimensions in environmental and social responsibility help to explain consumers' self-declared willingness to pay for environmentally and socially responsible product features? In discussion section, we explore from the managerial perspective, how the detected importance of wood products' environmental and social features be used in developing marketing these products. Our data consists of interviews with 227 Finnish adult consumers during 2004-2007 as exit data from home retail centers selling building materials. Perceived environmental and social responsibility of wood products was found using exploratory factor analysis to be a two-dimensional construct consisting of (1) general issues within environmental and social responsibility and (2) specific issues reflecting consumer needs for product safety. These dimensions were also found in logistic regression analysis to explain consumers' self-declared willingness to pay. The results also indicate that the environmentally most conscious group can be profiled with gender (female), older age and summer cottage ownership, while the level of education, forest ownership, professional status or housing type do not seem profile consumers with higher sensitivity to environmental and social product characteristics. Since perceived supplier characteristics associated with environmental friendliness were found to be linked with both domestic origin of wood and company ownership, there seems to be some scope for strengthening wood products marketing based on the concept "Made in Finland".

Keywords: wood products, consumer, environmental and social responsibility, market segmentation, Finland

POSTER PRESENTATIONS

PP001

Fast Growth in Relationship with Commercial Value of Scots Pine for High-Quality Wood Products after Special Sawing Application

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Clear, straight-grained and stable wood is preferred in the manufacture of solid-wood components and finger-jointed components for high-value joinery products, such as visually attractive windows and panorama and folding doors, as well as in panelling and mouldings. Fast diameter growth does not usually lead to wood free from knots even during the later stage of a longer rotation, but should promote a rapid formation of clear wood after pruning, enabling a shorter rotation age. Controlled live sawing of logs followed by parallel-to-surface sawing of flitches should result in the maximum yield of the best qualities, but eventually on the cost of total volumetric recovery.

In an empirical study, 100 pruned and 20 unpruned butt logs of Scots pine from five stands in Eastern Finland were sawn to battens and boards using the above-mentioned technique. Pruning was done 30 years before the study. Four stands represented forest sites with high or upper medium fertility, tree age and average radial growth ranging from 45 to 74 years and 2.7 to 3.5 mm per year, respectively; one stand was a reference with a modest site fertility and growth (1.6 mm per year). Battens were sawn first, firstly to solid window frame components, secondly to structural timber, the remaining slabs and conical core being cut to mouldings and packaging boards. The yield of different saw mill products were measured, and the sawn pieces were graded both as full-length pieces and as parts for finger-jointing, the criterion being clear faces free from any technical defects. The value of the products was determined according to the current market prices, both in the solid wood component strategy and in the finger-jointed component strategy.

The effect of growth rate and tree diameter on the yield, grade distribution and value per log volume was analysed for the pruned logs, and the results of fast-grown trees from the four stands were benchmarked against the slow-grown trees in the reference stand. Distributions of battens according to the grain straightness, ring angle (at the top end of log) and drying deformations were analysed after visual inspection and measurement as well, thus, showing the effects of the sawing technique, parallel to the growth rate. In addition, technical performance and practical solutions of the combined live sawing and parallel-to-surface sawing were discussed.

Keywords: Pinus sylvestris; wood material science ; special sawing; tree improvement; pruning; wood products

PP002

Early and fast screening of wood quality for a clonal radiata pine deployment population

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Pinus radiata's poor corewood properties—including low stiffness, dimensional stability and basic density—extend optimal rotation length and reduce profitability of plantation forestry. More than half a century of tree breeding has produced improved material for stem growth and form, and disease resistance. However, today's intrinsic wood quality shows little difference with that observed at the start of the breeding program. One strategy to 'catch up' with wood quality is to screen current deployment populations (i.e. seed orchards and clonal programs) for corewood performance.

In 2009 we established a nursery trial following a randomized complete block design, which included 20 clones with 35 replicates each, with trees tilted at 20° from the vertical. After 2 years, samples were cut lengthwise permitting the separate analysis of opposite wood and compression wood; only the former are reported in this paper. Dry Modulus of Elasticity averaged 3.15 GPa (0.06), with clonal genetic values ranging from 2.66 to 3.62; longitudinal shrinkage had a mean of 1.30% (0.06), with genetic values ranging from 1.03 to 1.49%; while basic density had an average of 334.91 kg m-3 (3.06), with clonal genetic values ranging from 303.84 to 355.82 kg m-3. Both dry MoE (0.40) and basic density (0.45) displayed medium broad-sense heritabilities, while longitudinal shrinkage (0.11) had a low degree of genetic control.

Trees for this deployment population were selected on stem growth and form with a small emphasis on basic density. Variability for other traits suggests that there is room for selection, particularly for modulus of elasticity, where we can already observe a 1 GPa difference in genetic value between best and worst trees at 2 years of age. We investigate the stability in time of these clonal differences in a companion paper in this conference (McLean & Apiolaza).

Keywords: Radiata pine, clones, breeding, wood quality

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PP003

Phenotypic variation in leaning *Pinus radiata* clones

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The modest stiffness and dimensional instability of much of New Zealand grown radiata pine is due to the short rotation length, which implies a large percentage of corewood; about 50% of timber in 25-year-old tree is corewood. Under these circumstances, a logical approach to wood quality improvement is to focus on corewood properties and to do this quickly implies the need for very early selection. Fortunately, trees show large variation in properties, offering opportunities to select saplings with the best properties.

Wood quality assessment in young trees (< 3 years) is complicated due to the seemingly random distribution of compression wood (CW), which is very prevalent in young trees. An understanding of variation in wood quality of CW and opposite wood (OW) is necessary to develop appropriate selection strategies. In this paper, phenotypic variation in OW and CW in two-year-old radiata pine trees is reported. 35 replicates of 20 clones of radiata pine seedlings were grown with an artificial lean of 30-45° from the vertical. OW and CW samples from each of the leaning stems were extracted. The two distinct wood types were than evaluated for dynamic modulus of elasticity, basic density, longitudinal shrinkage and volumetric shrinkage. CW properties were significantly different from OW. CW basic density was 62% higher and volumetric shrinkage was 38% lower. The dry acoustic velocity in CW was just 9.5 % lower than in OW but its longitudinal shrinkage was three times higher. Dense CW was 24 % stiffer than OW. There was no relationship between CW and OW properties. Clone differs significantly in dry stiffness and longitudinal shrinkage in OW so there are opportunities to breed for stiffness and stability.

Keywords: corewood, early screening, Pinus radiata, opposite wood, compression wood

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PP004

Quality and Quantity of DNA in Wood Stored for Long-period after Harvesting

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For applying molecular DNA techniques for identifying the species of wood and wood products, we investigated changes in the quantity and quality of DNA in wood during storage. We extracted DNA from wood samples of Cryptomeria japonica stored for 0, 1, 3, 5, 11, 15, 23, 27, 40, 44, 75 and about 400 years, and wood samples of Chamaecyparis obtuse stored for 2, 5, 10, 19, 44 and 59 years. For C. japonica, fresh sapwood yielded more DNA than fresh heartwood. The amount of DNA extracted from wood samples stored for 1 year or more after cutting was below the limit of detection by measurement with a UV spectrophotometer. A chloroplast DNA region with a length of 527 bp was amplified by polymerase chain reaction from the DNA extracted from sapwood of C. japonica stored for 0, 1, 3, 5, 11, 15 and 23 years and from heartwood stored for 0, 3, 11, 15 and 23 years, and, from the sapwood of C. obtusa sored for 2 and 10 years. A shorter length of chloroplast DNA with a length of 82bp was amplified for all of the wood samples used in this study, except the sample stored for about 400 years in C. japonica. Longer the storage period, smaller the amount of DNA in the sapwood of C. japonica. DNA amount remaining in the sapwood of the sample stored for about 400 years was estimated less than 1% of one of wood stored for 1 year, by the real time PCR method.

The efficiencies of DNA extraction and the amplification of genes by PCR from wood were different among individual samples for the heartwood of C. japonica and the sapwood and the heartwood of C. obtusa. Our results suggest that optimizing DNA extraction protocols for wood stored for long periods will improve the utility DNA identification of wood products, with taking account of the amount of wood sample, removal of extractives, length of PCR products and so on.

Keywords: DNA; wood; storage; PCR; Cryptomeria japonica; Chamaecyparis obtuse

PP005

Heritability and correlations among biomechanical parameters involved in stem straightening in *Pinus pinaster* Ait. progenies

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Maritime pine (Pinus pinaster Ait.) is the conifer which major volume of wood is obtained in Spain. In this species the wood quality is usually low due to the lack of stem straightness. In addition, stem flexuosity produces an increase in the costs of transport and manufacturing of the row material. Recently, an alternative method for early selection of the stem straightness has been proposed, based on the biomechanical processes underlying the stem straightening reactions instead of the evaluation of stem form (Sierra de Grado et al. 2008). We studied the variability among progenies in the gravitropic and autotropic reactions, and the efficiency of compression wood in the stem straightening process, following the same method. Plants from 38 Pinus pinaster half-sib families from the Norwest Interior provenance and 6 different provenance commercial seeds controls were used. When the plants were one year old, they were artificially tilted at 45º. The kinetic study of the stem form changes (angles of deviation from the horizontal) were measured based on photographs taken during a 4 month period after tilting. Subsequently, compression wood was analyzed in four stem cross sections per plant. The compression wood efficiency in the straightening process (estimated by maturation strains) was calculated with Fournier's biomechanical model (1994).We estimate heritabilities and genetic correlations among variables related with stem straightening process. We found high significant correlations among gravitropic movements driven by secondary growth and maturation strains, and high heritabilities of these movements. It suggests that a high genetic control of gravitropic movements driven by secondary growth exists, so these parameters might be interesting for early selection in breeding programs.

Keywords: Pinus pinaster, biomechanics, compression wood, straightness, gravitropism, breeding programs, early selection.

PP006

A temperature signal from microfibril angle, tracheid diameter and wood density in low elevation Huon pine (*Lagarostrobos franklinii*)

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Tree ring widths have been widely used for temperature reconstruction, but there are many sites where it has not been possible to obtain a climate signal. In this study, conducted at a site previously considered of limited dendrochronological value, we found that, in contrast to using ring width sequences, using wood properties enabled the development of strong chronologies. In addition to wood density, tracheid diameter and microfibril angle (MFA) showed great potential. Furthermore, these wood properties, unlike ring width variation, exhibited strong, consistent correlations with temperature, site water availability and drought. The use of these wood properties may provide an opportunity to utilise ring-width-complacent sites for climate reconstruction. In particular, a large resource of ancient, low elevation Huon pine in western Tasmania, in which climate signals have not been found using widths, may now be useful as part of the broader effort to reconstruct southern hemisphere climate.

Keywords: MFA, SilviScan, dendroclimatology, Southern Hemisphere temperature, xylem, climate change, Tasmania

PP007

Growth Stresses and related wood properties in 3 genetic materials of Eucalyptus managed for sawlog

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In the next decades high valuable wood from tropical forests is likely to be substituted by hardwoods coming from sustainably managed plantations. One genus with high substitution potential is Eucalyptus, where several species with outstanding growth and wood quality exist. Eucalypt solidwood products for higher value utilizations are very promising from both, an economical and ecological point of view. The plantation grown wood, managed with clear quality targets for a specific use, is highly competitive to tropical and temperate hardwoods. On the other hand eucalypts are well known for occurrence of high growth stresses. Those, when liberated during, felling, storage or processing, cause severe splitting or warping in roundwood and lumber, resulting in low quality products or low recovery rates.

In southern Brazil considerable areas are managed with the main objective of high value sawlog production. Several genetic materials and provenances have been used for establish the plantations being the most important E.grandis, E. dunnii and a cloned hybrid of E.saligna x E. grandis. The material has been planted in annual periods starting from 2006 to 2009. The growers wanted to know, if there is any influence of growth stress level and tension wood formation depending on the genetic material and the applied management regime.

For the study 22 temporary sample plots for each material were established at the ages 24, 36, 47 and 62 month, considering a rather good as well as a regular site quality. In each plot growth strain release after the CIRAD Growth Strain Gauge method was measured at 1.3m, 25 and 50% of tree height. Close to the strain measurements samples have been taken for Near Infrared Analysis (NIR) to determine wood properties and the occurrence of tension wood. Applying this method, a "time series" of growth stress level development and tension wood formation could be analysed. The results will be applied for evaluating weather the genetic material used and the management system applied, may lead to an acceptable stress level in the produced sawlogs.

Keywords: Eucalyptus, NIR, growth stress, wood properties, sawlog management

PP008

Production of Planting Stocks of *Neolamarckia cadamba* (Kelempayan) by Leafy Stem Cuttings

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Neolamarckia cadamba (Kelempayan) is one of the species chosen for forest plantation in Malaysia because it is a fast growing species and suitable for planting in the plantation. The planting materials for this species are normally obtained from seeds or wildings. However, there is problem with regular seed supply because seeds are produced according to seasons. Due to this problem, vegetative propagation by stem cuttings can be an alternative technique to supplement the supply of planting materials. For this project, effect of medium and hormones on cuttings of Kelempayan were studied. This experiment was followed by the determination of suitable potting medium to raise the planting stocks produced from rooted cuttings

For the experiment on propagation by cuttings 3 media and 4 commercial hormones and control were used. The media used were sand, coconut husk and a mixture of these two media in the ratio of 1:1 while the hormones applied were 1) Seradix 2 (0.6% Indole butyric acid- IBA), 2) Seradix 3 (0.8% IBA) 3) Plantone-R 2000 (0.2% IBA+0.1% NAA-Naphthalene acetic acid), 4) Plantone-R 3000 (0.3% IBA+0.15% NAA) and 5) Control. For potting media experiment, media used were 1) 100% forest top soil, 2) soil:sand 3) soil:coconut husk, 4) soil:rice hulls, 5) soil:leaf compost and 6) sand:leaf compost. The ratio for each of these mixtures was 1:1.

Results for the experiment on cuttings showed that, there was no significant difference between other hormone treatments and control, but they produced significantly higher rooting than Seradix 3. Highest rooting was obtained with Plantone R-3000 (74.4%) followed by Seradix 2 (72.2%). Lowest rooting was obtained with Se-

radix 3 (27.8%). In terms of rooting media, no significant difference in rooting of cuttings was achieved. For the potting media experiment, increment in height measured at five months after potting was significantly higher in media of soil, mixture of soil:compost and sand:compost compared to mixture of soil:coconut husks and soil:rice hulls. Diameter increment was significantly bigger in mixture of soil:compost and sand:compost compared to mixture of soil:coconut husks and soil:rice hulls. The media with soil:compost had the highest height increment (20.4 cm) and the biggest diameter increment was obtained in media of sand:compost (9.1 cm).

Keywords: Plantation species: Vegetative propagation: rooting medium: hormones: potting medium

PP009

Identification of ancient charcoal fragments in Central Africa: meeting the challenge of species diversity

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Fossil pollen and charcoal fragments are preserved in lake sediments, in forest soils and in ancient human settlements. As such, vegetation history is remarkably well archived. However, Central African vegetation history has been poorly documented. Central African palaeovegetation reconstructions are based mainly on pollen analysis, while the charcoal archive remains hardly explored. Nevertheless, ancient charcoal analysis has proven worthwhile in temperate regions. One of the main challenges for charcoal identification in tropical regions is species diversity.

Therefore we developed and present a transparent charcoal identification protocol within an umbrella database of species names and metadata, compiled from the on-line database of wood-anatomical descriptions (InsideWood), the database of the world's largest reference collection of Central African wood specimens (RMCA, Tervuren, Belgium) and inventory and indicator species lists. This database covers more than 2900 Central African woody species, which is a large fraction of the total woody species richness of Central Africa. The protocol starts with an anatomical query within this database, focussing on genus rather than species level and proceeds with automatic extension and reduction phases taking into account metadata on (1) availability of thin sections within the reference collection, (2) species distribution and (3) synonymy. The protocol ends with a comparative microscopic study of wood reference thin sections and charcoal anatomy.

The protocol has been optimised for the Mayumbe region (DRCongo). We present first identification results from several radiocarbon dated charcoal collections (8000 - 200 cal yr BP), sampled in systematically excavated profiles in the Mayumbe forest. Identification results are mutually consistent. Also, these identification results are consistent with vegetation history based on palynological research within and around the research area. As such, anthracology complements palynology and a combination of both can lead to stronger palaeobotanical reconstructions.

Keywords: charcoal identification; Central Africa; climate change; vegetation reconstruction

PP010

Identification of timber species in the largest Italian collection of wooden statues, at the National Museum of the Palazzo di Venezia in Rome

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The Palace of Venice was built in the fifteenth century by the Venetian Cardinal Pietro Barbo, who later became Pope under the name of Paul II, and one century later donated to the "Serenissima", the Republic of Venice; the name of the palace derives from its destination as Embassy of the Republic in Rome. As for the Republic, also the palace from 1797 became property of the Austrian Empire, as Austrian Embassy; it went to the Italian State in 1916 and was intended to host a National Museum.

The most important and largest (over one hundred and seventy pieces) collection of wooden sculptures present in Italy, having various origin and production, Italian and European, is now kept in this museum.

From one hundred artefacts, partly exhibited in the museum and partly preserved in the deposits, were drawn 137 samples in order to identify the wood species, following the guide-lines for sampling and identification of species contained within the UNI 11118 : 2004 (Cultural heritage - wooden artefacts - criteria for identification of wood species).

The results of the analysis provided the art historian an important set of data in the complex task of identifying the exact origin of the "erratic" artefacts, combining the technological and scientific results obtained with the historical-artistic information; this because the wood species are related to very specific growing habitats, often related to the cultural areas of artistic production.

A total of 13 different timber were identified: 60% of identifications correspond to lime (Tilia sp.) and poplar (Populus sp.), where out of the total lime alone is 43%. Other timbers appear sporadically, but among them more significant are Swiss pine (Pinus cembra), European walnut (Juglans regia), sweet chestnut (Castanea sativa) and deciduous European oak (Quercus sp.).

Keywords: Wood culture; paper production; wooden screen molds; Museum of Paper; wood species.

PP011

Evaluation of Permeability of Hardwood Using Darcy's Law

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The information about wood permeability helps in the production processes of the timber industry as well as in the selection of genetic materials. Permeability is an important factor that indicates how the water moves into the wood. Therefore high values of permeability indicate the ease with which these woods will be processed and treated. Some of wood characteristics such as anatomical structure has influence on the permeability of wood, e.g. frequency of vessels, type and diameter of vascular elements, pit diameters, among others, interfere directly in the permeability wood.

There are difficulties of evaluating the permeability of the wood and lack of technical standard for this study .The aim of this study was to evaluate the permeability of hardwoods through the liquid and air flow using Darcy's Law. For this propose, samples were produced from six planks of different native species obtained in the Amazonian forest. Tests of air and liquid permeability were performed at the Laboratory of Wood Science and Technology, Federal University of Lavras, using the methodology described by Silva et al. (2008). Calculations of permeability were obtained using the equation described in Darcy's Law. We also analyzed the anatomical features and their influence on the permeability of the studied woods.

The values found for the liquid permeability of wood ranged between 2.07x 10-9 m^3 [m (N m-2) s]-1 and 3.28x10-9 m^3 [m (N m-2) s]-1. The values for air permeability ranged between 63.7x10-9 m^3 [m (N m-2) s]-1 and 140.2x10-9 m^3 [m (N m-2) s]-1. The samples showed no air air and liquid flow in the radial direction. Overall, Pearson correlation matrix indicated low values for correlation between the permeability (air and liquid) and anatomical characteristics. With the results we can conclude that the method using Darcy's Law was not satisfactory for evaluating the permeability of the hardwood, since it did not provide values for the permeability in the radial direction of the samples and poor correlation with the anatomical structures of wood was observed.

Keywords: Air and liquid flow; anatomy; Amazon timber

PP012

A Rapid Method for 3-Dimensional Stem Reconstruction and Analysis

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There is often a need to analyse tree stems 3-dimensionally for properties such as stem form, ring structure, branch properties and various other characteristics. A solution that has recently become popular is that of CT-scanning of stem sections. The extraction and transport of stem sections from the forest as well as the capital and running cost of CT-scanning equipment makes this a fairly expensive method. In a recently completed project a rapid and relatively low-cost method for the 3-dimensional reconstruction of full tree stems was developed that can provide some of the data typically available from CT-scanning.

A rigid steel log dissecting frame was designed and built to accommodate stem sections of up to 3m length and 60cm diameter. The frame consists of a rail and jig for a specially configured chainsaw, a sliding frame for a digital camera, a laser distance meter, and a clamping system to keep the log perfectly still while sawn. The dissecting frame can be assembled in the forest. Stem sections were positioned and clamped on the frame and cross-cuts made at perfectly right angles to the frame base. A high resolution image was taken of each cross-cut using a moveable digital camera which was positioned on a separate rail at a constant distance of the log cross-cut face. Since the logs were stable and the camera was on a fixed rail, images could be related to a fixed X-Y-Z axial system. Image analysis software was used to identify and digitise properties of interest into X-Y-Z co-ordinates. A series of images from logs of single trees were reconstructed into three-dimensional models of full trees.

The design, accuracy, various application results, practical challenges, advantages, limitations, and possible improvements using this methodology are to be addressed in this presentation.

Keywords: Stem reconstruction; stem analyses; image analyses; wood properties

PP013

Mechanical Load-Induced Secondary Cell Wall Formation and Its Regulation in Plant Cell

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The growth and morphogenesis of plants are strongly affected by external forces as well as the own weight. Trees generate the stress over their trunks and branches to cope with such a mechanical action and to support mechanically big tree bodies. The formation of reaction wood is an example of this important function. Some studies have clarified that mechanical load induces the formation of secondary xylem tissues in Arabidopsis thaliana. In the morphogenesis of tree under mechanical environment, an effective regulating system may function in the secondary xylem formation, but it remains poorly understood. A study for physiological responses to mechanical environment in cellular level is considered to elucidate a fundamental mechanism of morphogenesis in tree. Physical and mechanical properties of wood strongly depend on its cellular and cell wall structures. The formation of these structures is closely related to the mechanical environment which the differentiating cells in trees undergo. An analysis of secondary metabolic activity in plant cell under mechanical environment is expected to contribute to the establishment of the genetic modification of wood quality.

In this study, the relationship between the force applied and expression of the genes involved in secondary cell wall formation in the A. thaliana liquid cultured cells was quantitatively investigated. The deposition of secondary metabolic substances in the cell wall was observed and the mechanical properties of the cells were measured. By applying the shearing force to the liquid cultured cells using a rheometer, the genes coding phenylalanine ammonia lyase and cinnamoyl–CoA reductase were up-regulated or down-regulated depending on the loading time. Some genes of transcription factors controlling the secondary metabolism were up-regulated. Observations by staining with phloroglucinol-HCl revealed the deposition of lignin in the cell walls of liquid cultured cells loaded for 6 hours. Based on the results obtained, a mechanism of the cell wall formation in tree under mechanical environment will be discussed.

Keywords: Mechanical Load; Secondary Cell Wall; Gene expression; Transcription

PP014

Structure and chemistry of roots and stumps of Norway spruce and Scots pine

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In Finland, there are over 0.5 million ha of drained nutrient poor peatlands where continued forestry production is not feasible. In those areas there is 15-50 t/ha exploitable wood biomass from which the biomass of stumps and thick roots is 20-30 %. Roots and stumps are usually left to the forest after felling of timber or alternatively, they are used for combustion and energy production. The chemical composition of spruce and pine wood and bark is largely known, but there are a very few studies dealing with roots or stumps. Conifer roots may have a very different composition due to the symbiotic associations that form between the roots and fungi (mycorrhiza) as well as between roots and endophytic micro-organisms.

In our work, chemical composition of extractives of wood material from roots and stumps of Norway spruce (Picea abies [L.] Karst.) and Scots pine (Pinus sylvestris). The samples were taken from a peatland site a day after felling the trees. The sample material was divided to stump (S) and three root zones (A, B, C) which differed according to their size and distance to the stem. Total extractive amount of different zones were analyzed after Soxhlet extraction. The chemical profile of samples was analysed by GC-MS after acetone extraction with sonication.

According to our results, the largest amount of extractives in Norway spruce was found in the smallest roots (zone C) with diameter less than 2 cm. The major components of spruce extractives were monosaccharides and resin acids. As minor compounds, fatty acids and lignans were found in some samples. In Scots pine, the largest amount of extractives was found in the smallest roots and also in the stump. The major components in pine roots were monosaccharides and resin acids (and fatty acids as minor compounds). The stump wood of pine contained also stilbenes, pinosylvin and its derivative. Roots show a very variable growth ring structure but no clear compression wood was detected in any root zones of spruce or pine.

Keywords: Norway spruce; Scots pine; Roots; Stumps; Extractives; Wood structure

PP015

Impact of the pine wood nematode, *Bursaphelenchus xylophilus*, on chemical and physical characteristics of *Pinus pinaster* wood

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The Pine Wood Nematode (PWN), Bursaphelenchus xylophilus, is the causal agent of Pine Wilt Disease (PWD) and is one of the most serious threats to pine forests worldwide. In 1999, the PWN was reported for the first time in Portugal and in Europe, south-east of Lisbon (Setúbal Peninsula), associated with dead trees of maritime pine, Pinus pinaster Ait. After the detection, this nematode has spread quickly to the Central Region of Portugal and in 2008 all continental Portugal was declared as affected area. More recently, it was also detected in Spain and in Madeira Island.

The PWN constitutes a serious problem for the worldwide forest economy leading to the annual loss of pine timber. Imposed restrictions on import of a raw softwood cause export value decreasing and disturbance of forest industry, based on use of pinewood as a raw material. However, the negative impact of the PWN is not limited to the above mentioned economic consequences. After tree invasion, nematodes begin to migrate, feed and reproduce within the resin canals causing development of cavitation and leading to a reduction or cessation of oleoresin flow in the infected trees. Thus, the problem of the PWD states another important economic aspect, such as the technological aptitude of PWN infected wood as a raw material by woodworking industries.

The objective of this research was to understand how anatomic changes of PWN infected wood and biochemical incidences of tree defense reaction affect gross calorific value, chemical composition, extractives, moisture content and flammability of P. pinaster wood. Comparative analysis of above mentioned characteristics of infected and uninfected wood was performed. The difference between the GCV and chemical composition for infected and uninfected wood was statistically significant for the GCV and for hydrogen and nitrogen contents. The GCV of infected wood varied between the highest value of hardwood and the lowest value of softwood. The values of equilibrium moisture content (EMC) were similar for infected and uninfected wood. The number of PWN/100g of wood has no impact on the heat release rate (HRR). The correlation between mass loss and PWN/100g of wood was statistically significant.

Keywords: pine wood nematode, chemical composition, extractives, heating value, moisture content, flammability, Pinus pinaster wood

PP016

Wood ring formation analysis based on a combination of microcores and X-ray profiles

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Wood ring formation analysis is crucial to determine the exact date associated to a yearly wood ring portion. It allows relating ring sections to environmental, physiological or management conditions during its formation.

A combined method for intra-ring dating will be presented.

During a growing season (from June 2009 to August 2010), the development of 38 Pinus radiata trees in an unmanaged stand in the Central region of Chile was followed. Every 15 days at the beginning of spring, and then every 30 days, a microcore (2 mm diameter x

12 mm length, with a Trephor instrument) and at 40 cm from the base of each standing tree was collected. The minimal disturbance generated by the instrument permits to take many microcores from the same tree.

Transversal slices of each microcore were obtained with a microtome, stained and photographed in a microscope, generating images of 2048x1536 pixels corresponding to a 0.85 x 0.64 mm. Each microcore corresponds to a sequence of 21 photographs in average. The images in the sequence were correlated, generating a continuous single large longitudinal image.

A segmentation algorithm based on a two band-pass filter in the Fourier domain was applied splitting the color images into three areas: cell wall, lumen and the reminder. The latter corresponds to wood defects such as holes, cracks and image background.

With a step of 0.159 mm (equal to an X-ray sampling resolution) the normalized microcores images were converted to wood density using the relationship: wood density = (percentage of cell wall per surface unit) * (cell wall density). A radial profile of wood density of each microcore was obtained.

At the end of the sampling period the trees were felled, and from each tree a sample for X-ray analysis was obtained from the same postion of microcores sampling. A radial X-ray profile of wood density with a resolution of 0.159 mm was obtained. Thus, each tree had an X-ray profile of the whole yearly ring, and also the partial ring profiles obtained at different times of the year by microcores.

Time correlation techniques were applied to determine the position of each microcore sequence into the final X-ray sequence, permitting to define the consecutive limits of the annual growth ring at a given date. Thus, the X-ray ring profile of each tree was divided into the different periods of the year, allowing an analysis of the wood density profile in relation to the corresponding environmental variables. In the same way, the microcore sequences permit to analyze cell wall thickness, lumen size, and number of cells, in relation to the corresponding environmental variables.

Research project FONDECYT 11085008 financed by CONICYT, Chile

Keywords: X-ray densitometry; microcores; intra-ring analysis; time correlation techniques

PP017

Relationship between foliage development and wood ring formation in Pinus radiata D. Don

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The relationship between crown development and the corresponding wood ring formation is an important issue, in order to understand the influence of environmental and physiological conditions on the development of wood.

During a whole growing season (June 2009 ? August 2010) the foliage and main apex development of 54 nine-year-old Pinus radiata trees in Central Chile were followed. Monthly measurements of apex elongation and needles growth were obtained. At the same time, microcores (2 mm diameter x 12 mm length, Trephor instrument) at the base of each tree were obtained. At the end of the growing season also an X-ray transversal profile of each tree was obtained. After dating each portion of the growth ring using the microcores and X-ray profile, the relation between ring development and the foliage and apex development were analyzed. Earlywood formation coincides with the strong elongation of the apex and needles growth. At the same moment shoot and needles stop growing, the ring continues its growth but changing abruptly from early to latewood. In 6 trees, the same procedure was applied, but eliminating during the whole growing season any apex (main apex, or from branches order 2, 3 or 4) with new needles. The abnormalities observed in the wood density profile of the yearly ring will be discussed.

The corresponding relationships between foliage and wood ring formation and the climatic variables during the sampling year are presented.

Research project FONDECYT 11085008 financed by CONICYT, Chile.

Keywords: crown development; wood ring formation; wood density; foliage growt

PP018

Influence of root development after transplantation in different provenances of *Pinus pinaster*

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The structural characteristics of the root system have a special interest in reforestation, affecting both the development and survival of plants and their stability (Sundstrom & Keane 1999; WATSON & Tombleson 2002). Existing information on the radical structure and allometry of the entire plant in forest species is still scarce (Danjon et al. 1999; Danjon et al. 1999; PEACE 2003) and even more so in terms of intra specific differences.

Given the great variability that provides the species P. pinaster in almost all morphological and adaptive characters that have been studied, it seems safe to assume that there is also a natural variability in the ability to generate different efficacy roots for anchorage.

In order to reforestate, the great influence of packaging used in the nursery over the morphology and further development of the root must not be forgotten.These data suggest the existence of genetic variability on characters associated with the roots that has not been deeply explored yet and could be a source of valuable input.

To progress in the study of growth, demography and root dynamics, there is he following rhizotrons trialt that allows visual monitoring of direct seeding treatments and experienced transplant over a year, using plants of two provenances of Pinus pinaster. The parameters studied were: general morphology, horizontal extent, vertical extent, angles of primary and secondary roots, primary root number, diameter and root length, total biomass and root / relationship. The radical elongation remained very low while the average soil temperature was below 10 ° C. When the average air and soil temperature

exceeded 15 º C, then root growth turned to be very fast. (GOZALO CANO, 1998).

Data were analyzed by analysis of variance (ANOVA). For measurements of root structure and mass of trees, the sampling unit was the individual and for the survival it was repetition. We conducted ANOVA on a repeated measures basis.. The analysis indicated that the high variability often presented by data derived from observation of roots, made it difficult to obtain statistical differences in most parameters studied.

Keywords: rhizotrons; root structure; stability; containers; genetic variability.

PP019

Glutathione stimulating CO2 uptake causes the increase in wood biomass production

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Glutathione is the tripeptide synthesized from glutamic acid, cysteine and glycine. It exists in reduced(GSH) and oxidized(GSSG) forms in plant and animal cells, and plays an important role in controlling the redox state. Recently, glutathione is known to stimulate the CO2 uptake in plants, causing the increase in biomass production.

We applied GSH and GSSG to Arabidopsis, Eucalyptus, Populus and Cryptomeria to investigate the CO2 uptake and the xylem production. GSSG promotes more abundant interfasicular fiber and vessel developments in Arabidopsis. GSSG promotes not only the elongation of stems and roots, but also the increase in stem diameter in Eucalyptus. In addition, specific gravity of xylem also increased in GSSG treated woods. Chemical composition of xylem is not affected by the GSSG treatment. Fiber length is similar among the specimens. GSSG also promotes the increase in number of palisade cells causing the increase in thickness of leaves. Starch grains in chloroplast are much smaller in GSSG treated specimen than in control. This may be caused by active translocation of sugars in phloem.

Populus were transformed to overexpress Arabidopsis γ-glutamylcsteine synthetase in the chloroplast and the cyto-sol. Both transformants showed slightly rapid shoot growth in comparison with the wild type.

Keywords: glutathione; CO2 uptake; Eucalyptus; biomass

PP020

Seasonal variation of amounts of starch in sapwood of Japanese cedar

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Apart from cellulose there are some other polysaccharides consisting of glucose units in wood. Among them starch is the most important reserve polysaccharide present in fruit and seed and other storing tissues. Thus, starch is also present in the parenchyma cells of wood tissue.

Compare with heartwood which is the part of dead tissue, a physiological function is active, change of starch content is large and supply, accumulation, and disappearance are repeated in sapwood. This starch content is regarded as having huge influence on the damage of bark beetle and other insects. The variation of amounts of starch in Japanese cedar (Cryptomeria japonica) is, however, still inadequately understood even today.

In this study, we investigated the seasonal variation of amounts of starch in sapwoods of standing trees and after transpirational drying, also known as leaf seasoning, biological drying, and delayed bucking for three months. Samples were taken twice per month, and checked the amounts of starch by light microscopy and chemical analysis.

Trend of seasonal variation of amounts of starch and effect of transpirational drying on it will be discussed in the presentation.

Keywords: starch; sapwood; transpirational drying; Cryptomeria japonica

PP021

Finnish and north-western Russian Coniferous Sawn Timber: Factors and Models for the Prediction of C-grades for strength

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The EN 338 standard for structural timbers´ strength classes is applied to coniferous sawn timber strength grading. It assigns a piece to a strength grade ranging from C14 to C50 (11 classes) according, for instance, by their bending strength, modulus of elasticity and density, where the value of the grade represents a minimum strength of the piece. All sawn timber used for construction purposes are to be graded according to the EN 338 standard by year 2013 in the EU countries. This requires precise and effective techniques to measure the mechanical properties of sawn pieces non-destructively, and the calibration of strength grading machines for different geographical areas requires a large sample of test pieces, which makes the process expensive and time consuming.

Logs and center-yield sawn pieces of Scots pine (Pinus sylvestris) (N 1069) and Norway spruce (Picea abies) (N 1162) from three regions in Finland and two regions in north-western Russia were studied for the variation in, and predictability of the C-grades. Log and sawn piece properties were measured and statistical analyses conducted on the differences between geographical regions, in particular. Based on the measurements and destructive testing according to EN 408, sawn pieces were assigned to a C-grade based on their mechanical properties. The aim was to find out how accurately it would be possible to predict the C-grade of a single sawn piece. Multinomial regression models were calculated to find the best possible combination of predictors of either log or sawn timber properties, or both. In addition, the focus of adequate grading result was examined; how accurately is it possible to identify sawn timber having

higher or lower strength grade, and how this information could be used in efficient raw-material utilization.

The most important predictors were the diameter of the largest dry knot and size of the log, when only log properties were used as predictors for both pine and spruce, classifying 47 % of the pieces were correctly for spruce, and 46 % for pine. When sawn timber properties were used as predictors, density, KAR and dimension of the sawn piece were the most important predictors classifying 52 % of the pieces correctly for both pine and spruce, outweighing other predictors. When MOE was available, it overruns all other predictors, and along with dimensions of the sawn piece, 75 % of the pieces were classified correctly for both species. When log and sawn timber properties are combined, without MOE, 53–54 % of the sawn pieces were correctly classified for spruce and pine, respectively. The two highest classes were correctly classified for 45–65 % of the cases, and with MOE available, approximately 85 %. Classes C18 and C30 were most commonly correctly classified for both pine and spruce, being the most common in numbers.

Keywords: bending strength; elasticity of modulus; density; machine grading; coniferous sawn timber; EN 338; EN 408; wood material science

PP022

Wood Quality and Physiomechanical Properties of Wood

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Two critical mechanical strength properties tests; modulus of elasticity (MOE) and modulus of rupture (MOR) tests were carried out using hardwood timbers from secondary forest in Papua New Guinea. The tests were carried out with the aim of comparing the MOE/MOR values with the previous published data of primary forest. Although, most wood processors commercially harvest hardwood timbers from the secondary forest, the technical data is sought from the previous publication data of the primary forest. The study was carried out to determine the strength properties of underutilized species and make available the engineering properties which could be used by expanding wood processors in PNG. Mack (1979) 'Australian Methods for Mechanically Testing Small Clear Specimens of Timber' and ASTM (D143-1994) 'Standard Methods of Testing Small Clear Specimens of Timber' were used as test methods to carry out the test. Ten hardwood timber species were used in the test to determine two significant strength properties of wood - the MOE and MOR values.

Test results revealed a high degree of variability between and within species of MOE and MOR. Statistically, the degree of variability of MOE was moderately distributed within the species rather than between the species. Alternatively, the variability of MOR amongst the timber species was greater between the species than within the species. Therefore, in practical terms, the lower MOE and MOR reflect the faster growth rate in the secondary forest compared with the primary forest. Thus it is a reflection of how the timbers require more time for the wood fibres to gain mechanical strength. The final analysis of results led to the determination of engineering properties which these values became critical for advanced processing of engineered wood products by the wood processing industries in Papua New Guinea.

Keywords: Secondary forest, Underutilised species, Strength properties, Modulus of elasticity, Modulus of rupture, Engineering properties, Degree of variability, Wood processors.

PP023

Growth eccentricity and tension wood formation in *Acacia mangium* seedlings at different angles of inclination

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In response to inclination stimulus, angiosperm trees generally form tension wood on the upper side of leaning stem in order to reorient their stem direction into vertical position. Tension wood generates a strong tensile force, which is sufficiently large as to bend the leaning stem upward. The formation of tension wood is frequently associated with an eccentricity of growth. In this study, we examined the effect of inclination angles on the growth eccentricity and tension wood formation in Acacia mangium seedlings.

One-year old Acacia mangium seedlings with uniform performance were used in this experiment. Seedlings were inclined at 0o, 30o, 45o, 60o, and 90o from vertical direction and then they were harvested 3 months after inclination. Transverse sections of stem 10 cm above the base of inclined seedlings were observed to investigate the occurrence of gelatinous fibers and growth eccentricity.

Our results showed that inclination induced growth eccentricity and formation of tension wood but the increase in inclined angle from 30o to 90o did not induce increase in the growth eccentricity and width of tension wood area. Furthermore, our results indicated that the development of tension wood in the upper side of inclined stem was associated with the growth eccentricity in Acacia mangium seedlings.

Keywords: Acacia mangium; growth eccentricity; inclination angle; tension wood

PP024

In vitro induction of secondary xylem like tracheary elements from hybrid poplar cultured cells

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Woody biomass is consisted of secondary xylem cells that form thick and lignified secondary wall. Therefore, understanding of mechanism of secondary xylem differentiation, in particular secondary wall deposition is needed for extensive use of woody plant resources. For sequential analysis of xylem cell differentiation, in vitro systems of tracheary element differentiation are useful. A single cell isolated mesophyll cells of Zinnia elegans has been widely used for model

system of xylem differentiation and a lot of cytological knowledge have been accumulated. But until now, there are no in vitro differentiation systems that induce secondary xylem like tracheary elements. Therefore, we have still luck of information of detailed process of differentiation of secondary xylem cells.

We established a new system to induce the differentiation of secondary xylem like tracheary elements using a hybrid poplar (Populus sieboldii ×P.grandidentata) callus. Tracheary elements were induced in callus derived from petiole of hybrid poplar cultured on an induction medium containing brassinolide without auxin. Tracheary elements were observed 10 days after callus had been transferred to induction medium. The rate of induction was increased as cultivation time set longer. Two-three weeks after induction, active differentiation of tracheary elements was observed. These tracheary elements formed modified structure of secondary xylem, such as bordered pits.

In addition, we established callus that expressed GFP-MAP4 (green fluorescent protein-microtubule associated protein 4) fusing protein by Agrobacterium method. In the transgenic callus, dynamic changes in orientation and localization of microtubules were observed in dividing and elongating cells.

Keywords: in vitro; microtubule; secondary xylem; tracheary elements

PP025

Influence of morphology of the parenchyma on the machinability of *Eucalyptus grandis* wood

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Size, frequency and arrangement of cells that make up wood are important characteristics which influence on the wood workability. So, these must be considered to improve the processing of that material. This study aimed to verify the influence of the radial parenchyma variation on the mechanical processing of log into lumber.

Six logs were collected between 3 and 6 meters in different trees of 24-years-old Eucalyptus grandis Hill ex. Maiden from commercial plantations in Brazil. Disks were removed from the ends of the logs and small specimens were cut in different relative positions from pith to bark (0, 33, 66 and 100% of the radius). The specimens were used in the preparation of permanent, histological cuts. The study of microscopic structures of the radial parenchyma was performed based on the IAWA Committee, providing the number of rays per millimeter, total height and width of the rays in the tangential plane and the average height and width of the radial cells. The wood samples belonging to the central (0 a 33%), intermediate (33 a 66%) and external (66 a 100%) regions of the log were machined and their performance were evaluated and the effects of the morphology of the parenchyma were examined.

In regard to the macrostructure, the rays visible under the lens were, on average, homogeneous and rarely heterogeneous, presenting variation in width of 3-15-33 mm; in height of 33-205-633 mm; and composed of 02-11-36 cells in height with variation of 7-12-19 rays per mm. These characteristics from the intermediate and outer regions were similar, but different from the central region.

The machining performances were investigated and also showed similar trends: the results from the intermediate and outer regions were closer between themselves, but different from the central region. Scores from 1 (best quality) to 5 (poor quality) were attributed for the performance of different types of cuts. The operations of jointing, planning and top moulding in the central zone obtained higher scores than those reached in the external zone. Stopped axial moulding and transversal cutter block yield presented poor quality machinability and similar scores in the three zones.

Significant Pearson correlations were found between the parenchyma features and the surface quality of some machining set-ups. However, it was not possible to predict the sense and the direction of the rays in relation to the cutting edges.

Keywords: anatomical features, radial parenchyma; machining operations; Eucalyptus

PP026

Technological Characteristics of 245 Tropical and Temperate Timbers Species

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Developed by the Cirad's "Mediterranean and Tropical Forest Products Research Unit", the new release of TROPIX software (version 7) presents the main characteristics of 245 tropical or temperate wood species.

For each species, TROPIX provides data and information on: the scientific and local names of the species described, their origins (distribution maps) and any commercial restriction according to the CITES regulation; appearance of the log or wood, including pictures of wood and wood utilisations; leading physical and mechanical properties; natural durability against fungi / dry wood borers / termites, and preservation; drying behaviour, including a drying schedule given for information; processing behaviour (sawing, machining, assembling); appearance grading and visual grading for structural applications; actual and potential uses and reaction to fire.

Some of this information is displayed in graphical format.

TROPIX 7 allows multicriteria search using preselected search terms or similarity to a different species. It also allows graphical species comparisons based on one or two physical or mechanical properties.

Multicriteria searches results, graphics and technical sheets can be printed or exported as files.

Keywords: Tropical woods; software; database; technological characteristics; uses

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PP027

Pinewood nematode effect in the modulus of elasticity of maritime pine wood

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Maritime pine, Pinus pinaster, is one of the most important forest species in Portugal, not only for occupying 27% of the national forest area, 8.8x105 ha, but also for its economic relevance, with a production of "softwood sawn wood" of 9.2x107 € in 2009.

The pinewood nematode (PWN), Bursaphelenchus xylophilus, is the causal agent of pine wilt disease causing death of pine trees. It is a quarantine organism in the European Union since 1976 (Directive 77/93/EEC) however, its presence was first detected in Portugal only in 1999. As a result of this situation, the movement of softwood has been regulated by the Commission Decision 2006/133/EC, amended by the Commission Decision 2006/993/EU and adapted to national regulations, Decreto-Lei no. 95/2011, 8th August, obliging the treatment of all softwood sawn wood. Considering that the maritime pine is a PWN susceptible species, the main goal of this study was to evaluate the effect of that nematode in some of its mechanical properties.

The effect of the PWN in the mechanical properties of maritime pine wood was assessed by the modulus of elasticity (MOE) in bending. This property has been identified as a good indicator of the ability of the wood for many uses requiring mechanical resistance, namely packaging and construction. The bending rigidity is also closely related to bending strength and hardness, but with the great advantage of being evaluated as a non destructive test.

In order to validate the results of the study, the methodology designed was based on the evaluation of the MOE in three treatments: sound wood, naturally infected wood and artificially inoculated wood. Wood density, one of the physical properties used to characterize wood samples and known to have influence in the MOE, was also evaluated. In each treatment the number of PWN per unit of dry weight (dw) was determined four times, in a period of three months.

The average number of PWN detected in the sapwood of 15 natural wood infected boards was 49.45±57.99 PWN/g dw but, no nematodes were detected in the heartwood. The sound wood inoculation was not very successful, as only 33 % of the boards were infected, with a μ±sd of 7.91±14.85 PWN/g dw.

There were significant differences between densities of sound or inoculated woods, 0.54 g/cm3, and the one of infected wood, 0.63 g/cm3. Nevertheless, no significant differences were found between the average MOE of sound wood, 7 100 MPa, and infected wood, 7 451 MPa, or between the sound and inoculated wood, 6 825 MPa.

Therefore, there is no evidence that the infection with PWN affects the MOE of maritime pine wood and consequently cannot be by itself a reason not to use the wood for packaging and other applications.

Keywords: Maritime pine; sawn wood; pinewood nematode; modulus of elasticity in bending; density; pine wilt disease.

PP028

Constituents of wood under different silvicultural systems

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The extractives, lignins and carbohydrates are the main chemical constituents of the wood. These components influence the production of charcoal and pulp. The objective of this study was to evaluate the influence of different thinning systems on chemistry constituents of the Eucalyptus (Eucalyptus grandis x Eucalyptus urophylla) wood.

The experiment was conducted with clones of Eucalyptus (Eucalyptus grandis x Eucalyptus urophylla) in Minas Gerais State, Brazil. Each plot was divided in four bands with similar sizes, representing each treatment. Initial average spacing between plants was 3 x 3 and the treatments were: T1= control, T2= 20% thinning of the basal area, T3= 35% thinning of the basal area, T4= 50% thinning of the basal area. Individuals with lower growth were eliminated in all treatments.

The total extractive was determined according to Tappi standard T 264 cm-97; insoluble lignin according Gomide and Demuner (1986); soluble lignin according to Goldschimid (1971) and carbohydrates according to Wallis et al. (1996). The experiment was conducted in a factorial design and the data analyzed by ANOVA and submitted to the Tukey test (5%).

The lignin content of treatment T4 was higher than that of the others treatments. The extractive content of T1 was similar to those of T2 and T3 and lower than that of the T4. The cellulose content of treatment T1 was similar to T2 and T3 and lower than that of T4. The hemicellulose content of treatment T1 was similar to those of T2 and T3 and lower than that of the T4. The biosynthesis is that lignins requires more energy while hemicellulose demands less. The practice of thinning reduces competition among trees and thus increasing energy availability. Plants with higher levels of thinning have higher lignin and lower values of hemicelluloses.

Thinning increases the quality of the wood for energy purposes, such as charcoal production, but does not improve the quality of wood for the manufacture of pulp and paper.

Keywords: cellulose; Eucalyptus; lignin; thinning

PP029

Comparative Wood Anatomy Of *Psychotria* L. Species In The Forest Remnants At Ilha Grande, Rj, Brazil

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Psychotria L. is the largest genus in the Rubiaceae family, containing approximately 2,000 species, also stands out in the Rubiaceae by the production of bioactive alkaloids and their complex taxonomy. The wood anatomy is an important evaluation tools that support for taxonomic, phylogenetic and evolutionary research. Moreover, the structural diversity found in secondary xylem of woody plants have an adaptive explanation and functional and can be directly linked to the plant habit as well as changes in weather conditions and water availability. The present work aims to characterize and compare the wood of nine Psychotria species, from Ilha Grande, RJ, to assemble the variety of cells, functions, organizations and some structural peculiarities and contribute to understanding the genus systematics.

Trees with similar diameters and with no apparent defects were selected. The samples were collected by non-destructive method. The descriptions, measurements take on the three anatomical sections and macerated, follow the procedures described by IAWA Committee. For vessel and fibre lengths, vessel diameters, and ray heights, the minimum and maximum values of all specimens are given for the overall range.

All species show distinct growth rings, marked by thick-walled and radially flattened latewood versus thin-walled earlywood fibres, vessel elements with diffuse-porous with appendices, solitary, in radial arrangements multiples of 2-6 elements or in clusters of 3-5 elements; simple perforation plates, and lateral plates; vestured and alternate intervessel pits; vessel-ray pits similar to intervessel; septate fibretracheids with average length between 900 and 1600µm.; axial parenchyma absent or rare and fusion rays. Histochemical tests revealed that all species have alkaloids in all wood cells. The species could be segregated by the size of intervascular pit, the average length and average tangential diameter of vessel elements, number of vessels per mm ^{2} and the presence of tyloses and deposits in the vessels; the pit size and the fibre wall thickness, width, height and cell composition of the rays, the presence or absence of aggregate rays, surrounding cells, perforated ray cells, cells with walls disjunctive and mineral inclusions. The results showed the importance of wood anatomy for the identification and segregation of the species studied.

Keywords: Atlantic rainforest; cell characterization, Rubiaceae; systematic; Wood Anatomy.

PP030

Variation in Some Anatomical and Physical Properties of Two Indigenous Hardwood Species Growing in Different Zones in Sudan

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Sudan is endowed by a great diversity of tree species, nevertheless the utilization of wood resources has traditionally concentrated to a few number of species. With the great variation on the climatic zones of Sudan, great variations are expected in the anatomical and physical properties between and within species. This variation need to be fully explored in order to suggest best uses for the species.

Modern research on wood has substantiated that the climatic condition where the species grow has significant effect in wood properties. Understanding the extent of variability of wood is important because the uses for each kind of wood are related to its characteristics; furthermore, the suitability or quality of wood for a particular purpose is determined by the variability of one or more of these characteristics.

The present study demonstrates the effect of rainfall zones in some anatomical and physical properties of two indigenous hardwood species growing in Sudan namely; Acacia seyal var. seyal and Balanities aegyptiaca. The investigated anatomical properties were fibers and vessels diameter, lumen diameter and double wall thickness as well as fiber length. While basic density was investigated as physical properties. The wood materials were collected from two zones, one with relatively low rainfall (273mm annually) which represented by North Kordofan state and White Nile state and the second with relatively high rainfall (701 mm annually) represented by Blue Nile state and South Kordofan state.

The result of the current study reveals highly significant differences between zones in basic density for both species. Balanities aegyptiaca's fibers and vessels dimensions not affected by the rainfall zones. While Acacia seyal var.seyal affected significantly in almost all fibers dimensions and in vessels double wall thickness. Nevertheless no significant differences have been found between zones in neither vessels diameter nor vessels lumen diameter. From these results Acacia seyal seems to be more sensitive to the effect of rainfall zones than Balanites aegyptiaca.

Keywords: Acacia seyal var.seyal; Balanities aegyptiaca; rainfall zones; density; anatomical and physical variation

PP031

Variation in wood anatomy of "Arruda" informal group of *Caesalpinia echinata* Lam. (Leguminosae) in Brazil.

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Caesalpinia echinata Lam., known as brazil wood, is a native species from the Atlantic Rain Forest at the coastal zone of Brazil that is distributed from Rio Grande do Norte (5º11'56"S –35º27'39"W) to Rio de Janeiro (22º54'10"S – 43º12'27"W). The species is categorized by the taxonomists in tree informal groups along its distribution, but not yet in subspecies or varieties. Although the populations present outstanding characteristics in respect of number and size of the leaflet and the wood color, none wood anatomy research in the literature mentioned these groups. This study analysis latitudinal trends in wood anatomy of the informal group of C. echinata with smallest leaflet, named "Arruda" and widespread in occurrence zone. Were collected 25 samples between 5ºN and 22ºS latitude. Wood variability was evaluated in relation to temperature, rainfall and latitude data. These components were submitted to multivariate statistical analysis. The principal component analysis revealed three groups separated by two factors that explain 46.6% of the total variance. The factor one explains 27.1% of the total variance and separated the specimens from Rio de Janeiro (RJ) and Espírito Santo (ES). The specimens from RJ and ES occupies the higher latitudes, both in Southeast of Brazil, the highest loadings were: latitude, temperature

and estimated area of the vessel elements. The second factor explains 19.5% of the total variance and grouped the specimens from the Northeast. Paratracheal axial parenchyma confluent and the length of the vessels showed the highest loadings. Similar groups were observed in the cluster analyses. We conclude that C. echinata wood characters are important to separate "Arruda" populations of RJ and ES from the others from lower latitudes. The specimens from RJ separate to ES samples by lower vessel length and presence of axial parenchyma confluent. The samples from Northeast (Rio Grande do Norte, Paraíba and Bahia) present the lower values for estimated area of the vessels that corresponds with lower latitudes.

Keywords: Caesalpinia echinata, arruda, wood anatomical variation, statistical analysis.

PP032

Wood anatomy of eleven species of *Machaerium* Pers. (Papilionoideae -Leguminosae) in the Atlantic Rain Florest Domain

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Machaerium species are popularly known as jacaranda and provides timber for construction and luxurious furnishings. Some species are currently rare due to predatory exploitation and reduction of natural habitat. Moreover, the genus is important in the recovery of degraded areas due to the establishment of symbiotic relationships with nitrogen fixing bacteria. Based on the economic and ecological importance as well as the scarcity of information about the anatomy of its species, this work aimed to study the wood anatomy of eleven tree species of Machaerium of the Atlantic Rain Forest. Samples were collected by non-destructive method and processed by methods usually employed in wood anatomy studies.

All species have the features described for the Leguminosae: vessels with simple perforation plates and vessel-ray pits similar to intervessel pits, and also for the subfamily Papilionoideae: intervessel vestured pits alternate, storied axial and ray parenchyma and prismatic crystals in the axial parenchyma cells. In addition, all species showed solitary vessels and in radial multiples, apotracheal parenchyma diffuse with two-cells strand, disjunctive parenchyma cells, libriform and gelatinous fibres. With the exception of Machaerium stipitatum and Machaerium hirtum the other species showed growth ring with distinct boundaries, with potential for further dendrochronological analysis.

Statistical analysis showed significant characters for the segregation of species, among them the axial parenchyma, which the relevance was highlighted by previous authors. The most significant features according to the multivariate analysis were: apotracheal axial parenchyma diffuse, paratracheal scanty, vasicentric, aliform and confluent. The wood anatomy results were consistent to recent phylogenetic studies for Macherium based on the Bayesian analysis chloroplast DNA mtK and nuclear DNA ITS 5.8S where the sections of the genus were not supported. The wood anatomy of Machaerium would provide data of great importance for combined morphological and phylogenetic analysis involving the group.

Keywoorks: Wood anatomy, Machaerium, Leguminosae, Papilionoideae

PP033

Wood anatomy of *Chaetostoma* DC. and *Microlicia* D. Don (Melastomataceae)

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Wood anatomy features have provided relevant information to taxonomic, phylogenetic and ecological studies. The wood anatomy of Neotropical Melastomataceae is poorly known, especially in the Microlicieae tribe. The genera Chaetostoma and Microlicia are morphologically similar, being difficult to establish their taxonomic and phylogenetic boundaries. This study analyzes the wood anatomy of three species of the genus Chaetostoma DC.: C. albiflorum, C. armatum and C. cupressimum and three species of Microlicia D. Don.: M. aviculares, M. decussata and M. fasciculata. The samples were collected in Cerrado biome in the state of Minas Gerais, Brazil, and were processed through the usual wood anatomy techniques.

The species showed homogeneity in some anatomical features, namely, simple perforation plates, vestured intervessel pits, libriform fiber with distinctly bordered pits, and axial parenchyma scanty paratracheal. These characteristics are reported in the literature for all Melastomataceae, and are considered typical of the family. Despite the great homogeneity of the characteristics, multivariate analysis proved useful for revealing the existence of a pattern of clustering among species. Furthermore, the anatomical characters of wood have diagnostic value to separate them. All Chaetostoma species were grouped by cluster and principal component analysis, while the Microlicia species were not. This result is consistent to morphological phylogenetic analysis of the Microlicieae tribe, based on 10 parsimony-informative characters, which recovered a monophyletic core Microlicieae but provided no further resolution among genera.

Keywords: Wood anatomy, Microlicieae, Chaetostoma, Microlicia.

PP034

Effects of soil scarification and growth rate on compression wood in boreal lodge pole pine

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Compression wood is formed as a result of displacement of the tree from its original position due to e.g. disturbance by frost heaving

and erosion, or excessive external forces due to wind and snow. Factors affecting tree stability, and occurrence of compression wood, are root development and the relation between crown size and root distribution. Soil scarification may affect root development and growth of seedlings.

The aim of the present study was therefore to compare different soil preparation methods that are known to affect these parameters differently – mounding, disc trenching, ploughing and no soil preparation - 18 years after treatment. Two field experiments were analysed, one of low site fertility and one of mediate fertility, consisting of 16 plots, situated in the Middle part of Sweden (Lat 62° N, Long 14° E). Four trees per plot, two medium sized trees, and two large size trees, were sampled. From each tree stem discs from five to six different heights depending on tree height, were extracted starting from stump height and with three whorls between each height. The discs were scanned and analysed with respect to compression wood, out-of-roundness, and pith eccentricity using semi-automatic image analysis software developed for this purpose.

Growth rate had a large influence on the occurrence of compression wood. For larger trees on the more fertile site and for ploughing, compression proportion was about three times higher compared to no scarification. There was also a significant effect on the proportion of compression wood free diameter for both sites and all treatments. All properties analysed; compression wood, out-of-roundness and pith eccentricity decreased with increasing height in the stem. The results stresses the importance of evaluating the effect on the wood raw material produced of increased growth and instability that more radical soil preparation may produce.

Keywords: out-of-roundness, Pinus contorta, pith eccentricity, reaction wood, soil preparation

PP035

Validation of tomography in standing Quercus robur as a tool to study within-tree variability of wood properties

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In recent years a range of methods from geophysics have been transferred to forestry and arboriculture, especially decay detection and hazard tree assessment. Sonic tomography is now widely applied, with electrical resistivity tomography (ERT) as a recent addition.

Stress wave velocity in wood is related to density and elasticity. However, wood is not isotropic and stress wave velocities are collected in all directions from tangential to radial. In addition, in cross-sections with defects, the true distance traveled by the wave is not known. Thus, relationships between wood properties and tomographic data might actually by quite lose.

Several studies report high correlations between the amount of decay detected by the tomograms and that actually present in the cross-section. But so far, there have been only few and limited studies showing spatial correlations between tomographic and wood data.

Electrical resistivity depends on water and ion content. Thus, electrical resistivity tomography mainly visualises chemical properties. In Quercus robur, data from electrical resistivity tomography correlated with pH, Kalium, and Magnesium.

The objective of this study was to validate the results of non-destructive tomographic techniques obtained in standing trees against properties of wood samples collected after felling and to assess the use of these tools to study within-tree variability of wood. We compare the spatial distribution of tomographic data with that of wood density, MOE, and MOR.

Keywords: Non-destructive testing; density; modulus of rupture; modulus of elasticity
European oak (Quercus robur)

PP036

Anatomical characterization of the Wood of Faveira (*Parkia gigantocarpa* Ducke), occurring in the Brazilian Amazon

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The Amazon has the largest diversity in fauna and flora in the world. So much wealth attracts the attention of many who want to preserve and sustainably exploit. To preserve we need knowledge of the species, especially those that produce commercial timber. The wood anatomy is the study of secondary xylem of plants, their structure, organization, functions and characteristics of each cell element, thereby forming a heterogeneous and anisotropic structure. The anatomical study also allows, species lacking reproductive organs (flowers and fruits) can be identified to taxon family or even identifying and distinguishing apparently similar species.

Due to the large sale of Amazonian woods, the identification of these species by macro and microscopic characterization of wood are of extreme importance, because the specimens are no longer endowed with vegetative organs (flowers and fruits). The specimens were collected in the Brazilian Amazon, near the capital of Amazonas state, Manaus/AM. The macroscopic and microscopic descriptions followed the traditional methods used in studies of wood anatomy. Based on the anatomy of the species studied has characters that are fundamental to the identity and characteristics of the genre, such as growth indistinct layers, pores visible to the naked eye large, diffuse porosity, vessels with tangential arrangement. Axial parenchyma visible to the naked eye, paratracheal diamond aliform, aliform confluent may occur, rays visible only under 10x lens on cross and tangential planes, with vascular straight lines, in the radial spokes are somewhat mixed. Presence of crystals in radial cells.

These macroscopic characteristics when observed may provide identification oreven the distinction of species apparently identical.

Keywords: Anatomy wood, Faveira, Parkia , Brazilian Amazon

PP037

Variation in Fibre Length Distribution in Scots Pine and Norway Spruce

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Fibre dimensions and fibre lengths especially, have a strong influence on the performance of different wood based products. It is therefore of interest how fibre length varies within and between trees. In the present study fibre length distribution, mean values, standard deviation, skewness and curtosis were studied in radial and longitudinal direction. Hypotheses tested were that standard deviation increases with increased fibre length and that fibre length is negatively related to ring width. In addition results from the automatic fibre analyser was evaluated by doing analysis of the images used to evaluate proportion of damaged fibres and incorrect measurements.

From ten Norway spruces and ten Scots pines four discs were taken at 1 %, 1.3 m, 30 % and 60 % of tree height. From each disc three samples were taken at different distance from the pith. The samples were macerated in hydrogen peroxide and acetic acid, thereafter three sub samples from each sample were measured with an optical fibre analyzer During the analysis, pictures of the measured fibres were saved and classified by length. A sample of the pictures was then checked manually to see if the measured values were correct and represented undamaged fibres.

A deviation quotient was calculated by dividing mean length of the pictures with correct measured fibres with the mean length of the length class. For both spruce and pine the mean deviation quotient were 0.96. That means that the fibres that were correct measured were on average 4 % shorter than the mean for all measured fibres. Generally the fibre length increased with height in the tree and with the distance from the pith. On an average for the ten trees, the shortest arithmetic fibre length value was 0.94 mm in spruce. The longest value was 1.60 mm. For pine these values were 0.64 and 1.67 mm. There was no correlation between ring width and fibre length. The standard deviation increased with increasing fibre length and was almost as big as the fibre length. The distribution of tracheids was most skewed and had the sharpest peak at stump height.

Keywords: Picea abies, optical fibre analyzer, Pinus sylvestris, skewness, tracheid

PP038

Wood Characterization of *Eucalyptus urophylla* x *Eucalyptus grandis* Clones in Areas Subject to Damage by Winds

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Forest plantations in the Vale do Rio Doce in Minas Gerais have suffered damage caused by the action of wind, especially in areas of lowlands and in young stands. Studies to identify relationships between the susceptibility of trees of the wood properties are of great importance, allowing selection of clones more tolerant to wind action. Thus, the purpose of this study was to characterize the wood of trees of ten clones of the hybrid Eucalyptus urophylla x Eucalyptus grandis, 30 and 35 months of age, on the strength of the tree to falland the anatomical, physical, mechanical and chemical characteristics of trees. The study site was in lowland regions, where trees are more vulnerable and prone to damage from winds with altitude near 250 m and with low intensity of the climatological winds and frequent occurrence of micro-atmospheric explosions. For this, the dendometric characteristics of the trees were measured and evaluated and strength tests of the tree to fall were done, simulating the effect of wind and a non-destructive method for the determination of longitudinal residual strain. In the laboratory sample of wood were prepared and then analyzed the quantitative anatomical parameters of wood, for the vessels and the morphology of the fibers, the density, the bending, the concentrations of extractives, lignin and holocellulose and calculated the growth stress. The conclusion is that the clone showed the best results, especially in the testing of breaking strength, the physical and mechanical properties evaluated selected for planting in areas susceptible to wind action. For the chemical composition, the clones showed close values for the levels of extractive, lignin and holocellulose, serving only as indicative for the production and yield of cellulose. The endurance test and the mechanical and physical characteristics stood out as the most suitable parameters for the assessment and classification of clones susceptible to wind action, whereas the clones that showed the best results were common. However there is need to broaden the base information regarding the susceptibility of trees to wind.

Keywords: action of wind; tree wood; Eucalyptus urophylla x Eucalyptus grandis

PP039

Effect of Poplar Rust on Basic Wood Density

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Populus is one of the most important commercial genus planted in Argentina. The high growth rates of clonal plantations provide raw material for lumber, veneer, plywood, pulp and particle board industries. Therefore the continuity of wood supply required by different industries is of great importance.

Melampsora leaf rust is a serious disease of Populus spp. that can result in a reduction of photosynthetic leaf area, premature defoliation and productivity loss. It is also widely presumed that heavy infections might influence the wood quality due to insufficient formation of latewood and lignification.

To assess the effects of rust on wood quality, we evaluated basic density (oven-dry weight / green volume) according to TAPPI T 254-om 94 on 200 cross-sectional disks collected at breast height from 2-year-old plants of P. deltoides 'Onda' (I 72/51) with rust (not sprayed) and without rust (sprayed periodically with 25.8 g ai/ha of tebuconazole from early December). Disease progression was

monitored every fifteen days by counting the number of uredia per square centimeter on a random sample of ten heavily infected leaves per treatment.

The first pustules were observed during the last week of December with a peak in the second half of January. Sprayed plants did not show any apparent disease symptoms. Basic density in healthy plants was significantly higher (323 kg/m3) than in rusted ones (312kg/m3). Defoliation caused by rust affects growth through two different processes: on the one hand, the lower leaf area decreases light interception and hence the photosynthetic capacity, on the other hand, senescence and abscission of leaves occur with higher levels of nutrients retained by the fungal biomass, reducing the re-translocation of nutrients to growing and storage tissues. This reduction could modify the cell wall thickness and thus the wood density.

Our results highlight the importance of rust control, because the disease not only reduces growth but also the basic density, which has an important influence on technological properties and the quality of wood.

Keywords: Populus deltoides; Melampsora medusae; poplar rust; wood density.

PP040

Effect of topography factors on growth and morphological traits of Oriental Beech plus trees

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This study was done to improve our understanding on the influence some physiographic

factors including aspect and altitude on quantitative characters of beech (Fagus orientalis Lipsky) plus trees. This research was conducted in Experimental Forest Station of Gorgan University that is located in a temperate forest of Golestan province in the north of Iran. In this research, two parcels at high altitudes (800 - 900m) and two parcels at lower altitudes (550 - 650m) with east and west aspects were selected as well. After selecting of plus trees in every parcels, the characteristics including tree total height, stem height without branch, crown length and radius, trees diameter, annual mean growth of diameter and bark thickness were measured. Greater amounts of annual diameter growth were detected in east direction which had a significant difference ($P<0.05$) with west direction. Results are indicating that the tree total height, stem height without branch, crown length to total height ratio and annual growth of diameter had significant differences ($P<0.01$) between two altitude classes and the most total height and stem height without branch were observed in high altitude class. Crown length to total height ratio and also annual growth of diameter were decreased with increasing of altitude. Analysis of variance showed that interaction effects had no significant differences for all of studied characteristics. In total, our study supports that west slopes and upper altitudes have more appropriate conditions for growth of beech plus trees.

Keywords: Fagus orientalis Lipsky, altitude, aspect, quantitative characteristics.

PP041

Effect of spacing on growth characteristics of P*aulownia fortunei* in north of Iran

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Paulownia fortunei as fast-growing and exotic species from China was planted to determine the best spacing aspect of wood production per area in nursery of Shast kalate forest by random complete block design in three spacing (5×6, 8×6 and 7×7 meters) and three replications. The characteristics of fourteen years old trees were measured including DBH, total height, bole height without branch, two cross diameter of crown and then timber volume, crown length and volume and growth rates of annual and mean and also in period calculated by stem analysis. The variance analysis (ANOVA) and means comparison were done by F test and Duncan respectively. The results indicated that significant differences among spacing aspect of the growth rates. Also up to do this research, the trees did not receive to maximum volume mean growth to cutting except the trees in 8×6 meters spacing. Generally the results signified the each trees had the most DBH, height and volume mean growth in period at 7×7 meters spacing but 5×6 meters spacing had the most wood production mean per hectare per year with 24.65 cubic meters by considering to final individuals per hectare.

Keywords: Paulownia, Spacing, Wood production, Growth.

PP042

Biotechnology application in identification of suitable *Populus deltoides* clones for pulp and paper industries

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Todays, increasing of wood demand is one of the most important problems in our society. Clones of Populus deltoides from salicaceae as an exotic fast-growing species have a good potential for wood planting in the large area. These clones are different aspect of resistance to ecological variation especially temperature and also lignification that is unsuitable material for paper industries. Peroxidase enzyme as a temperature and lignification marker was used for introducing of the best clones for paper manufactures. Sampling was done from one – year old seedling of the five clones and studied quantitative and qualitative activities of Peroxidase enzyme during five months from before, during and after cold seasons (September till May). The results indicated that clone 72.51 had the most resistance to cold from before and during cold months and also mean lignification for planting in middle and upland and clone 67.51 and 69.55 had the mean resistance to late cold and also mean lignification for planting in low land area.

Keywords: Populus deltoides, Peroxidase, Cold Resistance, Lignification.

PP043

Radial and longitudinal variation in vessel and ray cell anatomy of Maple Wood (*Acer Velutinum*) in Plantation and Natural forest in Iran

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Variations in vessel and ray cell features of maple tree (Acer Velutinum) in natural forest and plantation plot in North of Iran were assessed. Three trees of every site were randomly selected and were cut. Test samples were prepared radially (inner, middle, and outer) and longitudinally (1.3, 50% of bole height and under living branches).

In radial direction, the vessel diameter (µm), wood ray frequency (mm-1), and ray cell height showed an increasing trend from pith to bark in both groups. Vessel density (mm-2) showed a decreasing trend; wood ray density (mm-1) showed an increasing trend; and mean ray cell width was instable in natural trees. In plantation trees, vessel density and wood ray density revealed an adverse movement comparing to natural trees, while the mean ray cell width showed a decreasing change from pith outwards.

In longitudinal direction, vessel density and ray cell height had increasing trend from pith to bark in both two groups. In natural maples, wood ray frequency, wood ray density and mean ray cell width demonstrated an increasing movement from bottom upwards, while vessel diameter was instable and highest value appeared in middle part. In plantation trees, vessel diameter, wood ray frequency and mean ray cell width demonstrated a fluctuation trend from down to upper part. The highest values of wood ray frequency and wood ray diameter were revealed in upper part near the living branches as vessel diameter was in bottom part and mean ray cell width in the middle. To sum up, the findings revealed higher quality of wood in natural plantation due to low amount of vessel and wood ray. These changes directly influence the wood density and eventually end-uses.

Keywords: Maple tree, anatomical properties, radial variation, longitudinal variation.

PP044

Heartwood Distribution in British Sitka spruce and Scots pine

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The conversion of sapwood to heartwood has a significant effect on wood durability, moisture content and permeability, properties which are important to both structural and non-structural wood products. These differences in wood properties mean separating sapwood and heartwood at the saw mill can improve the performance of the end wood product. The amount of heartwood varies within and between trees, therefore a method for accurate identification of the heartwood-sapwood boundary is necessary. Allometric equations can be used to predict the boundary from easily measurable properties such as stem diameter or area. Heartwood distribution models can also identify stands with a higher volume of heartwood prior to felling, and can influence stand management, allowing more efficient forest practice and increased value of standing timber.

Heartwood distribution has not yet been described for British commercial species under UK climatic conditions. We developed models to predict heartwood and sapwood diameter and area 1) within any disc, 2) with height in the standing tree, 3) its variation between trees and stands for Sitka spruce and Scots pine, the two most widely planted species. The heartwood age rule, which predicts the number of rings of heartwood from cambial age, was also tested.

There was a strong relationship between heartwood and disc radius and area in both species, and sapwood area was strongly related to disc area. Parameter estimates for the heartwood age rule were similar to published values, whereas published models over-predicted heartwood radius. The heartwood boundary closely followed the stem profile and taper functions were used to model its distribution. Models predicting sapwood area were improved by the inclusion of canopy measurements. Heartwood models were improved by the inclusion of tree age, suggesting on suitable sites with low wind risk, a longer rotation length may present the simplest means of increasing heartwood volume. Final models have been incorporated into wood quality models, to facilitate increased utilisation of heartwood.

Keywords: Heartwood; sapwood; taper function; heartwood age rule; mixed effects models

PP045

Tracheid Allometry and Hydraulic Architecture in *Pinus palustris* and *Pinus elliottii* Trees

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Pinus palustris Mill. (longleaf pine) and Pinus elliottii Engelm. var. elliottii (slash pine) frequently co-occur in lower coastal plain flatwoods of the United States, with longleaf pine typically inhabiting slightly higher and better drained microsites than slash pine. The hydraulic architecture and tracheid dimensions of roots, trunk and branches of mature longleaf and slash pine trees were compared to understand their role in species microsite occupation.

Root xylem had higher sapwood-specific hydraulic conductivity (ks) and also was less resistant to cavitation compared with branches and trunk sapwood. Root ks of longleaf pine was significantly higher than slash pine, whereas branch and trunk ks did not differ between species. No differences in vulnerability to cavitation were observed in any of the organs between species. Across all organs, there was a significant but weak trade-off between water conduction efficiency and safety. Tracheid hydraulic diameter (Dh) was strongly correlated with ks across all organs, explaining more than 73% of the variation in ks. In contrast, tracheid length explained only 2.4% of the variability. Nevertheless, for trunk xylem ks was 39.5% higher at 20 m compared with 1.8 m stem height, this increase in ks was uncorrelated with tracheid diameter and cell wall thickness but was strongly correlated with the difference in tracheid length.

Tracheid allometry changed markedly between sapwood of roots, trunks and branches, possibly reflecting different mechanical constraints. Even though vulnerability to cavitation was not different for sapwood of roots, branches or the trunks of longleaf and slash pine, higher sapwood to leaf area ratio and higher maximum sapwood-specific hydraulic conductivity in roots of longleaf pine are functional traits that may provide longleaf pine with a competitive advantage on drier soil microsites.

Keywords: Wood anatomy; slash pine; longleaf pine; hydraulic conductivity; vulnerability to cavitation,

PP046

Water Availability and Genetic Effects on Wood Properties of Loblolly Pine (*Pinus taeda* L.)

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We studied the effect of water availability on basal area growth and wood properties of 11-year-old Pinus taeda L. (loblolly pine) trees from contrasting Florida (FL; a mix of half-sib families) and South Carolina coastal plain (SC; a single, half-sib family) genetic material.

Increasing soil water availability via irrigation increased average whole core specific gravity (SG) and latewood percentage (LW%) by 0.036 and 6.93%, respectively. Irrigation did not affect latewood SG or wood stiffness, but irrigated FL and SC trees had more latewood due to a 29 day longer growing season. Irrigation didn't affect the length of corewood production, but irrigated trees had earlier transition ages, producing outerwood ~3 years before rainfed trees. The increase in whole core SG and LW% was moderate because irrigation promoted earlywood growth in corewood formed before canopy closure, but after year 7, rainfed and irrigated trees had similar earlywood growth but irrigated trees had more latewood growth, increasing ring SG and LW%.

The SC half-sib family had higher SG and greater LW% than trees from FL independent of irrigation due to greater yearly latewood growth. Thus, absence of soil water stress extended seasonal diameter cessation date but did not change latewood SG or wood stiffness.

Keywords: Wood properties; loblolly pine; irrigation; water availability; specific gravity; latewood production.

PP047

Determination of Relationship between Particles Size and Mechanical Properties of Particleboard by Ultrasonic Technique

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Non destructive test (NDT) is a new technique in quality control process of different products. It has many advantages that has caused its extension in different industries such as wood industry.

In this study two kinds of particleboard were made by small and large particles using UF resin in hot press. Particleboards density was 0.7 gr/cm3 and their thickness considered 16 mm. After particleboard manufacturing and conditioning, test samples were prepared. Then ultrasonic waves transition time were measured in length, width and thickness of samples and ultrasonic waves velocity were calculated. Afterward MOE, MOR and IB of samples were measured. Then regression between ultrasonic waves velocity and mechanical properties was determined in different directions of samples.

According the results, ultrasonic waves velocity in longitudinal direction of particleboard samples was more than other directions, significantly. Also ultrasonic waves velocity in particleboard samples made of larger particles was more than samples made of smaller particles. The most amount of regression between ultrasonic waves velocity and MOE, MOR and IB was determined in thickness direction of particleboard samples.

Keywords: NDT, Particleboard, Particles size, Mechanical properties, Ultrasonic waves

PP048

Assessment of bending properties of 32-year-old Taiwan incense cedar (*Calocedrus formosana*) wood using nondestructive methods

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Taiwan incense cedar (Calocedrus formosana), a conifer endemic species of Taiwan, is a highly valuable species widely used in furniture, artistic carvings, decoration, construction and building materials. However, because of its good physical and mechanical performance, the amount of Taiwan incense cedar plantation area has gradually decreased. For subsequent sustainable management and effective utilization, decreasing the tending cost and improving the wood properties of plantations have become the most important management problems now.

In recent years, the nondestructive evaluation method was widely used to inspect the properties of wood and wood products. These results encouraged us to hypothesize the use of nondestructive techniques may be useful to assess and prove the wood quality in standing trees. The objective of this study reported here was to assess the physical and mechanical properties of Taiwan incense cedar (Calocedrus formosana) standing trees by nondestructive techniques (NDT), avoiding strengthening the species restoration. In addition, the relationship between characteristics of standing trees and wood properties were established. Moreover, the correlations among the velocities, dynamic MOE and static bending properties of Taiwan incense cedar were also investigated.

In this study, twelve Taiwan incense cedar standing trees at about 32-year-old were selected. After standing trees and logs measured by ultrasonic wave testing, small clear specimens were cut and conditioned to 12% moisture content for three kinds of nondestructive testing (ultrasonic wave, tap tone and vibration methods) and static bending test.

The results indicated that the velocities and bending properties were decreased with tree height increased. In addition, it was found the velocities of specimens were greater than those of logs and standing trees. After regressive analyzed, the correlation coefficients (r) were 0.79 for standing trees and logs and 0.70 for logs and specimens, respectively. Moreover, not only the velocities measured by ultrasonic wave (Vu), tap tone (Vf) and vibration (Vt) methods, but dynamic MOE were also found to be well correlated with the static bending properties of specimens (r = 0.86-0.92 for combined group). In addition, the values of dynamic and static MOE showed the following trend: DMOEu > DMOEf > DMOEt > MOE. For all specimens, the r values were found to be 0.92 for MOE and DMOEt, 0.75 for MOR and DMOEt, respectively.

Based on the results of these experiments, it can be concluded that it was highly assumed that the nondestructive methods can be provided basic information from standing tree to specimens for future management practice and wood utilization of Taiwan incense cedar.

Keywords: Taiwan incense cedar; Nondestructive techniques; Ultrasonic wave method; Tap tone method; Vibration method

PP049

Measuring green wood thermal properties

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In order to circumvent the soaking of wood prior to peeling an IR heating system, directly embedded on the peeling lathe, was a solution concluded from previous research. Its feasibility has been investigated through a numerical model of heat transfer within a rotating green log under an external IR source while peeling. The knowledge of green wood thermal properties is essential to feed into the model characteristic material values as a function of wood Moisture Content in order to obtain accurate simulation results. Characterising the thermal properties of green wood would also result in a better understanding of the slicing, forming and drying processes.

Wood is a heterogeneous material whose thermal properties have been determined and the various roles played by its structural characteristics (density, species, heartwood/sapwood, type of rays, longitudinal/transversal direction) demonstrated. However, the influence of Moisture Content on the thermal properties of green wood has never been studied.

This paper proposes the use of a Transient Plane Source (TPS) technique to determine thermal conductivity, thermal diffusivity, and specific heat capacity of green samples of beech, birch, douglas-fir and spruce wood. The principle consists in using a hot disk sensor of several square centimeters placed between two sample pieces, used both as the heat source and temperature sensor.

This technique was preferred to the more conventional Transient Hot Wire and Transient Hot Plane methods which measure temperature evolution locally, by a thermocouple, and not the whole surface. This choice was motivated by the desire to obtain consistent results independent of wood heterogeneities (earlywood, latewood, knots).

By simulating several heating scenarios, this model establishes itself as a necessary decision-making tool for the optimised design of an in-line IR heating system directly embedded on the peeling lathe.

Keywords: Beech, birch, douglas-fir, spruce, thermal properties (conductivity, diffusivity, heat capacity, effusivity), green wood.

PP050

Investigation on the fundamental properties of cross-laminated timber (CLT) using nondestructive methods

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The purpose of this study was to develop a new engineering wood material (Cross-laminated solid wood timber, CLT) made from Taiwania (Taiwania cryptomerioides), Japanese cedar (Cryptomeria japonica) and Southern pine (Pinus spp.) swan lumbers. In addition, feasibility of this kind of product used as construction and building materials was also investigated.

CLT is a kind of engineering integrating plate product. Compared to other sheet engineering products, CLT is not only the elements of structural wall, but also directly used as load bearing wall and shear wall structure. In addition, CLT and glulam can use as the construction and building materials in laminated wood building construction. This study here was prior to investigate the properties of laminae and CLT by nondestructive testing (NDT) evaluation, including visual graded method, ultrasonic wave method, vibration method, tap tone method and static bending test.

Results indicated that the bending modulus of different grades of lumber in decreasing order were Class2 > Class 1 > Class 3 > Below grade for Taiwania lumber and Class 1 > Class2 > Class 3 > Below grade for Japanese cedar laminae, respectively. However, there were no significant different in all grade classes. According to regression analysis, there were well positive relationships between dynamic modulus of elasticity (DMOE) and modulus of elasticity (MOE) values for all specimens, the R2 value was 0.81 for DMOEu and MOE, 0.86 for DMOEf and MOE, 0.86 for DMOEaL and MOE, 0.86 for DMOEaT and MOE, respectively. Results also indicated that the tap tone and vibration test were the better nondestructive methods for lamina evaluation. In addition, it also demonstrated that nondestructive evaluation techniques can effectively and economically grading wood material.

Although the longitudinal MOE (Ext) of 3-layers and 5-layers CLT by bending test were lower than the theoretical calculation and plate vibration test value (Exc), the longitudinal MOE values had trends of Excu (modulus calculated from ultrasonic wave testing) and Exca (modulus calculated from vibration testing) > Exc > Ext. Moreover, there were well relationships between Exc and Ext. The R2 value was 0.84 for Excu and Ext, and 0.67 for Exca and Ext, and 0.69 for Exc and

Ext, respectively. There was well relationship between Ey and Eyt on transverse direction. The R2 value was 0.57 for Eyc and Eyt. Shear modulus (Gxy) and poisson's ratio (uxy) were also well relationship between plate vibration test (Gxyc and υxyc), ASTM D 198 (Gxyt) method and compression test (υxyt). The R2 value was 0.91 for Gxyc and Gxyt and 0.97 for υxyc and υxyt. Based on the results of these experiments, CLT fundamental properties can be concluded by non-destructive methods that highly correlated with experimental values.

Keywords: Cross-Laminated Timber; Panel vibration; Modulus of elasticity; Shear modulus; Poisson's ratio

PP051

Prediction of bending properties for beech wood (*Fagus orientalis* L.) using stress wave method

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In this study, bending properties of beech wood (Fagus orientalis L.) was predicted using stress wave method. Wood samples which have different cross sections and length were weighted and measured in order to calculate their apparent densities. Moisture content of the test pieces was measured with a pinned meter. Density, moisture content and dimensions of the samples were used as input for the MTG timber grader which was utilized to predict dynamic MOE values of lumbers. MOE values of the lumbers were determined using three point bending tests. Using load-deformation graphs, elasticity and strength in bending values were then calculated. Coefficients of determination between measured and predicted MOE's were seemingly high (0.85). Furthermore, correlation between density and static MOE, dynamic MOE and bending strength values are 0.4, 0.42 and 0.19 respectively. It is apparent that stress wave method has the potential and capacity to predict the stiffness of beech wood. Statistical regression models will also be used to predict bending properties of beech wood.

Keywords: bending properties, stress wave, beech wood

PP052

Validation of beech (*Fagus sylvatica L.*) branch scar quotient to determine internal knottiness using CT technology

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Occluded knots appear on the bark of smooth-barked species, especially beech, as so called "branch scars/seals". With the growth in girth the branch scar alters the dimension only in horizontal direction. Therefore the quotient of width and height of the scar allows to deduce the size of occlusion of the branch.

This criterion, known as the "branch scar quotient" respectively "branch seal quotient", is based on a rule published by KNIGGE/SCHULZ in 1966. It describes the possibility to determine the radius of occluded knots on beech by measuring the relation of their branch seal width to branch seal height.

From that it is possible in certain precision to determine directly the branch containing core of underlying stem diameters.

In this context it is of particular importance that in the revision of European Norm for hardwood round timber (EN 1316-1) as well as of new grading rules in Germany (RVR) the implementation of thresholds are stipulated.

Altogether 46 seals with subjacent knots were removed as sample materials. Logs of beech with stem diameters between 30 and 55cm were used, found in the stands in the southwest of Baden-Württemberg. A wide range of branch seal quotients from 1:1 to 1:6 could be investigated in that extensive approach.

A computed tomography (CT) analysis was preposed. This approach was helpful in two ways: to support in destructive radial cutting through the knot. In the real (radial) view measurement was possible to determine the ratio between knotty and clear wood very precisely. Secondly by manual measurements a "ground truth" reference system is established which allows to develop a branch model for internal knot structure based on CT images for fresh wood.

The results of the statistical analysis are ranked as highly satisfying.

To explore the relation between calculated percentages of the knot containing stem core from the branch seal quotient vs. the manually measured knot containing core, a statistical analysis was set up. To determine the direct relation between these variables, a correlation was calculated. With the resulting correlation coefficient of r = 0,91 a tight positive linear relationship could be identified.

The regression analysis also expressed a very tight linear relationship through a straight line showing a gradient of y = 1,0005x – 0,0047 and a coefficient of determination of R2 = 0,83. From the gradient, it can also be derived that there is actually no over- or underestimation of the knotty core by trend, calculated from the branch seal quotient. With the gradient of 1,0005x the regression straight line also nearly perfectly represents the bisecting line between abscissa and ordinate.

The work on the internal knot model for Beech is in progress.

Keywords: knots in beech; branch scar, clear wood, knotty core, branch scar quotient, grading rules in Europe and Germany, CT-scanning

PP053

Trunk structure, CT scanning and tree architecture

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The future of log grading and sawing optimization is moving further towards the detection of most external and internal features. The recent results gained with a medical X-ray CT scanner and a manual procedure of image interpretation (Colin et al., 20101) let expect new ways for improving industrial CT scanning.

The objective of this report is to depict how can be taken maximal advantage of the computer tomography to recover as many as possible architectural features.

Logs of spruce, fir, oak and other broadleaved species were scanned, recovered from individuals either with good or bad external quality. Primary growth, phyllotaxis, bud arrangement, knot arrangement and shapes were quantified. Detailed studies on sessile oak provided encouraging results on epicormic knot detection. It turned out that species-specific architectural features strongly constrain wood defects.

Our results give access to procedures of species recognition, log grading and sawing optimization accounting for the species-specific architectural patterns.

Keywords: X-ray CT, tree architecture, wood defects

1Colin F, Mothe F, Freyburger C, Morisset JB, Leban JM, Fontaine F. 2010. Tracking rameal traces in sessile oak trunks with X-ray computer tomography: biological bases, preliminary results and perspectives. Trees-Structure and Function, 24: 953-967.

PP054

Response of Chemical Index to Decay in *Juglans mandshurica* Maxim and *Pinus koraiensis*

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The cellulose content, lignin content, and relative crystallinity were measured using nitric acid-ethanol method, acid insoluble lignin, and X-ray diffraction method to further explore the process of wood decay. The main chemical indicators for healthy wood and rotted wood at different decay levels in two species Juglans mandshurica Maxim and Pinus koraiensis were analyzed. Results indicated that the cellulose content and relative crystallinity decreased and acid insoluble lignin content increased as wood decay increased. X-ray diffraction results showed that there were no significant changes in the lattice structure between healthy wood and rotted wood. Approximately 98.3% and 99.9% of the variations for wood decay in Juglans mandshurica Maxim and Pinus koraiensis can be explained by the comprehensive effect of the above chemical indicators.

Keywords: wood decay, cellulose content, acid insoluble lignin, relative crystallinity

PP055

Characterization of defects in *Pinus radiata* pruned logs

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Management schedules applied to P. radiata plantations during the past 20 years in Chile are generally characterized by carrying out two or three prunings, complemented by one or two thinnings, to obtain pruned logs for the sawmill and plywood panels industry. As a product of the implementation of these management schedules, pruned logs that are 5 to 6 meters in length are usually obtained which present a clear wood yield of between 10% and 22%.

In order to evaluate the relationship between the external characteristics of pruned logs and the presence of internal defects, such as internal checks, bird eyes, resin veins and resin pockets, more than 3,000 pruned logs from 17 plots of Arauco forest land were evaluated in sawmill and plywood plants.

The results obtained shows that 23 per cent of the evaluated logs have visible external defects, such as resin flush, epicormic shoots, mechanical damage and severe bumps, especially without rind. Defects with greater presence, by the evaluated logs, were bumps and mechanical damage from silvicultural management (thinning and pruning), consisting of 17% and 14% of the evaluated logs, respectively.

Defects such as bird eyes and strong bumps significantly affect the clear wood yield in the plywood and sawn lumber industry, reducing the clear wood yield to a level close to 60%.

A specific study oriented to determine the existence of defects in sawn lumber showed that between 26% and 50% of the wood that was potentially clear was declassified by the presence of raw material defects. The most important defects observed were resin veins (44%), bird eyes (29%), resin pockets (24%) and internal checks (3%).

Keywords: Radiata pine; external defects, clear wood, log segregation, lumber, plywood, sawn lumber.

PP056

The influence of PF impregnation on physical and mechanical properties of plantation Poplar lumber

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The properties of planted poplar lumber (Populus tomentosa) impregnated with low molecular weight phenol-formaldehyde (PF) solution was studied in this paper. The physical and mechanical properties of control and PF impregnated lumber were investigated, the results showed that: After PF impregnation, the density of lumber is higher, and density uniformity is more even across the earlywood and latewood than that in control samples. The MOE and MOR of Poplar lumber were significantly improved by PF impregnation, but the toughness sharply decreases, it was 77% lower than that of control sample. The hardness of impregnated lumber was 70% higher than control samples. Anti-shrinking efficiency of impregnated lumber was 24.8%, Moisture excluding efficiency was 21.2%; the Anti-swelling efficiency was 37.7% in water absorption, and the ratio of tangential-radial swelling rate was beyond 30%. The dimensional stability and anisotropic property can be greatly improved, but the surface wettability was worse than control samples.

Keywords: Populus tomentosa, impregnation, dimensional stability, physical and mechanical property, low molecular weight phenol-formaldehyde resin

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PP057

Comparison of sorption characteristics and thermodynamic properties of *Pinus sylvestris* L. wood after various ageing processes

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The wood of Pinus sylvestris L. is one of the most commonly used timbers in both carpentry and structural applications. Its physico-mechanical properties have been widely studied, including the sorption curves. However, no comparison has been made of the hygroscopic equilibrium points of the wood of this species using samples subjected to various ageing conditions.

The hygroscopic and thermodynamic behaviour of four groups of Pinus sylvestris L. wood were studied: recently felled wood; wood submerged for 103 years; 205-year-old wood forming part of a structure; and 1170 year-old wood from excavations.

The 35ºC and 50ºC isotherms were plotted following the saturated salts method and fitted using the GAB model. The hysteresis coefficients were used to compare the isotherms and the integration method of the Clausius-Clapeyron equation was applied to determine the thermodynamic parameters.

Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction analysis (XRD) were used to study possible changes in both the chemical composition and the cellulose crystal structure.

In all cases, higher equilibrium moisture contents were observed in the aged wood than in the recently felled wood, primarily due to the increase of amorphous zones available to become sorption centres inside the structure of the cellulose. Similarly, FTIR analysis showed obvious hemicellulose degradation in the submerged wood and the 1170-year-old wood but not in the 205-year-old wood.

An increase in the hysteresis coefficient was also observed, indicating a decrease in the free energy in the hysteresis cycle and therefore greater hygroscopic stability in wood subjected to various conditions of conservation than in recently felled wood.

Thermodynamic studies have not shown a clear tendency in the behaviour of total heat of wetting. Although in the submerged wood and the 1170-year-old wood it was higher than recently felled wood, in the 205-year-old wood it was lower.

Keywords: Isosteric heat; isotherm; hygroscopicity; Fourier transform infrared spectroscopy (FTIR); X-ray diffraction (XRD).

PP058

Use of nondestructive evaluation techniques for determining the quality of the wood of Amazonian species

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The nondestructive evaluation of wood is an important tool to determine the technological properties of this material, presenting the advantage of not interfering in its later use. Among the various techniques, the use of ultrasound wave stands out because of the relevance of the information that can be obtained in relation to mechanical properties of wood, particularly their elastic constants. As the ultrasound, the technique of image analysis is also a tool that provides fast and accurate results in anatomical characterization of the wood. Thus, in order to determine the quality of wood, from the technological properties of two Amazonian species (Symphonia globulifera L. f. and Enterolobium schomburgkii Benth.), were used techniques for nondestructive evaluation: ultrasound and image analysis . The equipment used in ultrasound test was USLab for wood, with 700V and transducers of 45kHz flat section. For image analysis system was used Leica Application Suite. Samples of this study were collected in furniture industry in the city of Cruzeiro do Sul, Acre, Brazil. The results obtained for the dynamic modulus of elasticity in the test of ultrasound was 22 793 MPa for S. globulifera and 16500 MPa for E. schomburgkii. In characterizing anatomic, S. globulifera showed librifom fibers, median (1.94 mm) overall diameter (29µm), diameter of the lumen (7µm) and wall thickness (11µm) deep. Paratracheal parenchyma aliform linear. E. schomburgkii presented librifom fibers; short (1.13 mm) overall diameter (20µm), diameter of the lumen (11µm), wall thickness (5mm) thick to thin. Paratracheal parenchyma aliform diamond. The nondestructive evaluation techniques used in this study proved effective in obtaining the technological properties, to determine the quality of wood from Amazonian species studied. These species show potential uses in various segments of the timber industry.

Keywords: Amazonian woods, anatomy, image analysis, ultrasound.

PP059

Cork plank and Stoppers characterisation by near infrared spectroscopy

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The objective of this viability study is to assess the potential of near infrared spectroscopy (VIS +NIRS) technology combined with multivariate analysis for characterising cork plank and stoppers according to the following variables: Visual quality, porosity, physical properties, mechanical properties and geographical origin.

The study was carried out on cork planks and natural cork stoppers from the most representative cork-producing areas in the world. Two training sets of international and national cork planks, comprised by 479 samples from Morocco, Portugal, and Spain and 179 samples from the Spanish regions of Andalusia, Catalonia, and Extremadura, were studied. A training set of 90 cork stoppers from Andalusia and Catalonia was also studied.

Original spectroscopic data were obtained for the transverse sections of the cork planks and for the body and top of the cork stoppers by means of a Foss-NIRSystems 6500 SY II spectrophotometer using a fiber optic probe. Remote reflectance was employed in the wavelength range of 400 to 2500 nm. After analyzing the spectroscopic data, quantitative equations and discriminant models were obtained with 70% of the samples. The best ones were then validated using 30% of the remaining samples.

The quantitative calibrations obtained using NIRS technology for porosity, visual quality and physical and mechanical properties are promising considering the heterogeneity and variability of a natural product such as cork. The qualitative analysis regarding geographical origin achieved very satisfactory results. At least 98% of the international cork plank samples, 95% of the national cork plank samples and 90% of the stoppers were correctly classified in the calibration and validation stage.

The results demonstrate the potential of VIS + NIRS technology as a rapid and accurate method for predicting the geographical origin of cork plank and stoppers. Applying these methods in industry will permit quality control procedures to be automated, as well as establishing correlations between the different classifications systems currently used in the sector. These methods will provide a certainly more objective tool for assessing the economic value of the product.

Keywords: Quercus suber L., NIRS, Cork plank, Stoppers

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Theme: Topic 15. Cork
Name of presenter: Cristina Prades

PP060

Detection of tension wood that causes non-recoverable collapse in *Eucalyptus globulus* using near infrared spectroscopy

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Eucalyptus globulus is widely planted worldwide, but utilization of this species for sawn and engineered wood products remains limited by the occurrence of tension wood affecting sawing and drying performance. In particular, tension wood can cause non-recoverable collapse when timber is dried, leading to increased processing costs and reduced product value.

Near-infrared reflectance spectroscopy (NIRS) scanning technology provides a fast and cost-effective way of assessing several commercially important wood properties, including cellulose content, density and microfibril angle (MFA). Each of these properties is typically altered in tension wood, and their measurement should allow the presence and extent of tension wood to be assessed. An ability to detect tension wood in standing trees by non-destructive methods (such as NIRS scanning of small wood-core samples) would be a valuable tool for assessing the suitability of plantation-grown E. globulus for solid wood products.

This research investigated the use of NIRS to detect tension wood associated with non-recoverable collapse in Eucalyptus globulus by determining the limits of cellulose content, wood density and MFA that in combination were associated with the occurrence of non-recoverable collapse.

NIRS spectra were taken from 175 wood cores from a 20 year old plantation, green and after drying to 12% EMC. Shrinkage measurements were obtained before and after reconditioning. An additional 20 core samples were analysed by SilviScan-3 to determine MFA and density variation. Spectra from these strips were used to build NIRS calibrations based on SilviScan data. Calibrations were used to predict cellulose, density and MFA with the spectra from the larger set, and the results were related to the shrinkage and collapse data. Wood properties predicted by NIRS were clearly associated with shrinkage, showing high cellulose, high density and low MFA at the points of measured non-recoverable collapse. These findings form a basis for a rapid screening method for the non destructive assessment of non-recoverable collapse associated with tension wood using intact increment core samples.

Keywords: eucalyptus; tension wood; near infrared spectroscopy; plantation; collapse

PP061

Influence of the slope of terrain on the spatial variability of the wood density within *Eucalyptus* trees

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The aim of this study was to understand how contrasting environments influence the wood formation in Eucalyptus clones and the effect on wood density and spatial variability. Wood density was assessed in clonal tests represented by 150 Eucalyptus urophylla x grandis hybrids with 6-year-old growing under different conditions. The main difference among the sites was the slope of the terrain: the clonal tests were replicated at plan site (0° of inclination), at site with 20°, and 40° of inclination.

In order to provide experimental data to perform this study, gravimetric (reference) method and near infrared (NIR) spectroscopy were combined for assessing the wood density in a large sampling of Eucalyptus wood. Hence, regression model based on NIR spec-

tra was developed for estimating such wood traits from NIR spectra recorded at different radial and longitudinal positions along the height of the tree.

This approach allows the examination of the patterns of spatial variation of wood density within Eucalyptus trees. Variations in wood density along the stem are less consistent than those in the radial direction, especially close the base of the tree. Overall, the wood density strongly varied from pith (460 kg m-3) to bark (600 kg m-3) at the base. The radial variation in wood density at the base was about 140 kg m-3 while the radial variation at 25% of stem height was slightly low (~130 kg m-3). At 50% of height the trait also increased radially (~104 kg m-3), but in relative low magnitude. The density slightly increased from pith to bark at 75% of height (~50 kg m-3) and at the top of the tree the variation was of lower magnitude (~20 kg m-3). The radial variation at the base take into account the wood formed from the first to the sixty year of growth while the variation in the top of the tree refers to the wood developed with few months of difference.

The pith to bark variations in wood density were higher in the trees from the site presenting 40° of inclination. At 25% of the tree height, the radial variation was 104 kg m-3 in the site plan (0°), 133 kg m-3 in the site presenting inclination of 20°, and 157 kg m-3 in the site with 40° of inclination. In conclusion, the higher the inclination of the terrain, the greater the magnitude of wood density variation. Sloped terrains induce formation of reaction wood influencing the radial variation in wood traits.

Keywords: Hardwood; plantation; adaptation; specific gravity

PP062

Investigation on strength grading of drift wood in Taiwan by using stress-wave-based tomography

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In 2009, typhoon Morakot carried out more than 1.5 million ton drift wood and caused a serious problem of dealing with these drift wood in Taiwan. Although most of these drift wood are low-economic, there are still have large diameter and fine quality logs which can used for many applications, such as furniture, flooring, outdoor decking, etc. Therefore, the first thing to utilize these drift wood is to confirm and classify their wood qualities. After classifying, it not only can save the processing time and cost, these wood materials also can be used in construction and building materials. In recent years, the non-destructive testing (NDT) and non-destructive evaluation (NDE) method were widely used to inspect the properties of wood and wood-based composites. Among these techniques, ultrasonic and stress-wave based imaging techniques are the easer, lower cost and more efficient for wood. The purpose of this study was to evaluate wood holes/defects using a stress-wave tomographic technique.

There are two experiments to evaluate wood quality by using stress-wave technique in this study. Firstly, 300 mm in diameter and 100 mm thick cross-sectional camphor wood (Cinnamomum camphora) disc was prepared to chisel circular hole from 10 mm to 230 mm in central side and captured by stress-wave tomography. Then feasibility of using this tomography to evaluate wood quality is confirmed. Secondly, twenty drift wood logs over 400 mm in diameter were selected. After visual grading, longitudinal velocity test and stress-wave tomography, disks were cut and soaked in water over fiber saturation point (FSP) for tomography and surface hardness test, then small clear specimens (20 × 20 × 60 mm3) were cut and conditioned in 20oC, RH 65% four weeks for density and compression test. In order to evaluate the shapes and sizes of wood defects, two-dimensional image tomographic software (Arbosonic software) developed by Fakopp (Hungary) was used.

Result indicated that the stress-wave velocity decreased with increased the hole area. In addition, the relative velocity decreased with hole area in highly correlation, the R2 value of path D was 0.99. The difference in colour tomogram between hole area and surrounding area was observed when over 3% hole area. On the other hand, the longitudinal velocity of drift wood logs ranged from 1217-3399 m/s, the average velocity value was 2257 m/s. Results also revealed that combined the longitudinal velocity and tomography technique can provide a method to detect the decay of logs effectively.

Moreover, there were well relationships between strength with scale velocity, the correlation coefficients (r) was 0.92 for hardness and 0.80 for compression value, respectively. Based on the results of these experiment, we indicated that the stress-wave-based tomography technique provide incipient information of wood quality. Furthermore, it could be used for standing tree risk assessment or wood structure defect evaluation.

Keywords: Drift wood; Nondestructive techniques; Stress-wave-based tomography

PP063

Determining Modulus of Elasticity of Modified Poplar Wood Using Estatic and Ultrasonic Methods

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Poplar is a fast grown tree which has recently been demanded for wood industries. The fast grown species has low density and strength. Therefore, they are not suitable for applications with high mechanical strengths. This research has been aimed to improve poplar wood strength by a Combined-Hydro-Thermo-Mechanical Modification (CHTM) technique.

Wood blocks were cut in sizes of 50×55×500 mm and treated with water at temperatures of 120, 150 and 180 °C in a stainless steel cylinder for 0, 30 and 90 minutes as holding time and then at a press temperature of 180 °C. The blocks oven dried and then their Static and ultrasonic modulus of elasticity were determined and correlatios have been developed between them.

Results revealed that the modified wood attained a higher MOE, but did not give good correlation between Ultrasonic and static bending MOE.

Keywords: Combined Hydro-Thermo- Mechanical treatment, Static modulus of elasticity, Dynamic modulus of elasticity, Nondestructive evaluation.

PP064

Effect of wood properties on radial distributions of ultrasonic wave velocity in softwood stem

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The ultrasonic wave velocity is an important parameter for nondestructive testing of wood. It varies from the pith to the bark within the trunk. Such inhomogeneous distributions are disadvantages to apply the ultrasonic technique to a nondestructive testing method. Therefore, it is needed to know the distributions of velocities and clarify their mechanism. The objective of this study is to elucidate the effect of wood properties on within-tree variation in the ultrasonic wave velocity in softwood.

The velocities of longitudinal ultrasonic waves propagated along three orthotropic (longitudinal, radial, tangential) directions in Japanese cedar and Japanese cypress were measured with the sing-around method. In addition, the radial variations in velocity and in wood properties, namely, the tracheid length (TL), microfibril angle (MFA), and air-dried density (AD) were also measured. The radial variations in the velocities and wood properties and the correlations among them every three types: juvenile, mature, and total woods were investigated in order to clarify the mechanism of velocity distributions.

The velocities in the longitudinal direction changed from the pith toward the bark. Their radial variation showed the same patterns as those in the TL and opposite to those in the MFA and the AD. However, the velocities in the radial and tangential directions exhibited constant values. The velocities in the longitudinal direction exhibited strong correlations with the TL, MFA, and AD at a 1% significant level. The correlations of juvenile wood were stronger than those of mature wood. These findings revealed that the wood properties, i.e., the TL, MFA, and AD greatly influence the velocities in the longitudinal direction for softwood.

Keywords: Longitudinal wave velocity; Within-tree variation; Tracheid length; Microfibril angle; Density

PP065

Relationship between apparent density and moisture of the wood below the FSP

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The quality of wood can be calculated from its density, which can be obtained from the average value or its variation with different methods: from the basic density or dry bulk density in diferent moisture levels. In some laboratory testing methods, density is determined from the apparent moisture content below the fiber saturation point (FSP).

The objective of this study is to obtain an expression that relates the basic density of wood with a moisture density it in the wood below the FSP. The study was divided into two parts: first the basic density was related to the apparent dividing one by the other and have been used definitions of volumetric shrinkage and moisture on a dry basis to simplify the resulting expression into an equation with four unknowns: basic density, density apparent, moisture density, and volumetric shrinkage. In the experimental part was obtained an empirical expression for the volumetric shrinkage as a function of the density. We used 45 samples of wood species Eucalyptus grandis, after cutting 15 trees. Of each plant were extracted and sawn 3 samples in the form of rectangular polygon with dimensions: 2.0 x 3.0 x 5.0 cm in the tangential, radial and axial respectively. The samples were immediately submerged in water after cutting to avoid losing moisture. In the assay were obtained from the measurements of volume and mass during the drying process which took place in the natural environment and then temperature-controlled environment to the complete drying of the samples.

Finally, we obtained an empirical expression of the volumetric shrinkage as a function of density, which was replaced in the theoretical expression generating the final equation. We compared the results of experimentally determined densities with the densities calculated from the expression and found that there was no statistical difference. Thus, we obtained a single, unified expression to transform basic wood density in bulk density with moisture below the PSF of wood or vice versa, with the results of the densities calculated using the same very close to those determined experimentally.

Keywords: basic density; specific gravity; eucalyptus

PP066

Rapid QC of MUF Resin for MDF Manufacture via NIR Spectroscopy

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Melamine-urea-formaldehyde (MUF) resin is extensively used in the production of medium density fibreboard (MDF) panels. The resins are often modified to impart moisture resistance or to minimise formaldehyde emission in the completed panel, particularly to meet the stringent Californian EPA Air Resources Board (CARB) emission standards.

Often, the MUF resins are manufactured at a specialist resin plant distant from the MDF production facility. At the time of manufacture, the resins are tested for a variety of properties (which may include viscosity, pH, solids content and others) and a Certificate of Analysis is issued for each batch of resin. At the MDF facility, the fresh batch of resin is transferred to holding tanks, which may or may not contain large volumes of existing, and aged, resin, which results in an unknown degree of dilution of the fresh resin with old. As such the resin that makes its way to the fibre mat in no way resembles the resin described by the Certificate of Analysis.

However, MDF manufacturers would like to know the properties of the resin that is deposited on the fibre. In fact they would prefer to also have information on the chemical composition of the resin such

as the extent of branching in the methylol and methylene moieties and the reactivity of the resin in terms of gel time or adhesion testing. More importantly they require this information in real-time (or close to real-time) and cannot afford to wait hours for the results of testing.

Near infrared (NIR) spectroscopy provides a potential means for on-line or at-line determination of resin quality. A number of conventional and non-conventional resin properties have been correlated with NIR to establish rapid measures of key parameters which can be inserted into control charts to measure the resin performance.

Keywords: MUF; melamine-urea-formaldehyde resin, NIR

PP067

Usefulness of Portable Ultrasonic System for Investigating Wood Properties

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The aim of this study is to confirm the wood properties with portable ultrasonic system (KCT-2000). The system was developed for detecting internal defects on structural members in ancient wooden building. In on-site measurement, the applicability as well as the accuracy should be considered. The prototype of portable ultrasonic device was developed for enhancing these two aspects together.

In case of ultrasonic device, coupling gel was used between the face to face contact areas to improve the accuracy of detecting wood properties. However, in case of national treasures, it was banned due to the possibility of spreading the colour paints. Without the coupling gel, it is difficult to satisfy the accuracy of accepted data. To overcome this problem, the coupling medium was made with an elastomer on probe which was inserted in cylinder with spring to give regular pressure (60N). Moreover, the ultrasonic signal can be received easily by tablet computer with Labview program. It enables us to analyze the ultrasonic parameters, ultrasonic waves and energy distributions, related to the properties of wood. The central frequency of ultrasonic sensor was about 80kHz and the amp gain was designed to be amplified from 0 to 42db to make it possible to apply this system to even large size-structural members.

To confirm the usefulness of KCT-2000, as a simple test, the ultrasonic velocity according to the wood direction was conducted. The average velocity of longitudinal direction was 5997.6 (m/s), that of radial direction was 1706.2 (m/s) and that of tangential direction was 1242.9 (m/s). Thus, the velocity ratio was 4.83:1.37:1. Especially, the range of coefficient of variation (COV) was 0.002~0.015, which means that this system has the high reproducibility of test as well as high reliability of data. In the future, the anisotropic and non-homogeneous properties of wood will be investigated.

As a result of the study, the accurate and effective detecting process will be developed for investigating the wood properties and these results are expected to be actively used in on-site place for estimating the properties of wood product or investigating the deteriorations in structural wooden members.

Keywords: wood properties; ultrasonic parameters; ultrasonic system; wood material science

PP068

Torsional Strength of Wood Beams Twisted by Bolts

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In timber structures, structural members are often fastened each other by steel bolts and nuts. This type of connection mainly bears shearing loads and the specific allowable stresses are defined in various design codes. On the other hand, it would not be deniable that the bolted joints are exposed, though it would be very unusual cases, to the torsional forces around the longitudinal axis of the wood beams. It seems that wood is very fragile to such type of loading mode, but there are few reports on the strength characteristics. Therefor, we carried out basic studies on the strength of wood beams which are twisted by two bolts.

Test specimen were prismatic wood bars with two holes, in which steel rods were inserted, and the twisting moment was applied using these steel rods. The length and width of the test specimens were changed while its height was maintained at a constant value. Other experimental parameters were the distance between the two holes and the edge distance of one side hole. Tests were carried out using a manual loading equipment with a lever, recording the applied torque and two kind of twist angles: the angle between loading rods and the angle between fixed distance at the mid span.

Cracks were initiated from the bolt hole of the edge side, and test specimens were easily destroyed by a human power. The specific torsional strength increased with the increase of the width of specimen and the edge distance of the bolt hole. The amount of indentation at the loading bolts became clear from the ratio of the two twist angles. We can conclude that the twisting force around the bar axis at the bolt-joints should be avoided, but further study would be required to understand the bolt-nut fastening effect on it.

Keywords: bar twist; bolt hole; crack; torsional strength; timber structure

PP069

Intra Growth Ring Wood Density Measurement Using Hyperspectral Imaging and Neural Networks

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We report new results on a recently developed method that combines hyperspectral imaging and neural networks to measure the density of wood from coniferous trees. The density is measured with 79-µm spatial resolution, a value of the same order of magnitude as the transverse dimension of coniferous wood cells.

Hyperspectral imaging is a spectroscopic technique that forms an image containing the measurements of the interaction between light and matter for hundreds of wavelengths. In the present case,

the interaction measured is reflectance, which is defined as the percentage of light intensity that is reflected by the sample relatively to the incident light intensity. The hyperspectral image yy-axis corresponds to wavelengths between 380 and 1028 nm and the xx-axis to positions over a straight line on the sample.

Neural networks, in the present case multilayer perceptrons trained with the Levenberg-Marquardt algorithm, are mathematical processors, capable of learning functions from examples. Here they convert hyperspectral information into density values.

Hyperspectral imaging has several advantages over X-ray microdensitometry: 1) it does not use radiation harmful for health; 2) the experimental setup is simpler; 3) measurements are done for thousands of positions simultaneously instead of point-to-point. Various research groups reported using spectroscopy to measure wood density in regions a few millimeters wide. Their spatial resolution is significantly inferior to ours.

Neural networks were trained and their efficiency validated with sets of 21452 and 20291 points, respectively, measured on 42 samples from the same number of trees. Each set contained measurements from 21 trees, 17 from Pinus Pinea and four from Pinus Pinaster. The errors were evaluated using X-ray microdensitometry values as reference. The best neural network created has two neurons in one hidden layer and 55 principal components as input. The validation set results for squared correlation coefficient, root mean squared error and mean absolute percentage error are 0.843, 5.97x10-2 g/cm3 and 5.99%, respectively.

Keywords: Hyperspectral Imaging, Neural Networks, Density

PP070

Effect of moisture phase change on heat transfer in timber frame wall

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Recently, there has been growing interest in wooden houses in Korea. Most of wooden housings constructed in the last decade were light-frame constructions. The deterioration of wooden members in light frame walls threatens the structural safety of the building because the weight and lateral loads are supported by these members. High-moisture content of the studs is an important concern. Moisture creates a good environment for mould and mildew growth, resulting in health problems as well as possible structural weakening.

This research was planned to predict the distribution of temperature and relative humidity, which were important factors to affect the deterioration of wooden member in light frame wall, under transient outdoor air conditions.

For the purpose, housewrap, OSB sheathing, glass wool insulation and gypsum board were assembled and exposed to two transient boundary conditions- summer and winter. Temperature and relative humidity sensors were installed to the wall assembly and 1-D numerical analysis was used for the prediction. Then the measured and predicted data were compared.

From the results, finite differential method for heat and moisture transfer showed good agreement with experiment and calculated value. But, moisture transfer was more complicate. Because the model did not consider moisture buffering effect or etc.

Keywords: heat transfer, moisture transfer, building component, Numerical analysis, transient, moisture phase change

PP071

Assessment of hygroscopic performance of wood for interior building materials

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The living spaces constructed recently require high airtightness performance for saving cooling and heating energy. The chances to release steam caused by human activity in building reduced and people become reliant upon the artificial humidification facility. However, the inappropriate management of the artificial system frequently causes mold and fungi growth in air line, then those causes asthma, allergic rhinitis and other conditions that make it hard to breathe. It becomes important to find out the natural way to maintain good humidity conditions that meet the needs of the people.

The object of this study is to evaluate the hygroscopic performances of thermo-physically treated wooden materials and to offer building materials appropriate to human-friendly interior design. Korean Pine (Pinus koraiensis) lumber, OSB and Plywood samples were selected for the experiment. Sorption test (ISO 24353:2008) is used to determine the hygroscopic properties of the specimens by measuring the moisture content of the specimens with air temperature and relative humidity. The water adsorption and desorption rates of wooden materials and equilibrium moisture content of those at various relative humidity condition were measured. Effects of roughness, microstructure and functional groups of the materials on the hygroscopicity were analysed.

And the non-destructive and continuous measurement of moisture transfer rate on wooden materials was used to determine the surface moisture emission coefficient and the diffusion coefficient of wood in unsteady state using near infrared spectroscopy. The mechanism of the surface and internal moisture transport of water in wooden materials were theoretically dealt with the empirical results.

It is expected that the results from this study could contribute to install a system for evaluating and controlling the hygrothermal performance of wooden building.

Keywords: Hygroscopic performance; heat treatment; adsorption; desorption; roughness; SEM;

PP072

Effect of annual ring orientation on cracking of glulam beams

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The ability of a structure to resist degradation depends on its materials and design, but also the maintenance and the surrounding environment. For wooden structures in outdoor environment, such as bridge beams and columns, it is important for safety reasons to be able to determine when they can no longer carry the intended load, and when actions are needed to repair various damages or demolish and build new construction.

Glulam beams for outdoor exposure are subjected to cracking. Cracks can have influence on strength and decay since the cracks can be a passage for water and dirt.

Glulam beams consist of combining lamella of boards. The quality of the lamellas is taken into account during manufacturing in order to define strength quality of the products. Lamellas will have different annual ring orientation.

There are on-going field tests since 2007 of glulam beams and columns made of impregnated Scots pine (Pinus Silvestris) and Norway spruce (Picea abies), with different dimensions and surface treatment (oil, water based paint system and solvent-based based paint system). The testing grounds are in Bygdsiljum (Lat. 64°20'57"N, Long. 20°30'14"E) and Borås (Lat 57°43'N, Long 12°56'O.) in Sweden. For this investigation 20 "big beams" 140 mm x 450 mm 9 meters long and 45 "small beams" 140 mm x 315 mm were used. Also some "small beams" with widths 90 mm and 215 mm were included. Documentation at the start included dimensions of beams and columns, visual inspection, measurement of moisture content, measurement of dry paint-film thickness, CT scannning (Siemens SOMATOM AR.T) through the cross-section and scanning image of the surfaces. Cracks have been measured every summer. The beam's surfaces were photographed for further image processing as alternative to manual crack measurements.

Data from photos have been extracted with image processing to be analysed. Characteristics such as angle at which annual rings come out to the surface, width of annual rings, lamella position in the beam, and combination of lamellas in finger jointing and resulting propagation of cracks are going to be examined. The goal the full-scale test was to investigate the influence of annual rings orientation on cracking of glulam beams and give recommendations for the industry how to control cracking by considering annual rings orientation in beam lay-ups. So far it seems that there is a difference in surface cracks affected by annual ring orientation.

Keywords: glulam beam, cracks, durability, moisture content, surface treatment, outdoor test, multivariate statistics, image processing.

PP073

Relationship between main properties of spruce (*Picea abies*) resonance wood and its near infrared spectra

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The selection of resonance wood for violins is often based on the empirical knowledge of the instrument maker and appearance of the wood. Evaluation methods for tonewood quality grading relay on visual inspection, sound response and/or measurement of selected physical wood properties. Correct definition of resonance wood properties is within interest of scientist, music instrument makers, acoustician and musician. Unfortunately objective and universal guide classifying row material according to its physical, acoustic or mechanical parameters does not exist nowadays.

In this research some selected tone wood properties (such as density, proportion of late wood, ring width, colour) as well as modulus of elasticity were determined for spruce (Picea abies L. Karst.) harvested from Fiemme Valley of the Italian Alps. The primary objective of this research is to evaluate resonance wood grades by comparing its main properties. The other goal was to investigate suitability near infrared spectroscopy for developing an original methodology for rapid estimation of the resonance wood quality class.

Sampling and visual grading has been carried out with support of local foresters, professional timber graders and the industrial experts involved in to manufacturing of products made of resonance wood. All the wood samples have been graded in to four quality classes (from top 'grade 1 Extra' down to 'grade 3') with addition of two supplementary classes (M1 and M2, having peculiar indented ring pattern). Ten samples were chosen randomly from each class and provided to detailed characterization. Several parameters were measured such as; ratio of late wood, rings width, color coordinates (Lab). Moreover, the dynamic modulus of elasticity was measured by means of ultrasound (Sylva), BING and by forced vibration (Mobile Timber Grader). Finally, all samples were measured by means of Fourier Transform Near Infrared (FT-NIR) spectroscopy. Partial Lease Squares calibration models linking FT-NIR spectra with above mentioned physical/mechanical parameters were also developed.

Presented research was an approach to develop a novel objective and analytic methodology for quality grading of tonewood. Detailed FT-NIR spectral analysis highlighted some peculiar chemical components characteristic for resonance wood. Additionally performed Principal Component Analysis and Cluster Analysis allowed visualization differences between quality classes. Even if near infrared spectroscopy seems to be a very convenient and efficient tool for grading, the successful calibration must be based on very precise reference methods and extendad database of reference samples.

Keywords: Resonance wood, FT-NIR spectroscopy

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PP074

Studies on chemical composition of spruce wood in relation to its geographical origin by selected non-destructive methods

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Norway spruce is an important wood species growing in large areas of forests all around Europe. Several wood characteristics, such as density, width of annual rings, chemical composition, and in consequence mechanical strength, esthetical properties or durability, among others, are related to environmental and genetic factors. The research presented here is an attempt to exploit the potential of non-destructive methods (FT-NIR, FT-IR-ATR, XRF) toward wood assessment in relation to varying tree provenances.

Wood samples investigated in this project were of Norway spruce (Picea abies L. Karst.) growing in different locations and representing borders of the spruce range in Europe. Five sites have been selected for sample collection: central Finland, southern Estonia, northern Poland, southern Poland and northern Italy. Samples after drying, conditioning and appropriate surface preparation were measured by means of Fourier Transform Near Infrared (FT-NIR) and Fourier Transform Mid Infrared Attenuated Total Reflectance (FT-MIR-ATR) (Vector22n and Alpha by Bruker Optics GmBH respectively) in the zone of mature wood. Powdered samples (particles smaller than 0.5mm) were also measured using a portable XRF: Oxford - X-MET5100. Traditional "wet" chemical analyses were performed in parallel to the spectroscopic measurements in order to provide reference data.

Preparation of a database of FT-NIR spectra for woods of different European locations was the opening objective of this study. Significant differences in the spectrum shape, especially in the intensity of peaks characteristic to lignin, amorphous region of cellulose and hemicelluloses has been observed on the model spectra. In consequence, cluster analysis performed on a fresh solid wood allowed correct separation of spectra measured on samples from different locations. In analogy to FT-NIR, also in a case of a FT-MIR-ATR, comprehensive separation of spectra scanned from the spruce samples have been obtained by using both, cluster and principal component analysis. XRF measurements detect following elements in different quantities and configurations: Ca, Cu, Zn, Sn, Sr and Mn.

Presented spectroscopic methods FT-NIR, FT-IR-ATR and XRF as a non-destructive, fast and low-cost techniques, in combination with appropriate data managing procedures, offers an effective tool to discriminate wood groups of different origin.

Keywords: wood provenance; FT-NIR, FT-IR-ATR, XRF, non destructive testing

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PP075

Validation of a X-Ray densitometry method for the determination of *Eucalyptus grandis* and *Eucalyptus urophylla* radial density profile

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The X-ray densitometry is considered one of the main non-destructive techniques for the analysis of wood due to the high precision and practicality. The method has been applied in determining the density of the wood, and the density variation is a result of the anatomical structure and chemical composition of the same. This technique is still used in the identification of growth rings and determine the pattern of radial variation of density.

This work aimed to ascertain the reliability of the information obtained by the x-ray densitometry technique in determining radial density profile on clones from Eucalyptus sp.. To this, it were used two and three clones of Eucalyptus grandis and of Eucalyptus urophylla, respectively, with 53 months of age. For radial profile of density determination, withdrew a sample, from each individual, was withdrawn perpendicularly to the axis, passing through the medulla at 1.30 m above the ground. The remainder of the radial sample was sectioned into small specimens with two millimeters of thickness, approximately, for determination of density by hydrostatic method.

Analysis of the data obtained showed that the pattern of radial variation of density obtained by the technique in challenge is very similar to the standard achieved by the determination of density by hydrostatic method, inferring so that the technique is reliable for this kind of analysis.

Keywords: Variation, clones, density.

PP076

Application Of The Method Of Immersion In Water And Attenuation Of Gamma Radiation For Determining The Density Of Wood

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There are several methods for determining the density of wood, some of them quite simple as direct measurements of mass and volume by immersion in water or mercury and other more sophisticated methods such as X-rays, using a beam of gamma radiation or x-rays. When the objective is only to determine the average value of sample density, the simplest traditional methods can generally be used even with a certain advantage over nuclear methods. However, when you need more details over the sample, with measurements in millimeters for each density, is required then the use of nuclear methods. The method of immersion in water, known as the

method of maximum moisture content, has been widely used in Brazil for determinations of volumes of samples saturated with water and consequently for the determination of the density of the wood. This method, although accurate, is limited because it requires the saturation of the samples in water, which is not always possible. Therefore, for determinations of volumes and densities for other values of humidity, different moisture saturation, this method is still rarely applied. This is because the samples in this case will absorb water out of its compartment sink, may cause errors in measurements of thrust and consequently errors in the volume and density. However using a methodology appropriate to the dimensions of the samples, this paper aims to show that you can work in other bands of moisture, such as the equilibrium moisture content around 12%. The time spent in the immersion will be important in this case, and the sample sizes in the form of discs in the range 06 to 12 cm radius and 2 to 4 cm thick errors by water absorption are negligible, and easily correctable . Some equations, theoretical, experimental, processing will be extremely important here.

In this paper we propose the transformation equations of density, for example, get the basic density from the density at 12% and vice versa. This methodology also allows the use of large volume samples, for example, logs, allowing the determination of wood density in the field and the stockyards, without the need to use a drying oven. Just know the approximate moisture content of the sample at the time of determination of its density to be aware of any possible relationship between mass and volume, including the basic density. The technique of attenuation of gamma radiation will also be used for determining the density of the wood and the results will be compared with that obtained by immersion in water.

PP077

Modeling knots shape in black spruce (*picea mariana*) and jack pine (*pinus banksiana*)

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Wood quality models that describe the link between tree growth and knottiness have generally been calibrated using external branch measurements, which are often imprecise and costly to acquire. Using X-ray computed tomography (CT) it is now possible to describe the entire internal shape of knots with precision, and to relate it to external branch parameters.

We used a method based on pointing and tracking the knots on successive CT images taken along the stem to identify and reconstruct knots in 3D. All knots from the merchantable sections of 32 black spruce (Picea mariana (Mill.) B.S.P.) and 16 jack pine (Pinus banksiana Lamb.) trees were scanned for this study. These species were chosen both for their commercial importance in eastern Canada and for the fact that, in the sawn timber, knot size is an important cause of visual downgrade. Trees were sampled along a sequence of ages in stands that had never been subjected to any silvicultural treatments. In total, we reconstructed the shape of more than 3,500 knots in jack pine and approximately 18,000 in black spruce.

Using a nonlinear approach, we fitted a model of knot geometry based on a Weibull function. Separate equations were used to describe 1) the curvature (pith position) of the knot and 2) the evolution of the knot diameter along its pith. The combination of these two equations allowed an accurate representation of knot shape using only seven parameters. We extracted these parameters for each knot and modeled them as functions of the external branch and tree characteristics. For black spruce, the model residuals from the curvature equation were less than 4 mm for 75% of the observations, whilst the residuals from the diameter equation were less than 1.7 mm for 75% of the observations. In jack pine, the corresponding statistics increased to 5.8 mm and 3.6 mm, respectively.

To facilitate the integration of the developed knot model into a tree growth model, we expressed knot shape as a function of external branch and tree characteristics. For example, the parameter which describes the slope of the knot curvature close to the bark is positively related to the branch insertion angle in the stem, but negatively influenced by the diameter of the branch and the stem diameter, and therefore by the overall vigour of the tree. The resulting model explained approximately 75% of the variance in this parameter. Overall, the use of knot parameters which can be predicted from external tree-level variables facilitated the integration of our model into a tree growth model.

Keywords: knots, nonlinear modeling, computer tomography, image analysis

PP078

The Usage of Gamma Ray Attenuation Method for Eucalyptus Wood Density Evaluation at Past Ages

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The main objectives of the development of clonal eucalyptus forests are rapid growth and productivity. Considering the great diversity of species, the genus Eucalyptus has the potential to attend different segments of wood industry. One of the principal parameters for wood quality evaluation is the basic density, especially when considering industrial and energy purposes. This property has relatively simple determination and is well correlate to several other wood properties.

The objective of this study was to determine basic density of wood on the ages of 2, 4 and 6 years of the physiological development of Eucalyptus spp. 6 years old trees using densitometric radial profiles obtained using the method of gamma ray attenuation and, additionally, taper functions and DAP measurements to define the regions of the profiles corresponding to each one of the past ages (2 and 4 years). Trees provided by Duraflora S.A. were sampled for each of the ages studied covering two clones (C1 - higher productivity and C2 - lower productivity) and two distinct regions (I – Itapetininga and LP – Lençóis Paulista – both at Sao Paulo State, Brazil), ranked by the company as higher performance and lower one, respectively.

Densitometric profiles (apparent density – 12% MC – and, indirectly, basic density) from discs along the 6 years old trees height were obtained by the gamma ray attenuation method. Subsequently, based

on measurements of stem diameter along the height for 2 and 4 years old trees, taper functions were adjusted, allowing establishing the regions of the original densitometric profiles corresponding to each of the past ages. The weighted average basic density of trees in each of the situations and ages studied were calculated, finally, using the formulation of Pronin.

The results indicated that 6 years old trees of clones C1 and C2 of the region of Lençóis Paulista (LP) had weighted average basic density of 465 kg/m3 and 425 kg/m3, while the same clones in Itapetininga (I) region had 417 kg/m3 and 397 kg/m3. For the ages of 2 and 4 years clones C1 and C2 from the region of Lençóis Paulista (LP) also had higher weighted average basic density related to Itapetininga (I) region clones densities. The results indicated that the gamma ray method was an effective tool for determining the local density as well as complete and partial disc densities, allowing estimation of density at past ages. It was detected the increase of the weighted average basic density from 2 to 6 years, with higher percentage increases in the period from 2 to 4 years when related to the period from 4 to 6 years.

Keywords: Density; Eucalyptus spp.; taper functions; wood quality; precocious selection.

PP079

Effect of Moisture Content on the Dynamic Properties of Scots pine Wood

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Moisture content is one of the most important factors that affecting the mechanical properties of wood. The nondestructive evaluation (NDE) tools are widely used for evaluating the mechanical properties of wood and in the pre-assessment of the green logs and lumbers. Therefore, it is crucial to explore the behavior of the acoustic velocity at different moisture levels.

An experimental study has been performed to reveal the effect of moisture content on the behaviour of the acoustic velocity and the dynamic Young's modulus of Scots pine wood during moisture reduction process from 120 % to 3 % MC. The Scots pine wood specimens were prepared and soaked in water for a sufficiently long time, and the measurements were performed in the longitudinal direction of the specimens using ultrasonic and longitudinal vibration methods at each moisture level.

The relationship between moisture content and the acoustic wave velocity obtained from the ultrasonic and the longitudinal vibration methods can be expressed in the form of the second order polynomial equation. The acoustic velocity values obtained from the ultrasonic were higher than those obtained from the longitudinal vibration method at all moisture levels. The results revealed a significant influence of the moisture content on the acoustic wave velocity and the dynamic Young's modulus. The wave velocity generally decreased with increasing moisture content. The dynamic Young's modulus below the fiber saturation point (FSP) decreased with increasing moisture content. However, above FSP, increased with increasing moisture content. The experimental data of the dynamic Young's moduli were adjusted above the FSP using the effective density, which rely on the mobility of free water instead of the bulk density. The adjusted dynamic Young's modulus values for the two nondestructive methods agreed with the general phenomenon that the mechanical properties above the FSP remain fairly constant.

Keywords: Ultrasonic; longitudinal vibration; moisture content; dynamic Young's modulus

PP080

Prediction of kappa number of Blackwood kraft pulps by near-infrared spectroscopy and partial least squares regression

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Kappa number determination is an indirect estimation of the residual lignin content in the pulp being an important measure of pulpwood quality and an indicator of the degree of delignification and bleachability. The determination of the Kappa number with standard methods is time consuming, destructive and costly and thus impractical when a large number of samples has to be evaluated.

Near-infrared (NIR) spectroscopy, a fast, non-destructive and accurate method was already successfully used to assess lignin content of wood and pulp.

A total of 90 Blackwood (Acacia melanoxylon R. Br.) wood discs, belonging to 20 trees from four sites in Portugal, were used in this study. A NIR-based PLS-R model was developed to predict the Kappa number of Acacia melanoxylon R. Br. pulps obtained under identical pulping conditions.

The 1stDer+VN (first derivative in combination with vector normalisation) pre-processing of the NIR spectra in the wavenumber range from 6102 to 5446 cm-1 was used for the calculation of the partial least squares regression model. The best model obtained had a root mean square error of prediction of 0.52 of Kappa number units, a coefficient of determination of 0.84, and a RPD of 2.53.

Keywords: Acacia melanoxylon; pulp yield, kappa number, NIR, PLS-R

PP081

Estimation of extractives content of *Eucalyptus globulus* from Argentina by near-infrared spectroscopy

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Wood extractives, the non-cell wall components that can be removed by solvents, can play an important role in the protection of the living tree as well as derived wood products. On the other hand they can be detrimental for pulp and paper, paint and varnish films and adhesives.

Removal of extractives from the wood meal is generally the first, very time-consuming step during the wet-chemical analysis of wood meal. However, an even slower step is the evaluation of the extractives which includes a very slow step associated with recovering the extract from the solvent, for gravimetric determination. Although faster and more accurate methods have been proposed they are still demanding when a high number of samples has to be analysed.

The simplicity, rapidity, and high reproducibility of near-infrared spectroscopy (NIRS) in combination with partial least-squares regression (PLS-R) method is well accepted and this approach has already been used to assess extractives content has the potential to dramatically increase sample throughput.

The aim of this work was to develop NIR-based PLS-R models for the prediction of the extractives content of E. globulus wood form Argentina with acceptable quality for use in breeding programs. The model using 1stDerVN (first derivative in combination with vector normalisation) pre-processing of the NIR spectra gave the best model for ethanol (R2 = 0.93; RMSECV = 0.41% and RPD = 3.7) and total extractives content (R2 = 0.90; RMSECV = 0.46% and RPD = 3.2).

The external validation of the model was performed with an independent sample set (100 samples) to evaluate the precision of the model. The statistics obtained for ethanol (R2 = 0.90; RMSEP = 0.45% and RPD = 3.2) and total extractives content (R2 = 0.88; RMSEP = 0.51% and RPD = 2.9) show that these models are well suited to assess the extractives content of E. globulus wood from Argentina.

Keywords: Eucalyptus globulus; S/G, extractives, near-infrared spectroscopy

PP082

Assessment of lignin composition (S/G ratio) of *Eucalyptus globulus* from Uruguay by near-infrared spectroscopy

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High syringyl/guaiacyl (S/G) ratios are advantageous for chemical pulp production due to higher delignification rates, higher pulp yields and lower chemical consumption.

The determination of lignin composition by wet-chemical analysis is time-consuming and costly and therefore impractical when a large number of samples have to be evaluated. Analytical pyrolysis is a good alternative but even if time requirements for the pyrolysis procedure are well below those involved in wet-chemical analysis it is still demanding in large screening programs.

The simplicity, rapidity, and high reproducibility of near-infrared spectroscopy (NIRS) in combination with partial least-squares regression (PLS-R) method is well accepted and this approach has already been used to determine lignin composition and has the potential to dramatically increase sample throughput over that possible with degradative techniques and analytical pyrolysis alone.

Analytical pyrolysis data were used to develop a NIR-based PLS-R model to assess lignin composition (S/G ratio) of Eucalyptus globulus wood from Uruguay. The model was developed using a total of 60 samples representative of the natural S/G ratio range. The model using 1stDerVN (first derivative in combination with vector normalisation) pre-processing of the NIR spectra gave the best model with a root mean square error of cross-validation (RMSECV) = 0.030, a coefficient of determination of .94 three PLS components, and residual prediction deviation (RPD) = 4.1.

The external validation of the model was performed with an independent sample set (20 samples) to evaluate the precision of the model. The statistics obtained (R2 = 0.95; RMSEP = 0.08 and RPD = 3.0) show that the model is well suited to assess the lignin composition of E. globulus wood from Uruguay

Keywords: Eucalyptus globulus; S/G, analytical pyrolysis, near-infrared spectroscopy

PP083

Nondestructive Evaluation of Amazon Wood

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Non-destructive techniques (NDT) can be defined as those which identify physical and mechanical properties of materials without changing its capacity for future use. The study of wood and your products by means of these techniques is widespread and dates back to the 1960s. The differential in relation to the technical destructive, lies in the speed of the evaluation and the reduced cost, various measures can be made, improving the confidence level of results. There are many studies on the topic for temperate conifers, to the Amazon woods, are few studies using this technique are available. The objective of this study was to use the non-destructive wood techniques to evaluate and predict the bending properties of three commercial Amazon woods.

We evaluated the species Nectandra cuspidata Ness & Mart., Mezilaurus itaúba (Meissn.) Taub., e Ocotea fragrantissima Ducke. The species were identified anatomically in the Laboratory of Wood Anatomy of the National Institute of Amazonian Research, from the

analysis of the macroscopic characteristics of wood, observation in pocket magnifier (10x) and observation of the histological sections in microtome. Were fabricated and tested 120 samples, according to COPANT standards. Before the destructive bending test, the samples were evaluated non - destructively through the technique of stress waves for determining the dynamic modulus of elasticity and propagation of waves speed.

The Tukey test showed significant differences between the species for physical and mechanical properties. There was no relationship between the propagation waves speed and wood density, however, the Pearson's correlation between the propagation waves speed and static and dynamic MOE, showed values up to 0.90 with $\alpha = 0.01$. Linear models were adjusted to relationships between the propagation waves speed, dynamic and static MOE for each species and for all data, in both cases the models showed high R2, but superior results were found to analysis of all data. In estimating the static modulus of elasticity, the dynamic modulus of elasticity explained 95.0% of the variation of the observed data. The relation between wave speed and MOE are high, to estimate MOE, the wave propagation speed explained 85.0% of the variation of the data. It is concluded that the method is suitable for predicting the bending properties, capting also the intra-specific variations, allowing the development of models with good predictability.

Keywords: Tropical forest; material selection; wood; stress waves.

PP084

Global Nirs Models to Predict Main Chemical Compounds of Eucalyptus Woods

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The Nirs technology is particularly well-suited to tree improvement programmes where huge numbers of samples must be analysed, but it can be used in any forestry application where the rapid measurement of wood property data is required or to screen unknown samples. Forest breeders include chemicals wood properties as selection criteria for new varieties, especially lignin, cellulose, hemicellulose. Efforts to develop multi-site, multiple-species, multiple age calibrations are rare. Because of the genotype x environment/age interactions, we try to develop a very useful multispecies Nirs calibrations to predict chemical properties for varied eucalyptus in term of species, age, and site plantation.

Global near infrared models to predict wood properties of Eucalyptus were developed using more than one hundred samples well representatives from 3,000 wood samples. These calibration set was selected on spectral data based on Mahalanobis distance. Samples were provided from different country and location (Congo, Senegal, Brazil), including different species and hybrids of Eucalyptus (E. urophylla, E. grandis, E. camaldulensis, E. urophylla x E. grandis, E. urophylla x E. pellita) from different age (from 5 to 30 years old). The global models tested by cross-validation, based on our own reference data, shown encouraged fits for extractives, lignin, cellulose, hemicelluloses. The models for lignin and extractives showed higher fits than cellulose and hemicellulose even if for these late, the model remained sufficient for prediction. The high variability of chemical properties due to the sampling, associated to the good repeatability of reference measurements, provided high values of model parameters. These results suggest that global calibration could be useful in tree breeding program and for different experiment trials from the fields, to rank genotypes for extractives, lignin, cellose, and hemicelluloses. Local models are more accurate usually and in order to get local models, we are improving our sampling in term of number and origin of wood. The main interest of this type of calibration is the possibility to screen samples for different species, different origins and the other interest is to select new samples to be included in calibration and validation sets.

Keywords: Nirs; Eucalypt; wet-chemistry; multi-site calibration

PP085

Sustainable Mycology Alternatives In Natural Forests And Conifer Plantations In México

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Concepts of mycoforests, mycosylviculture and mycoparks and their relationship to education, production and sustainable management of fungi in forests in México are analyzed. These concepts applied in Mexican protected areas, parks and forestry rural communities and improve socio-economic conditions. Two decades ago commerce of wild edible mushroom in the world was relatively small; mushroom industries were selling their products in a rather informal way. At the end of the 80´s important changes in mushroom commerce occurred; and it became organized in activities such as mushroom picking, cleaning, processing and packing and selling to retailers. Mushrooms prices may depend on factors such as: size, freshness, color, abundance, appearance, flavour, texture and familiarity of sellers and buyers with the species. Currently natural forests and forest plantations where mushrooms grow produce an important income in some European countries. Those countries have multifunctional forest practices integrating mushrooms into sustainable forest management. Mexicans living in most rural forestry conditions are used to picking and eating wild edible mushrooms every year. Natural forests in protected areas and national parks are ideal places for implementation of mycosilviculture and mycopark projects, mushroom courses may be offered to park officers and people living in rural communities inside parks and protected areas. These activities will serve to educate people and generate yearly income for them and these activities should be conducted in keeping with current laws to achieve sustainable management and conservation. Forest management programs and mushroom harvesting practices for commercial and home purposes use should be regulated to ensure sustainability. Thus, mushrooms pickers should buy mushroom picking permits, price to accord to their activities. Money obtained from these permits can be reinvested in forest and edible mushroom management that focuses on multifunctional conservation practices. Countries already applying some degree of mycosilviculture practices to mycoparks or truffleculture include France, Italy, Spain, Potugal, United States of America, New Zeland, Australia, Argentina, Chile, Israel and Morocco. Every year these countries produce significant income from wild edible mushrooms.

Keywords: sustainable mycology, education, mycoforests, mycosylviculture, mycoparks, México.

Research for the Future: Non wood forest products and how they will protected

PP087

Antifungal Activities of Phytochemical Constituents from *Cunninghamia konishii* Hayata against wood decay fungi

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Cunninghamia konishii Hayata (Taxodiaceae), one of the five most valuable conifers in Taiwan, is an endemic tree that grows at elevations of 1300 - 2700 m in Taiwan's northern and central mountains. The study was to isolate and identify the antifungal compounds from the ethanolic extract of C. konishii wood, and to evaluate their antifungal activities against wood decay fungi. The results showed that the n-Hex. soluble fraction of ethanolic extract from C. konishii wood had an excellent inhibitory effect against Lenzites betulina, Trametes versicolor, Laetiporus sulphureus, and Gloeophyllum trabeum. By following the bioactivity-guided fractionation procedure, four sesquiterpenes, T-cadinol, cedrol, T-muurolol, (-)-epi-cedrol and three diterpenes, 13-epi-manool, cis-abienol, isoabienol, were identified from the active subfractions. Among the main constituents of ethanolic extract from C. konishii, T-cadinol, cedrol, and T-muurolol inhibited efficiently the growth of wood-rot fungi. Results of this study show that the ethanolic extract of C. konishii wood may be considered as a potent source of T-cadinol, cedrol, and T-muurolol as new natural antifungal agents.

Keywords: Cunninghamia konishii; wood; extract; wood decay fungi; antifungal activity

PP088

Succession after Fire of Fungal Fruiting Bodies in Mediterranean *Pinus pinaster* Stands in Spain

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In this study we present the results of a 4-year survey aimed at describing the succession of fungal communities following fire in a Mediterranean ecosystem in Northwest Spain, dominated by Pinus pinaster.

After a large wildfire in 2002, six 2 x 50 m study plots were established in burned and unburned areas corresponding to early and late succession stages. During the autumn seasons from 2003 to 2006, fruiting bodies were collected and identified. We also collected information about dry and fresh weight, the saprotrophic or mycorrhizal status and the edibility of every species.

During the four-years sampling, a total of 115 fungal taxa were collected (85 in the late stage and 60 in the early stage) from which only 30 appeared along the whole succession. Mycorrhizal population not only increased the number of species from early to late stage but also shifted in composition. After fire, pyrophytic species such as Pholiota carbonaria, Peziza violacea, Rhizopogon luteolus and Rhizopogon sp. appeared. The effect of fire on fungal fruiting body's production was opposite depending on the saprotrophic or mycorrhizal status of the species: mycorrhizal decreased 6-fold, while saprotrophic increased 4-fold. Production of edible species was negatively affected by fire, decreasing significantly the potential of rural populations to harvest marketable mushrooms.

The provided results can be useful to forest managers for optimization of management and harvest of these increasingly appreciated non-wood resources. Management may also prevent or alleviate stand-replacing wildfire in these Mediterranean forests.

Keywords: Fungal community succession, fungal production, fire, Mediterranean ecosystem

PP089

Soil accumulation of CCA and CCB active ingredients measured inside a stake field test

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CCA and CCB treated wood has been used in outdoor applications since many years, extending the service life of many utilities like poles, bridges and other wooden structures. However, one current concern is the possibility of long-term accumulation of leached metalic compounds, of both preservatives, in soil adjacent to treated wood structures.

To evaluate this possible contamination, the soil inside a field stake test was sampled for chemical analysis. This stake test follows the IUFRO (International Union of Forestry Research Organizations) recommendations and was installed 30 years ago at Experimental Station of Luis Antonio (21º 32' S and 47º 42'W), State of São Paulo, Brazil.

Soil, samples were collected in 21 points inside the area occupied by the stake test, all points located near by the stakes with higher retentions of the two preservatives (11 kg/m^3 for CCA-C and for CCB). Control samples were collected in areas with natural vegetation, outside the experimental plot.

The soil analysis was carried out according to the method approved by the Environmental Agency of São Paulo State (CETESB) and the results compared to the Quality Reference Values (VRQ) adopted by the same Agency. All results for arsenic, chromium, copper and boron were below the VRQ values, demonstrating there was no soil contamination.

Considering that low values found could be attributed to a possible soil microbial activity or a sharp leach in the early years of expo-

sure, other soil samples were taken from an analogue experiment installed in the same local, but only three years ago. The results showed that the content of the four elements involved were also below the VRQ values and very close to those observed in the field established 30 years ago.

Keywords: wood preservation; Pinus spp; CCA; CCB; soil contamination; metallic compounds leaching.

PP090

Water absorption and desorption of non treated, pressure impregnated, and pine oil treated glulam made of small diameter Scots pine and Norway spruce

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A growing proportion of harvested timber originates from the first or second commercial thinning stands in Finland, which means smaller average log volumes in comparison to final felling stands. Nowadays approximately 10% of the saw logs entering softwood saw mills come from thinning stands. Smaller log volume means not only increased demands for efficiency of material handling in logistics and manufacturing processes but also challenging wood properties such as higher proportion of juvenile wood and sapwood. Due to these facts, products made of small diameter logs are prone to twist and check, and have reduced durability against weather. These properties can be improved by a number of preservation methods. The objective of the study was to define the water absorption and desorption velocity of non treated, pressure impregnated and pine oil treated glulam.

In this study, the 6 inner lamellae of the glulam beams originated from small-sized logs, whereas the surface lamellae at both sides were made of larger logs. All materials were harvested from southeastern Finland in Autumn 2009. Beams with 44 x 200 mm cross cut dimensions were glued using MUF resin. Beams were divided into three treatment groups, of which treatment 1 was based on Norway spruce and treatments 2 and 3 were based on Scots pine. Treatment 1 was not impregnated, treatment 2 was impregnated into AB class with copper-based preservative in commercial pressure process, and treatment 3 was impregnated with pine oil using the process of Ekopine Ltd. After the treatments, 20 pieces of 200 mm-long specimens were sawn from each treatment group, thus totalling 60 water absorption specimens with 44 x 200 x 200 mm dimensions. The cross cut surfaces of the specimens were sealed using several layers of waterproof varnish. By this, we ensured that the water movement took place via the side surfaces of the specimens. The air-dry specimens (MC 7.7–12.6%) were immersed into water for 6 weeks. After that they were brought to a standard climate (65% RH, 20 °C temperature). Again, their mass was recorded until it did not change anymore.

Pine oil impregnated glulam resisted the water absorption more than non treated and pressure impregnated glulam. During the water immersion, the MC of wood increased up to 71.0, 58.4 and 22.7% for pressure impregnated, non treated and pine oil impregnated gluelam, respectively. Due to the low initial MC after the absorption period, pine oil impregnated glulam dried rapidly below 20% MC, while the drying of non treated and pressure impregnated glulam to the same level took 3-4 weeks. In conclusion, pine oil impregnation of timber from small-sized logs can be considered to be an effective and ecological preservation method for timber used in outdoor constructions. For load carrying structures, pine oil impregnation appears to be an efficient way to maintain the MC of wood below the level that enables mold growth.

Keywords: absorption, desorption, pine oil impregnation, Pinus sylvestris, pressure impregnation

PP091

Improvement of biological resistance of soft and hardwood by heat treatment

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Heat treatment of wood at relatively high temperatures is known to be an effective method to improve biological durability of wood without using any chemical. The present study was performed to investigate the effect of heat treatment on the resistance against fungal attack. Heat treatment of Pinus roxburghii (softwood) and Populus deltoides (hardwood) was done at 210oC for 0.5, 3, 5, and 24 h in vacuum oven under N2 atmosphere. Fungal resistance of heat treated wood was determined through soil block bioassay test in laboratory against Oligoporus placentus (brown rot) and Trametes versicolor (white rot). Heat treatment of Pinus roxburghii and Populus deltoides revealed a clear improvement of the resistance against the brown rot and white rot fungi. Results revealed that heat treatment of both wood species showed remarkable protection at longer time of treatment against both the test fungi. Increasing process time appeared to affect the resistance against both test fungi in both wood species.

Keywords: Heat treatment, Pinus roxburghii, Populus deltoides, Oligoporus placentus, Trametes versicolor

PP092

Use of a short span field test to evaluate termite resistance of *Eucalyptus grandis* and *Bobgunnia madascariensis* in a tropical environment on the Zambian Copperbelt

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Despite being preservative treated, the life span of transmission poles and fence posts in service on the Zambian Copperbelt province is close to fifteen years but lasts only two years for untreated timber mainly due to termite damage. This low service life span is exerting more pressure on an already over burdened timber resource base. The study proposes to use an accelerated field test investigation to facilitate initial assessment of several lesser known indigenous timbers for their termite resistance. To determine the service life and natural durability of Eucalyptus grandis and Bobgunnia madagascariensis to termite attack, samples of each wood species were field exposed to an aggressive species of subterranean termites for four weeks. Morphological and molecular analyses confirmed that the aggressive species of termites in this study was Coptotermes formosanus, commonly referred to as Formosan subterranean termites. Results indicated that E. grandis can be labelled as susceptible (S) following standard natural durability rating procedure on the basis of service life projected from short term field exposure weight loss determination. Using short duration exposure weight loss and visual designation, similar to the Gulfport scale, B. madagascariensis was designated as very durable (D). These results showed that natural durability of timber against termites can be estimated after a short duration field exposure to Formosan subterranean termites. This method offers a fast short span field test for screening promising lesser known tropical timbers.

Keywords: Formosan subterranean termites, Natural durability, Weight loss/Gulfport scale, DNA technique, Eucalyptus grandis, Bobgunnia madagascariensis

PP093

Characterization of the Dislodgeable Solids Collected from Chromated Copper Arsenate Treated Southern Pine

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Solids dislodged from the surface of chromated copper arsenate (CCA) treated southern pine boards were collected using a test tube brush wiping method and analyzed to determine their chemical composition. Images from environmental scanning electron microscope (ESEM) show that the solids consisted mainly of wood splinters. The high count per second of carbon and oxygen from energy dispersive X-ray analyzer (EDXA) confirms the presence of wood fibers/splinters. Besides C, O, AS, Cr and Cu, solids also contain Fe, Ca, K, Cl, S, Si, Mg, and Na as evidenced by EDXA. Less than 4 percent by weight of the collected solids were As, Cr, and Cu. The total content of As, Cr and Cu from solids collected from CCA treated and unexposed boards was about ten fold higher than the amount collected from boards exposed outdoor in Michigan climate for 6 months.

Keywords: AA, CCA-treated wood, dislodgeable solids, ESEM-EDS, water repellent, XRD

PP094

Assessment of the potentials of recycled engine oil and palm kernel oil as wood preservatives

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Several chemicals have been used in the wood industry as preservatives resulting in varying degrees of improvement in durability and other associated qualities. Factors often considered in the choice of chemical preservatives include cost, ease of penetration, fixation and retention, efficiencies and recently the environmental implications. The latter factor has led to the establishment of standards in different countries with regards to the acceptable level of toxicity and hence the development of various environmental-friendly chemical preservatives.

Wood samples from the less-durable Nigerian hardwood species Ceiba pentandra were impregnated with recycled engine oil (REO) and palm kernel oil (PKO) and the changes in the following properties were investigated; mechanical properties by 3-point static bending test, water uptake and thickness swelling by soaking in water for 24hours at room temperature, weathering resistance by exposure to artificial irradiation for 120hours and durability by fungal decay test.

Impregnation with recycled engine oil resulted in significant increase in modulus of elasticity but insignificant changes in modulus of rupture. In contrast, impregnation with palm kernel oil resulted in significant reductions in both properties. Impregnation with recycled engine oil and palm kernel oil resulted in significant reductions in water uptake. There were no significant differences in the effects of recycled engine oil and palm kernel oil on the changes in water uptake. There was significant reduction in thickness swelling after impregnation with palm kernel oil and recycled engine oil with the anti-swelling effect of the recycled engine oil being greater than that of the palm kernel oil. Impregnation with recycled engine oil resulted in significant reduction in total colour change during exposure to artificial irradiation which is an indication of improvement in colour stability. Contrarily, impregnation with palm kernel oil resulted in significant increase in total colour change indicative of deterioration in colour stability. Weight loss as a function of fungal decay was significantly reduced after impregnation with both oil types indicative of significant improvement in durability. The improvement in the decay resistance is more pronounced under impregnation with palm kernel oil than with recycled engine oil.

From the results of the study, it is evident that the use of recycled engine oil and palm kernel oil as wood preservatives is promising with the recycled engine oil having superior advantage on the basis of wood properties and cost.

Keywords: recycled-engine-oil, palm-kernel-oil, impregnation, wood-preservation, wood-properties

PP095

Decay Resistance of some wood species against *Nattrassiae mangiferae* Fungi found in Ninevah Governate, IRAQ

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A survey was conducted to isolate and identify decay fungi on commercial wood species in Ninavah Governate, Iraq. The results of survey show that decay fungi were present on oak (Quercus aegilops) , poplar (Populous nigra); sycamore (Platanus orientalis), willow (Salix acmophylla Boiss), walnut (Julglan regia), Pinus and larch (Tamarix articulate vahl).

The following decay micro organisms (basidiomycetes and ascomycetes) were isolated on wood: Nattrassia mangiferae (H. & P. Sydow) Sutton & Dyko, Alternaria Nee, Fusarium Link., Aurobasidium (Viola & Boyer.), Cephalosporium (corda.), Phytophthora, Amblysporium (Fres.), Dendryphiopsis (Hughes.), Ulocladium Prenss and used to run a laboratory test which show N. mangiferae was the most virulent with significant weight loss and damages on wood.

Keywords: Resistance, Nattrassiae mangiferae, woods.

PP096

Flexural Properties of Wood Treated with Micronized Copper Formulation

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The effect of preservative pressure treatment using newly introduced waterborne micronized copper azole (MCA) formulation on the density and the flexural properties of red pine (Pinus resinosa) and hybrid poplar (Populus spp) woods with southern pine (Pinus spp.) as a reference species was investigated. The penetration of the preservative was evaluated by monitoring the presence of copper in the shell and core sections of treated samples with copper indicators and the amount of copper uptake during the treatment by chemical analysis using X-ray fluorescence (XRF). The density and flexural properties of untreated and treated samples were evaluated and compared using one-way ANOVA. Within 95% interval of confidence, no significant difference was found in density values between untreated and MCA treated samples. Treatment did not significantly affects flexural MOR and MOE of red pine. Surprisingly, the flexural properties of untreated hybrid poplar were superior to that of red pine. MOR and MOE of hybrid poplar were significantly reduced after the preservative treatment. Unlike Southern pine, the copper retention in the shell of red pine was significantly higher than in the core suggesting a poor penetration of the species. Hybrid poplar showed relatively lower preservative retention compared to the conifers. Difference in density, MOR and MOE values of treated red pine from Michigan and Wisconsin provenances was not significant. Increase in the treatment pressure duration from 1 to 2 hour did not affect either density or flexural properties of red pine significantly; however, the amount of copper retention in the shell was increased compared to that in core samples.

Keywords: Red pine; Hybrid poplar; micronized copper azole; flexural properties; MOR; MOE

PP097

Field-testing of Norway Spruce Claddings with Monitoring of Moisture Content, Material Temperature and Microclimate

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The physical function of a cladding is to protect the interior construction. Under normal circumstances the performance requirements can be met for a very long time, meaning that the technical service life of a wooden cladding can be very long. Since the cladding is a major part of the facade, it also has visual requirements that may define the aesthetic service life, and often it is much shorter than the technical service life. The visual changes that occur during weathering may be colour changes, abrasion or wear, blistering, flaking, and even cracks in the wood or coating, but more often growth of mould and blue stain fungi.

A field test with claddings was established in southern Norway to study the variation in moisture content in the cladding, the material temperature and the ambient microclimate. The aim of the field test is to provide data that can be used to estimate aesthetic service life of claddings based on material properties, surface treatments, and climate. One of the primary objectives is to identify conditions that are critical for establishment and development of mould and blue stain fungi. The field test will also be used for preference studies in order to identify critical levels of visual changes.

Claddings were made of Norway spruce (Picea abies (L.)) from two sites with different growth conditions. It includes both heartwood and sapwood, and both juvenile and mature wood. Selected boards were crosscut into four pieces, of which three were treated with different paints, and one was left untreated. The samples are exposed in an open environment, facing either north or south. Relative humidity and temperature is measured in air close to surfaces, and wood temperature and moisture content are measured in the claddings. Moisture content is calculated by measuring direct current resistance across grain, and corrected for temperature. Mould growth and blue stain fungi, as well as mechanical changes on the surface of the claddings were evaluated visually according to the EN 927-3 standard. Results from the first year are presented. It shows differences in moisture content and material temperatures depending on colour and exposure, whereas the differences in mould growth are minor so far.

Keywords: Norway spruce, cladding, coating, moulds, blue stain fungi, field test

PP098

Northern European Scots pine – a survey on permeability differences in sapwood

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Wood is a natural building and construction material vulnerable to attack from fungi and insects when it is exposed to certain climate conditions. Both conventional wood preservatives and different kinds of wood modification techniques are applied to extend the service life outdoors. A successful protection presupposes a homogeneous distribution of the protective agent within the wooden structure.

Scots pine is widely distributed in Eurasia, and can adapt to a multitude of different growing conditions. It is important for the building industry, and often impregnated for enhanced durability. Generally, Scots pine sapwood is classified easy to impregnate. However, the industry has experienced large differences in the material permeability. These differences and inhomogeneity in permeability within the impregnation batches of sapwood lead to higher impregnating costs, as the processes have to be adapted to the most refractory material. Yet, material selection prior to impregnation in favour of assortments easy to treat is not in practice.

Scots pine sapwood from 25 different sites in Northern Europe was collected and impregnated. It was sought to get a study material from a wide range of growing conditions. This included ranges in climate, site index and social status of the tree, since these factors are important for the anatomical structure. The variation in permeability was interrelated with these factors, and it could be shown that growing conditions, origin and tree diameter are important contributors. The associated changes of window pore membrane area, chemical composition, extractive content, and macroanatomic properties are being studied and interrelated with the permeability. The present paper gives an introduction into the project and presents an overview of the results.

Keywords: Scots pine sapwood, permeability, natural variation, growing conditions

PP099

Improvement of Douglas-fir heartwood impregnability to water

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In the ten next years, Douglas-fir will be the main softwood resource harvested in France. It will be mainly absorbed by the wood-frame construction growing market in Europe. A large part of this supplying will be devoted to EWP production, more particularly plywood and LVL. To process these products, bolts should be peeled and therefore require a heat treatment around 50°C. Usually, bolt are soaked into hot water during 12 to 72 hours, depending the wood species and bolt diameter but Douglas-fir green wood shows two particularities that complicate boiling efficiency: (i) the heartwood has a MC near FSP (30 to 40%) i.e. there is near no free water into tracheid (ii) it is impossible to impregnate this heartwood at atmospheric pressure with water. As a result, wood material being a very efficient insulator material, boiling of Douglas-fir prior to peeling for veneer production will take a very long time, free water being the main medium allowing heat transfer into green wood.

This paper includes a review of the anatomical, chemical and physical factors responsible of this very bad impregnability of Douglas-fir heartwood. According to this analysis, a first set of preliminary tests has been performed in order to improve the impregnation. It consists of soaking small samples (20 mm * 20mm * 120mm in RTL basis) into hot water at atmospheric pressure (i) at different temperatures (every 10°C between 50 and 90°C and for different treatment durations (5 to 22 hours) (ii) putting a tensoactive product into water (iii) applying ultrasonics waves (200 kHz / 400 W) in order to provoke micro-cavitation and then rupture of bordered pit torus. The results have proven the inefficiency of such treatments on Douglas-fir impregnability, even on small samples. A second set of test has been conduct to quantify the influence of extractives and of drying (heating, vacuum) under the FSP on heartwood permeability. If extractives appear to not have a real impact, it is no more true for drying treatment that deeply improve the permeability. One of the hypotheses is that drying process may have caused micro cracking into the cell walls

Other tests are in progress in order to quantify the speed of sorption of liquid in the longitudinal and transverse directions.

Keywords: Douglas-fir, permeability, peeling, boiling, surface tension, ultrasonic treatment, drying

PP100

Assessment of decay risk of airborne wood-decay fungi

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The decay risk of airborne wood-decay fungi was investigated by using an air sampler. Japanese cedar disks measuring 7.8 cm in diameter and about 3 mm in thickness with moisture content at about 100 % were placed in a "BIOSAMP" air sampler and exposed to 1000 liters of air. Air sampling was carried out from June to September at the same sampling site in Tsukuba, Japan. The exposed disks were then incubated for 16 weeks in a damp container kept at 26 ± 2°C. During the incubation period, wood mass loss ranged from -15 mg to 807 mg with a mean mass loss of 244 mg. Factors affecting mass loss were explored. Wood moisture content and ratio of heartwood area proved to be significant factors. In addition, five weather factors were found to influence mass loss. Disks that were sampled on a cloudy day showed significantly higher mean mass loss compared to those sampled on a sunny day.

Filamentous fungi from 16-week incubated disks were subcultured to investigate the relationship between the taxa of airborne fungi and the decay risk. Fungi grown on the disks were isolated and DNA extracted from each isolate was amplified with the primers ITS4/ITS5. The DNA sequences of the amplified products were determined and compared to the sequence data of GenBank to determine the species or genus according to a BLAST search. This search revealed that the isolate consisted of 5 major taxa, namely Bjerkandera sp., Phanerochaete sp. (A), Phanerochaete sp. (B), Polyporales sp. Polyporus arcularius, and 6 minor ones. Statistical analysis revealed that the major taxa were trapped on the disks in similar weather conditions except for Bjerkandera sp., which was trapped at a cooler temperature. The analysis also proved the disks to which Phanerochaete spp. or Polyporales sp. were attached showed higher mass loss. It is concluded that, under these experimental conditions, related species of P. sordida play an important role in increasing the decay risk caused by airborne wood-decay fungi.

Keywords: decay risk; airborne fungi; air-sampler; identification; white-rot

PP101

Kraft pulping characteristics of three moroccan eucalypti

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Two eucalyptus hybrids (EGC 39, EGC 241), resulting from crosses between Eucalyptus grandis and Eucalyptus camaldulensis, were investigated to see if they could produce kraft papermaking fibers with low lignin and adequate physical properties. The two hybrids were harvested at an age of 8 years along with 6-8 year old Eucalyptus camaldulensis (Rostrata). All three eucalypti were grown in the area of Gharb in the North-West of Morocco. The tracheids in the two hybrids had a very high Runkel ratio (2 x cell wall thickness/ lumen diameter) and produced kraft paper sheets with low tensile strength due to a low degree of fiber collapse thus a low relative bonded area. These fibers could be used to increase the stiffness of a papermaking furnish. They should also increase surface smoothness due to their low fiber diameter. The lignin in the EGC 39 chips was more reactive in kraft and soda-AQ pulping as compared to the other two eucalypti. Methoxyl analyses and nitrobenzene oxidation (NBO) of the in-situ lignin (wood meals) were performed, and it was concluded that the syringyl content of the EGC 39 lignin was less than or equal to those in the other two eucalypti. However, the guaiacyl fraction of EGC 39 contained more uncondensed β-O-4 dimeric structures that are known to be quite reactive.

Keywords: Eucalyptus; Kraft pulping; Fiber dimensions; Pulp strength; Lignin characterization

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PP102

Effect of Heat Treatment on the Physical Properties of Three Plantation Woods Grown in Taiwan

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Three plantation wood species include China fir (Cunninghamia lanceolata var. lanceolata), Japanese cedar (Cryptomeria japonica) and Honduras mahogany (Swietenia macrophylla) grown in Taiwan were used in this study. Heat treatments were carried out at temperature levels of 170°C, 190°C, 210°C and 230°C for time spans of 1 h, 2 h, 4 h and 8 h in a heating unit. The objective of this study was to evaluate the effect of heat treatment on some physical properties of wood specimens.

Maximum mass loss of near 20% was found for wood samples treated at 230°C for 8 h. There was a decrease of 5%-10% in wood volume after heat treatment. The values of equilibrium moisture content at given relative humidity of heat-treated wood samples were significantly lower than those of the untreated ones. The values of shrinkage determined from green to oven-dry conditions for treated samples were significantly lower in comparison with untreated samples, and the difference between the percentage of tangential and radial shrinkage was reduced after thermal modification. The anti shrinkage efficiency (ASE) in tangential and radial directions of wood samples increased along with the increase of treatment temperature and time. An ASE of 50% was obtained by heating wood samples over 210°C.

The higher the temperature and the longer the time span, the greater the color change of the heat treated wood samples. However, there were no significant differences between the color of wood samples treated for 4h and 8h at the same temperature. Heat treated wood samples showed less color change than control samples by weathering test and turned grey in color after exposition to sun, UV and moist for few weeks. The differences of L*, a* and b* values between heat-treated and untreated samples decreased with increasing exposure duration. There was a slight increase in MOE when wood was thermally treated at temperatures under 190°C. The bending strength and work to maximum load of heat-treated wood specimens significantly decreased along with the increase of treatment temperature and time. The reductions in static bending strength properties of China fir were lower than those of the other two wood species, and the highest strength losses were found in Honduras mahogany.

Keywords: Heat-treated wood; equilibrium moisture content; dimensional stability; bending strength; color change.

PP103

Investigation on Stress Carrying Capacity of Miter Frame Corner Joints with Dovetail Fitting Constructed of Particleboard and Medium Density Fiberboard (MDF)

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The aim of this study was to investigate stress carrying capacity of dovetail fitting connected corner joint made of particleboard and medium density fiber board (MDF) under diagonal tension load. In this study, the effects of dovetail type distance including 1, 2 and 3 cm and dovetail types including Butterfly and H shape key were investigated. L-shape joints (15×5×1/6) were tested at loading rate of 5 mm/min. The adhesive type was polyvinyl acetate (PVAc). The results showed that the lowest ultimate stress carrying capacity (2.058 Mpa) was obtained for the joints made of particleboard with butterfly key with 3 mm distance and the highest stress carrying capacity (2.796 Mpa) was obtained for the joint made of MDF, with H shape key with 1 cm distance.

Keywords: L- shape joints, stress carrying capacity, Butterfly, H shape, MDF

PP104

Machinability Tests in Wood Samples of Five Brazilian Native Species

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The study of native species has fundamental importance for the furniture sector, so that we can find better use of raw materials, better product quality solid wood and reduced cost.

The present study compared machining tests on samples of wood from five Brazilian native species, evaluating the results for each test conducted in accordance with the rules and pre-defined procedures and comparing them with each other.

Were evaluated ten samples of wood, two of each species studied ("Angelim", "Cedro", "Canela", "Ipê" and "Muiracatiara"), with dimensions of 30cm x 12cm x 1.5 cm each one, obtained in a carpentry shop in the district of Perequê, city of Angra dos Reis, state of Rio de Janeiro.

All assessments made following the procedures described in the American standard ASTM D 1666-87. The machining tests were performed: for drilling and hinge pin, planning, sanding, splitting nails and a lateral tear.

In the machining tests, the "Muiracatiara" wood had the best outcome among all species, showing great aptitude for the furniture sector, while the "Cedro" wood showed less satisfactory results, showing a direct relationship of wood density with the results.

Keywords: Wood machinability, wood workability, Brazilian native wood

PP105

Influence of changing air conditions on deformation of composite furniture elements

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Traditional technology of veneering wood-based panels has existed in furniture industry for last fifty years. It is made an assumption that in case of avoiding wrapping wood-composites panels have to be finished with materials of the same properties. Anyway, studies done on one-sidely veneered boards shows that it is possible to change technology of finishing wood-based panels to asymmetrical veneering. The key to this solution is to find glue that after crosslinking forms elastic glue-line.

The goal of the study is to determine the grade of deformations in elements of asymmetrically veneered furniture after long-lasting increased humidity. There were studied four groups of composites finished with various kinds of wood- I group with Macassar ebony and American mahogany, II group with Macassar ebony and beech, III group with birch and Sapeli and IV group with Sapeli and beech. Kinds of veneers were chosen because of their physical properties such as linear shrinkage and porosity.

All boards were veneered with the same type of glue that was polyisocyanate glue that creates flexible glue-line. Anyway, first and second group of samples were finally finished with polyurethane varnish, but third and fourth group were finished with acrylate varnish.

Results of studies showed that asymmetrical veneered elements can be used in spaces with increased humidity (for example kitchens and bathrooms) but only if introduce good technology. First of all, it was observed that samples varnished with polyurethane, after existing in increasing humidity, warped more than samples varnished with acrylate. It is shocked because literature provides that polyurethanes are the most waterproofing and elastic polymers (because of that they are used in furniture industry).

Secondly, obtain results show that in case of using acrylate varnish high porosity difference or high shrinkage difference between used veneers doesn't lead to benching composites. However, if boards were finished with polyurethane varnish, they don't preserve their shape. Studies show that shrinkage and porosity have an influence on deformations in the veneered board. The main factor affecting the deformations of asymmetrically veneered boards is ratio between shrinkage and porosity. A high difference in porosity values with low difference in shrinkage causes small geometrical deformations. Similarly, samples save their shape stability if it is high difference in shrinkage values with low porosity difference.

Keywords: asymmetrical veneering, porosity, shrinkage, varnishing

PP106

Particle matter during boring operations

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Particle matter during machining is a well known problem in terms of health risks for the machine operators and in terms of energy consumption because of the high energy needed for the suction systems. The particle diffusion in the working space as well as diametric composition of the particles produced in different machining operations are not yet well known. A study was undertaken in order to better understand the particle emissions during boring operations using different bits, different materials and feeding speeds. Particleboards, plywood, solid wood, MDF were bored with the boring head in horizontal and vertical position. The particles par litre were measured in real time by the means of a laser particle counter dividing the particle matter in 5 classes: 0.3-0.5, 0.5-0.7, 0.7-1, 1-2, 2-5 µm according to their aerodynamic diameter. A first series of measurement were performed with the suction system switched off in order to evaluate the rough emissions of the single processes and because of the low kinetic energy of the particles in boring operations the suction system is very far from the head being very ineffective. By the way a high concentration of fine particles were measured during boring operations that being very mobile, goes around very easily. The concentration of high diameter particles have shown to be very limited above the bits when boring because of a rapid and spontaneous sedimentation. A low energy suction system placed near the working head was tested showing how, because of the low kinetic energy of the low diameter particles, these particles can be trapped very easily prevent their diffusion.

Keywords: Particle matter, boring, suction, low energy, MDF plywood, solid wood

PP107

The Manufacture of Plywood from India-charcoal Trema (*Trema orientalis*) and Wood Oil Tree (*Aleurites montana*)

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The purpose of this study was to investigate the Trema,wood oil tree, radiata pine and red meranti veneer as raw materials, the urea formaldehyde resin adhesive to three amount of glue (240,260,280 g/m2) and different veneer composition, 9 mm thick plywood was manufactured, and to assess their related properties. The moisture of all panels can meet the test standards. Plywood's density increased with increasing the urea resin amount(240 ~ 280 g/m2). Normal bonding strength (Type I) of all the plywood specimens can be met the CNS 1349, while the warm water bonding strength (Type I), except the top, bottom for the red meranti veneer and core for the wood oil tree composition herein may be made by testing standard. There were the significant linear regression correlation between the spreading resin amount and normal bonding strength of plywood. Plywood static bending strength for the parallel to grain direction better than the vertical orientation. The plywood construction form and spreading resin amount will effect on its bending strength. Plywood static bending strength for the radiata pine veneer and Trema wood are the best, while the whole board from the wood oil tree were the worst. And also the spreading resin amount and plywood bending strength (/ /, ⊥) showed a significant linear regression correlation. MOE of the plywood constituted of the red meranti and Trema and red meranti and radiata pine veneer are the best, however the whole composition of wood oil tree and wood oil tree with radiata pine constitute are the worst.

Keywords: Trema; wood oil tree; plywood; bonding strength;static bending strength.

PP108

Properties of Particleboard Panels Manufactured from Treated Wheat Straw

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Production of composite panels from non-wood raw material such as wheat straw is getting more popular in European countries. The objective of this study was to evaluate some of the properties of experimental particleboard panels made from wheat straw treated with various processes. The raw material was treated with acetic anhydride and steam and mixed with untreated commercially produced softwood particles at a ratio of 40 by 60 to make single layer particleboards using urea formaldehyde as an adhesive. Control samples without any treated material at above ratio were also produced. Bending strength, internal bond strength, and dimensional stability of the samples were determined based on European Standards. The results revealed that the treatment of wheat straw particles significantly improved both physical and mechanical properties of straw particleboards. The highest mechanical properties of the panels were found for those panels made using wheat straw treated with 9% solution of acetic anhydride. These samples had 2.4 times higher bending strength values than those of the control panels. Internal bond strength characteristic of the same type samples also had twice higher values than those of control samples. Dimensional stability of the samples, including thickness swelling and water absorption were also enhanced as a result of treatment. Thickness swelling and water absorption of panels made from treated raw material had up to 43% and 9% improved values as compared to those of control samples, respectively. Based on the findings of this work such treatment process could have potential to be used as alternative method to enhance properties of the panels.

Keywords: Wheat straw; treatment; particleboard; acetic anhydride; steam

PP109

A new method of pilot scale production high grade oil palm plywood: Effect of pressing pressure

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Nowadays, the use of waste material such as, saw dust, rice husk, coconut coir, empty fruit brunch (EFB), oil palm mass and oil palm stem (OPS) as alternative material for wood-based industry in producing various commercial product have been extensively explored. Nevertheless, the use of OPS as raw material replacing hardwood species in plywood production has been in practice for the past 10 years. In Malaysia, the use of OPS plywood panel mainly focus on non-structural, low grade utility purpose and low price materials such as packaging panel and formwork.

The low mechanical property in conventional OPS plywood panel has limits it application in structural and other applications. This problem is due to density variations inside the trunk itself and the anatomical structure of the stem which comprises solid vascular bundle and loose parenchyma cells. The outer part of OPS is comprise abundant of vascular bundle and less parenchyma, while the inner of the OPS trunk consist of less vascular bundle but high amount of parenchyma cells. Hence, in this study we explored the potential of a new resin treatment approach using LmwPF in order to produce high grade OPS plywood. The OPS veneers after soaking were dried to desired moisture content (MC) and then used further assembly (without cold-press) and further continue with hot-press at 140^{0}C for 14mins.

In this pilot scale project, we explore the potential of LmwPF resin recipe treatment as new OPS production methods in order to produce high grade OPS plywood. The additional process was pre-treatment of dry OPS veneer by first soaking with LmwPF resin in resin pool. Pilot scale production of LmwPF treated OPS plywood was assessed for properties such as, thickness swelling, water absorption, hot-press pressure, bonding integrity, density, the modulus of rupture (MOR) and modulus of elasticity (MOE). LmwPF resin treatment of OPS in plywood production indicated that with this new resin treatment method, improvement of > 200% in strength, > 259% in stiffness, dimensional stability (> 6% thickness swelling and > 36% water absorption) as well as, 28% and 80% greater in dry and WBP shear, respectively as compare to the conventional method of commercial OPS plywood.

Keywords: plywood, oil palm stem, phenol-formaldehyde, resin, MOR, MOE.

PP110

Optimisation Of The Process Parameters Affecting Properties Of *Compreg* Wood Using Response Surface Methodology (Rsm)

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Response surface methodology (RSM) was applied to optimize the main process parameters affecting density, polymer loading and dimensional stability of compreg made from low density wood (Endospermum diadenum). Central composite design (CCD) using RSM with three process variables namely, phenol formaldehyde concentration (PC), pre-curing time (PCT) and compression ratio (CR) was used in this study. Wood strips (25 mm x 150 mm x 5 mm) were treated with low molecular weight phenol formaldehyde (mw 600) using a vacuum-pressure process. The process involved 30 min vacuum, filling of solution and left soaking in the solution at 690 kPa pressure for 30 min. After treatment, they were pre-cured at 65^{o}C prior to compressing at several compression ratios under hot press at a temperature of 150±2^{o}C for 20 min.

A total of five equations including four quadratic equations (Eqs. 1-4) and a linear equation (Eq. 5) were obtained in this study. In case of ASE, a quadratic equation cannot be constructed because "Pr > F" value of total model was more than 0.05 (Pr > F value = 0.196). The equations determined for density, weight percent gain (WPG), reduction in water absorption (RWA), thickness swelling (TS), and anti-shrink efficiency (ASE) were:

$$\text{Density} = 6281.7 - 41.43 \times PC - 118.38 \times CR + 0.607 \times PC \times CR + 0.589\ CR2\ (R2 = 0.791) \quad (1)$$

$$\text{WPG} = 662.34 - 2.958 \times PC - 14.52 \times CR + 0.088 \times PC2 + 0.089 \times CR2\ (R2 = 0.949) \quad (2)$$

$$\text{TS} = 33.53 - 3.522 \times PCT - 0.308 \times CR + 0.0261 \times PCT \times CR + 0.152 \times PCT2 - 0.0014 \times PC \times PCT2\ (R2 = 0.838) \quad (3)$$

$$\text{RWA} = 463.17 + 0.895 \times PC - 10.037 \times CR + 0.0613 \times CR2\ (R2 = 0.60) \quad (4)$$

$$\text{ASE} = -106.94 + 1.3529 \times PC + 1.373 \times CR\ (R2 = 0.50) \quad (5)$$

The "lack of fit" values were 0.152, 1.174, 0.945, and 0.280, for Eqs. 1-4, respectively. Because these values were all more than 0.05, the model was statistically appropriate for further analysis. Regression coefficients (R2 value) between the variables (PC, PT, and CR) and the responses (density, WPG, RWA, and TS) were reasonable (more than 0.60), indicating that the model can predict the change of density, WPG, RWA, and TS under various impregnating conditions. However, R2 value of ASE model (0.50) was somewhat low to suggest that the model can accurately approximate the relationship between the variables (PC, PT, and CR) and ASE.

Keywords: Response surface method, central composite design, compreg

PP111

Formation of SiC Nano-micro Rods from Bamboo Carbon Impregnated with Silica by Carbothermal Reduction

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Nano-sized SiC can be used for semiconductor applications and development of nanodevices due to its various superior properties. The existing synthesis methods of SiC nanorods are either complicated or need to be operated at high temperature. In this paper,

a simple approach of large-scale synthesis of crystalline SiC nano-micro rods was presented. Moso bamboo was carbonized and then impregnated with tetraethylorthosilicate(TEOS) sol by vacuum assistant infiltration process. The treated samples were then heated at 1450°C under Ar2 atmosphere. The FEG-SEM image revealed lots of nano-micro rods with diameter ranging from 100 nm - 500 nm and 30 mm or longer in the length, were formed inside the bamboo carbon. The X-ray EDS and XRD confirmed that the nano-micro rod was largely SiC. It was further found SiC nano-micro rods preferred to grow in the cavity of two big metaxylem vessels while it was seldom to form in the parenchemal cells or on the surface of bamboo carbon. Furthermore, the loading weight of SiO2 gel also significantly affected the growth of SiC nano-micro rods in bamboo. The present investigation indicates that bamboo could be used as a bio-reactor for fabricating SiC nano-micro rods at large scale.

Keywords: bamboo carbon; SiC; nano-micro rods; bio-reactor

PP112

Thermal conductivity of composites made of wastes of wood and expansive polystyrene

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To take account of ecological problems related with environment at the end of the Twentieth Century, the polymers are used in the developed countries in order to valorize the wastes of wood and fibers plants. Due to a lack of access to adapted glues, the populations of Africa countries use these wastes and fibers plants as source of energy and to embank the shallows. Such uses of the wastes don't guarantee the protection of the environment.

In all countries of the world, either is the level of their development, sale of the materials using the expansive polystyrene as packing generates important quantities of non biodegradable wastes. Management of these wastes is important.

So, the retraining of the wastes of the industries of woods and the expansive polystyrene packing to produce other building materials appears like an environmental and economic alternative.

In this context , that in the present work, a possibility of recycling wastes of woods and polystyrene packing in view to produce composite materials of wood has been examined.

The composite materials consist in that chips or sawdusts of wood sorted in particles of varied dimension and mixed according to a granular composition well defined. The different components are assembled with glue obtained from polystyrene of packing dissolves in a solvent. The thermal conductivity λ definite for this type of composite shows that this one can be used in the realization of the partitions and the artificial ceilings.

Keywords: Polystyrene, Wood, Granular Composition, Thermal Conductivity.

PP113

Manufacturing particleboard panels from roselle (*Hibiscus sabdariffa*) stalks and eucalyptus (*Eucalyptus camaldulensis*) wood particles

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The objective of this work was to evaluate the performance of particleboards manufactured from roselle (Hibiscus sabdariffa) stalks and eucalyptus (Eucalyptus camaldulensis) wood. The manufacturing parameters were as various roselle (Hibiscus sabdariffa) ratios in the mixture (0%, 25%, 50%, 75% and 100%) and press time (3, 5 and 7 min). Static bending, internal bonding strength values and thickness swelling (TS) after 24 hour water soaking of the panels were determined according to the procedure of European Union (EN) Standard. The results of the study demonstrate that roselle stalks can be an alternative raw material source for particleboard industry. The overall panel properties improved with an upper percentage of roselle particles added.

Keywords: Roselle, Static Bending, Internal bonding, Thickness swelling

PP114

Analysis and design of bamboo composite flooring by finite element method

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Hygroscopic warping of bamboo composite flooring due to the moisture content gradient between layers is a critical problem associated with the use of bamboo composite flooring. Warping, defined as the out-of-plane deformation of an initially flat panel, is a critical problem associated with the dimensional stability of bamboo composite flooring. This phenomenon causes considerable product value decreasing, frustration for manufactures and confidence losing for consumers. Therefore, there is a strong desire for knowledge on how to design high quality of bamboo composite flooring

A finite element model was proposed to predict hygroscopic warping of bamboo composite flooring. Geometrical parameters and bamboo species properties were used to evaluate the different construction of bamboo composite flooring. Detailed model development and computer simulation results are presented.

The results of this study show that the proposed model can be successfully applied to analysis and design of bamboo composite flooring resulting from moisture content change of each layer. It might offer a better understanding of warping behavior and the ideas how to design bamboo composite flooring with high quality as well as to

diminish the amount of its warping. These reliable results will benefit the design and development of the bamboo composite flooring and serve as references for practitioners.

Keywords: Bamboo composite flooring; finite element method; fygroscopic warping; moisture content gradient

PP115

Analysis and design of interference fit for wood dowel joint by finite element method

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Furniture is an apparatus needed in human daily life. The requirements for furniture design are appealing appearance, sound functionality, current fashion and structural safety. One of them most concerned is the structural safety of furniture. The structural safety of furniture includes strength of member itself and joint. In general, the wood furniture under loading almost fails in the joint, not member itself. Therefore, the design of joint strength is no less important than the design of member strength.

Solid wood is fibrous, porous, hygroscopic and orthotropic material. The moisture content of wood varies with change of air relative humidity, which causes the shrinkage and swelling of wood dowel and member with hole. Consequently, the joint strength of wood dowel and member with hole will be affected by this change. If the issue is ignored, looseness of connection is often seen in the solid wood furniture. An improved design idea comes with interference fit widely used for connecting two metal cylindrical parts. The interference fit means that assembling two parts by pressing or shrinking one member onto another creates a contact pressure and friction force at the interface of two mating parts. With interference fit of wood dowel and member with hole, the connection might be tied firmly.

The finite element method was successfully applied to the analysis and design of interference fit for wood dowel joint. The effects of panel type, hole diameter, penetration length, ring angle of wood dowel on the withdrawal strength of wood dowel were evaluated. The results showed that the withdrawal strength of wood dowel was significantly influenced by all evaluated factors. The results will benefit performance evaluation and development of wood dowel joint design and serve as a reference for practitioners.

Keywords: Finite element method; furniture; interference fit; wood dowel joint

PP116

Fungal and Termite Resistance of Zinc Borate-Treated Oriented Structural Straw Board

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The world's first oriented structural straw board (OSSB) manufacturing plant has been set up in China since October, 2009. The OSSB product is comparable to wood-based oriented strand board (OSB) in both physical and mechanical properties at comparable densities. It is therefore considered as a new building material in China. However, OSSB is subject to biological attacks due to straw's higher content of sugars and starches, especially in its kernels. Complete removal of kernels has proven to be a daunting task in the industrial production of OSSB. Therefore, OSSB has high risk to fungal and termite attacks as long as the kernels are presenting in the panel. The objective of this work was to investigate the practical feasibility of using zinc borate (ZB) as preservative in OSSB manufacture. The performance of ZB-treated OSSB against mold fungi, decay fungi and termites was examined in standard laboratory evaluations.

OSSB was fabricated with split wheat straw and diphenylmethane diisocyante (pMDI) resin. The ZB was added during panel manufacture to achieve preservative levels (wt.%) of 1.0%, 1.5%, 2.0%, and 3.0%. Untreated (0.0% ZB) OSSB samples were also evaluated along with comparison controls of untreated solid wood. It was observed that after a four-week exposure to mold fungi all samples had some mold coverage but the coverage on the ZB-treated samples was significantly lighter compared to the untreated OSSB. Decay test showed that the weight losses of ZB-treated OSSB blocks at 1.0% and 1.5% levels were significantly reduced compared to the untreated OSSB and solid wood controls, indicating superior performance of ZB-treated OSSB against decay fungi. The termite mortality indicated that none of the termites were alive at the conclusion of the test for ZB-treated OSSB. The results from these specific laboratory studies demonstrated that ZB retentions of 1.5% or above provide performance against decay fungi and termites for the OSSB panels. In addition, untreated OSSB has high susceptibility to mold due to the chemical features of wheat straw and incomplete removal of kernels. It is suggested to use moldcide spray on the board surface to provide sufficient mold resistance.

Keywords: Oriented structural straw board; zinc borate; mold; decay; termite

PP117

Dimensional stability of heat treated *Pinus roxburghii* Sarg. And *Mangifera indica* L. woods

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Heating of wood at lower temperatures (below 100°C) results only loss of free water from the wood resulting in seasoning of wood. Heating at higher temperatures (usually between 150 to 260°C) causes chemical, physical, mechanical and micro-structural changes in wood resulting in production of new modified material. Effect of heating temperatures and time duration on the dimensional stability of softwood (Pinus roxburghii Sarg.) and hardwood (Mangifera indica L.) was investigated. Wooden specimens of specific size were heated at 160, 190 and 210°C temperatures for 4, 8 and 12 hours in a heat treatment plant. Volumetric shrinkage and swelling, equilibrium moisture content (E.M.C.) at different relative humidities and water absorption was studied. Results revealed that heat treatment

at 210°C for 12h caused reduction in volumetric swelling (34.7%) and shrinkage (28.53%) as compared to control. Thermal treatment at 190°C for 4h resulted maximum reduction in E.M.C. in Pinus roxburghii Sarg. while higher temperature was required by Mangifera indica L. specimens. The ratio of E.M.C. between unmodified and modified wood decreased with increasing humidity. Decrease in water absorption was observed with treated Mangifera indica L. wood specimens.

Keywords: Pinus roxburghii Sarg.; Mangifera indica L.; equilibrium moisture content (E.M.C.); volumetric shrinkage and swelling; water absorption.

PP118

Use of different types of cover for improving dimensional stability of OSB panels

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The use of OSB (Oriented Strand Board) has been growing significantly and occupied market that were exclusive of the plywood. However, the main limitation of OSB is its low dimensional stability compared to plywood panels, that when in contact with moisture has a higher thickness swelling. In this context, this study aimed to evaluate the effect of different types of surface coating for OSB panels on their dimensional stabilities.

The experimental design consisted of four treatments: (i) application of a commercial water repellent product (SurfaPore W) composed of nanoparticles; (ii) application of a natural latex rubber coating; (iii) application of a mixture of paraffin (50%) and natural latex rubber (50%) coating; and (iv) control (no treatment). The different products were applied with a brush on the surface of the OSB samples. After treatment the samples were conditioned (20 °C and 65% relative humidity) and water absorption after two and twenty-four hours of immersion (AA2h and AA24h respectively) and thickness swelling after two and twenty-four hours of immersion (IE2h and IE24h) were determined according to ASTM D1037 (2006).

From the results it was observed that the commercial product composed of nanoparticles (SurfaPore W) promoted the significant decrease in all physical properties, while the treatments consisting in the coating with natural latex rubber or natural latex rubber with paraffin did not promoted significant improvement only of the property AA2h. Nevertheless, the different types of coating were effective in attending the specifications of the CSA standard 0437(1993).

Keywords: OSB panels; dimensional stability; nanotechnology; natural latex rubber; paraffin

PP119

Modern Multistore Buildings from Engineered Cross Laminated Timber

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Among renewable natural resources and CO2 neutral raw material and products, wood has in all its processing variations a prominent role. Therefore renewable materials, i.e. timber based products, will be used increasingly in the future, because they are considered sustainable and may provide a positive energy and carbon balance. An example of such a sustainable building product is the Cross Laminated Timber (CLT, X-Lam), which fulfils all new energy saving requirements. Due to the gluing (only 0,6% resin content) of longitudinal and transversal layers of timber (up to 45 mm thickness each; in Europe from resinous species), the swelling and shrinkage of the wood is reduced to a negligible degree. Thus, the standards of a modern building material are assured. The walls, floors and roofs made from it insulate well and can simultaneously carry loads. The CLT elements with a stiffening function (i.e. 10 cm for walls and 13 cm for floors) have a density of less than 500 kg/m^3. This makes the covering of large spans possible with the pre-manufactured elements of very large dimensions (3,5 x 13,5 m, limited only by transportation). Due to its thickness it is fireproof and has also a good sound insulation. The buildings made of CLT can be erected fast (few days). Generally the massive wood structure has a positive effect on the well being of humans. Thus, rain impermeability and finished visible surfaces on the inside are quickly possible. As far as the protection against the overheating of the building in summer is concerned, the X-Lam ideally counteracts the changes in temperature (optimal phase displacement): it both insulates and stores heat very well. An initiative for a special CLT standard was started last years. The actual regulation (EN 1995) used for buildings made of X-Lam based on Standards for Building Construction (EuroCode 5). The characteristics of CLT are differently defined, tested and presented, depending on producers, but according to the ETA. New residential buildings of eight floors made from CLT are in use in Sweden, Germany, England and Austria. In earthquake started to use this modern wood based material in special designed constructions. Also in regions with sever risk or damaged residential areas by natural disasters (earthquake, flooding, hurricane) special designed X-Lam based buildings are proved solutions guarantying short erection time on site, easy assembling and secure habitation. For the thermal rehabilitation of existing buildings, funded by federal states and communities, CLT is advantageous because of the high degree of prefabrication, the short erection period, the low weight, and the positive carbon footprint. Residential buildings, especially the public ones such as schools, kindergartens and administrative buildings have to be refurbished while staying operational. For these applications the use of highly prefabricated building elements shows crucial advantages.

Keywords: cross laminated timber, multistore ecological low energy buildings

PP120

Effects of Polymer Matrix Type on Accelerated Weathering Properties of Wood–Plastic Composites

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Because of the limitations of the use of fossil fuels, abundant, renewable, and low cost natural fibers have gained significant popularity as reinforcement materials in plastic composites over the past decade. Reinforcing plastic with plant fibers has many advantages, such as low density, low equipment abrasiveness, high stiffness and strength, low maintenance requirements, and good biodegradability. Therefore, wood-plastic composites (WPCs) have become one of the most dynamic sectors of the plastic industry. The global WPC market has experienced double-digit growth in North America and Europe, and the volume of WPCs is predicted to increase from 129,000 tons in 2008 to 427,000 tons in 2014. Currently, some WPCs for residential construction applications, such as decking, window framing, siding, and roof tiles, are being rapidly introduced to the marketplace. However, the durability of WPCs is generally poor; as a result, fading, chalking, and strength weakening caused by environmental exposure are major problems for their use outdoors

Thermoplastics, such as high and low density polyethylene, polypropylene, and polystyrene are the best known WPC products. However, only limited information is available on the weatherability and photodegradation of polyolefins and their composites to date. There are no prior reports comparing the different weathering behavior of a variety of polymeric matrix composites. It is well known that accelerated weathering testers are widely used for research and development, quality control, and material certification. Therefore, the purpose of this work is to compare the accelerated weathering properties of different types of WPCs, including virgin high density polyethylene (HDPE), recycled high density polyethylene (rHDPE-I and rHDPE-II), virgin low density polyethylene (LDPE), virgin polypropylene (PP), recycled polypropylene (rPP), virgin polystyrene (PS), and recycled polystyrene (rPS) based WPCs. Results showed that the modulus of rupture (MOR) and modulus of elasticity (MOE) of all WPCs decreased with increasing exposure time. Of these, the rHDPE-II based composite exhibited the highest MOR and MOE retention ratios after 2000 h of accelerated weathering, while the PS based WPC had the lowest values. In addition, the carbonyl index difference (CID) of various WPCs increased significantly as a function of exposure time. Among them, the polystyrene based WPCs exhibited the most severe surface photo-oxidation degradation, while the degradation of polyethylene based WPCs was the mildest. This result was consistent with the change in the surface cracking and flexural properties of the composites. The polystyrene based composites also exhibited higher moisture diffusion coefficients. The results of this study indicate that the mechanical behaviors of WPCs after weathering could be influenced by a combination of factors, such as surface oxidation, morphology changes, and moisture absorption.

Keywords: Wood-plastic composite; polymer matrix; weathering; mechanical behavior; photo-oxidation

PP121

Mechanical Properties of Corrugated Veneer-cored Panel

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Presently, lightness and simplicity of a material are key features considered in material design. A light material allows reduced energy consumption for its production and transportation. A simple material facilitates effective recycling without a complicated separation process.

Various types of wood-based lightweight panels are used for the construction of buildings and furniture. Lightweight paper honeycomb (PH) and plastic foam are frequently used as "core" materials, and rigid panels such as plywood are used as "face" materials to achieve excellent flexural rigidity. PH is an excellent core material owing to its cost effectiveness, but it is inapplicable for long-term use as it is not durable under highly humid conditions. Polystyrene foam is also a useful core material; however, the combination of wood and non-wood materials is discouraged as it hinders recycling of wood.

A lightweight core made of wood, enables the realization of a durable and recyclable wood-based lightweight panel. With this in mind, we developed a corrugated veneer (CV) as a core material. A similar concept, that of corrugated particleboard, has been previously proposed; however, only a few attempts have so far been made to develop a fine honeycomb structure using a veneer with excellent mechanical properties.

Thin veneers (0.3 - 0.8 mm thick) softened with water were placed in a ladder-like metal frame and dried in an oven to fix its corrugated shape. The CV was then sandwiched between two plywood panels with polyvinyl acetate glue. The final CV thickness was 4 - 14 mm depending on the corrugation wavelength. The density of the CV (- 40 kg/m3) was lower than that of PH for construction use, while its compressive strength in the thickness direction was comparable to that of PH. Since the CV supports compressive stress owing to its bending stiffness, it can absorb large strain energy before it is crushed completely.

The flexural rigidity of sandwich panel is generally determined from that of the face material and the shearing rigidity of the core material. As the shearing rigidity of the CV is greater than that of PH, a CV-cored panel is expected to show excellent flexural rigidity. The CV showed little anisotropy with regard to its shearing rigidity, probably because its anisotropy due to the honeycomb structure is compensated by that of the veneer.

Keywords: Engineered wood; corrugated veneer; lightweight panel

PP122

Bending strength and stiffness of MDP panels

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The objective of this study was to evaluate the influence of different types of raw material and laminate inclusion on the mechanical properties of MDP (Medium Density Particleboard). Panels made of sugarcane bagasse (from China market) and pine wood panels (from Brazilian market) were evaluated. The experiment design consisted of four treatments: (i) panels of sugarcane bagasse without laminate inclusion; (ii) panels of sugarcane bagasse with laminar inclusion; (iii) pine panels without laminate inclusion; and (iv) pine panels with laminate inclusion.

For the realization of the laminar inclusion on the panels that received the treatments (ii) and (iv) it was used a veneer of 2 mm thickness of Pinus oocarpa, 180 g/m^2 of phenol-formaldehyde in a simple glue line, 11 kgf/m^2 pressing cycle, temperature of 180°C during 3 min. Modulus of elasticity (MOE) and modulus of rupture (MOR) in static bending test were determined according to ASTM D1037 (2006). Results were evaluated by a 2 x 2 fatorial analysis (two types of raw material - sugarcane bagasse and pine wood; and two treatments for laminate inclusion - with and without inclusion), with subsequent use of Tukey test ($\alpha = 0.05$).

It was concluded that the laminar inclusion increased significantly the stiffness (MOE) and strength (MOR) of the panels to the static bending test in the two types of raw material. In respect to the type of raw material, the pine panels differed statistically from the panels of sugarcane bagasse when MOR was evaluated with and without laminate inclusion, and the MOE of the panels without laminate inclusion, presented higher values. While the MOE values of panels with laminar inclusion did not differentiate statistically between the two types of raw materials, showing that there was interaction between the treatments.

Keywords: MDP, sugarcane bagasse, pine, laminate inclusion

PP123

Effect of thermal treatment on the properties of the particleboard from sugarcane bagasse

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This work aimed to evaluate the effect of different temperatures of thermal treatment on the properties of the particleboard from sugarcane bagasse.

Five treatments were evaluated as follows: control (no treatment), thermal treatment at temperatures of 270, 240, 210 and 180°C. The panels were treated in a hydraulic press for 10 min, using the maximum pressure of 0.05MPa. Five repetitions was performed in each treatment and the properties of the panels were evaluated according to ASTM D1037 (2006). Non-destructive evaluation was performed by the method of propagation of stress waves by the stress wave timer (SWT) equipment. Comparison between the treatments was done by ANOVA and test of averages by Scott-Knott ($\alpha = 0.05$), as well as a Pearson correlation analysis and regression analysis between the destructive and nondestructive method (SWT).

With the exception of 180°C and 210°C temperatures, all other levels of thermal treatment promoted the significant improvement of the physical properties and the temperature of 270°C provided the best results. Nevertheless it was the only temperature that promoted significant decrease of the average values of modulus of rupture (MOR) and modulus of elasticity (MOE). Therefore, in the case of particleboards from sugarcane bagasse the thermal treatment at 240°C was the best option. The Pearson correlation demonstrated a high correlation (r^2=0.835) between the values of dynamic modulus of elasticity (MOED) obtained by stress wave timer, with the values modulus of elasticity (MOE) in static bending, being also significant for the linear regression analysis MOE=2,4643*MOED - 4469,8 (r^2=0,698).

Keywords: particleboard; sugarcane bagasse; thermal treatment; non-destructive method

PP124

Equilibrium moisture content of wood panels

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Considering that panels are made of wood, a hygroscopic material, once they have come in contact with the air, they absorb or lose moisture in the liquid or vapor phase until reaching an equilibrium. These variations present great importance for the proper use of each panel, since deformations related to this reaction resulting from the contact with moisture are undesirable and they also have direct relationship with others properties of the panels. The aim of this paper was to demonstrate different conducted researches involving the equilibrium moisture content of wood panels, which were developed by the Experimental Unit of Wood Panels (UEPAM) from the Federal University of Lavras, Brazil.

Particleboards, blockboard and multilaminated plywoood, hardboard, OSB, MDF, HDF and cement-wood were evaluated. The effect of production variables were checked for some types of panels: 1) types and levels of adhesive, 2) temperature, pressure and pressing time, 3) particle sizes, and 4) panels density. The determination of the panels equilibrium moisture content was performed considering different relative moistures (90, 80, 70, 60, 50 and 40%) and temperatures (30, 40 and 50ºC). It was also performed the equilibrium moisture content estimative for different types of panels from the 26 brazilian states, by using the equation of Nelson (1983) and the data of climatologic normals (series 1960-1990).

From the results obtained it's possible to conclude that: 1) The equilibrium moisture content varies depending on the panel type, 2) The equation of Nelson (1983) was efficient at the equilibrium moisture content estimative, 3) Increasing the pressing time and temperature decreases significantly the panels equilibrium moisture content, 4) The type and different adhesive levels considerably affect the panels equilibrium moisture content, 5) OSB panels, once produced with thicker strand particles, show lower values of equilibrium moisture content, 6) The increasing density of the panel results in the increas-

ing of the equilibrium moisture content and 7) The air moisture has got bigger influence over OSB panels equilibrium moisture content than the environment temperature.

Keywords: wood panels, equilibrium moisture content, production variables

PP125

Properties of Medium Density Fibreboards (MDF) Made from Kenaf (*Hibiscus cannabinus* L.) Using Thermo-Mechanical Pulping (TMP)

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The objective of this investigation was to evaluate the properties of medium density fibreboard (MDF) from kenaf (Hibiscus cannabinus L.). Raw material having of bast and core portions of kenaf was refined employing thermo-mechanical pulping (TMP). Experimental MDF panels were made using 12% urea formaldehyde adhesive at a target density of 0.70 g/cm^3. The modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), water absorption (WA) and thickness swelling (TS) of the samples were determined as function of refining pressure levels based on Malaysian Standards 1787: 2005. The study indicated that refining pressure had major influence on the all board properties with an exception of WA of the panels made from bast fibres. Low refining pressure level produced panels with less dimensional stability. On the other hand, high pressure levels produced panels with high dimensional stable, higher strength properties but low IB values. The ideal refining conditions for panels from bast fibres was using 5 bar of refining pressure produced sample with value of 21.2MPa, 1830MPa, 0.3MPa, 25% and 74% for MOR, MOE, IB, WA and TS, respectively. Panels manufactured from core fibres with low refining pressure resulted samples with high WA, TS, MOR and MOE but low IB value, while using high refining pressure produced boards with low WA and TS, but high MOR, MOE and IB values. The ideal refining condition was at 7 bar and such sample had 14.6%, 63.2%, 30.3 MPa, 3619 MPa and 0.66 MPa for TS, WA, MOR, MOE and IB, respectively.

Keywords: Refining pressure; physical properties; mechanical properties, kenaf bast, kenaf core.

PP126

Recent Advances in the Manufacture of Non-Conventional Building Materials from Agro-forestry Residues in Nigeria

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Inadequacy of affordable houses remains a major problem in many developing countries including Nigeria. The demand for housing in Nigeria has continued to escalate over the years as a result of population growth estimated at about 3.0 per cent per annum, rapid urbanisation due to rural-urban migration, relatively high cost of the preferred cement-based conventional building materials, and ineffective housing policies. One way of addressing the problem, therefore, is the development low cost culturally and architecturally acceptable building materials.

It has been established that agro-forestry residues are potential sources of alternative building materials that could be used in the production of low density, environmentally friendly and fire-resistant cement-based composites for a wide variety of exterior and interior, structural and non-structural applications in the building industry. This paper presents some of the findings of an on-going research and development efforts aimed at the manufacture and characterization of wood-cement composites from coconut husk rattan cane particles and baggase coupled with equipment development for cottage level manufacture of floor and wall tiles and roofing sheets from these materials. The effects of chemical pre-treatment and aqueous extraction of water soluble cement inhibitors on the hydration behaviour as well as strength and sorption properties of the composites have been examined.

Findings have shown that with suitable pre-treatment, acceptable building components could be manufactured from the three agro-forestry materials tested.

Keywords: Non-conventional building materials; agro-forestry residues; wood-cement composites

PP127

Study on the Utilization of Foamed Wood-Plastic Composites as the Core Materials in Sandwich Composite Structures

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This study delineates the possibility of using foamed wood-plastic composites (WPCs) as the core materials in fabrication of sandwich composites. The objective of this work was to evaluate the mechanical properties of aforementioned sandwich composites as well as their insulating properties. In order to have better insights, two types of foam cores were prepared including; Foamed WPCs, and Polyurethane foams. Facings for both sandwich composites were the same, and they consisted of Polyethylene, saw dust in the shape of wood flour with mesh size of 60, Stearic acid as a lubricant, and MAPE as a coupling agent. These components were extruded in a twin-screw laboratory extruder and then hot pressed in a hydraulic press. For foamed WPCs, components were the same as mentioned above except for Azodicarbonamide and zinc-oxide. Azodicarbonamide acts as a foaming agent for Polyethylene polymer and Zinc-oxide decreases the melting point of the foaming agent. These materials were also extruded in the extruder. The granules were also pressed in a special hydraulic press which was designed to produce

foamed WPC boards. Polyurethane foams were also prepared by mixing Polyol and Isosyanate in a cold mould. In order to make a sandwich structure, foam cores were attached to the facings by the use of epoxy resin.

Results indicated that, it is possible to use foamed WPCs as the core materials in production of sandwich composites. It was also concluded that although foamed WPCs showed better mechanical strengths, but Polyurethane foams have more advantageous over foamed WPCs in terms of their insulating properties. Both sandwich composites with Polyurethane or foamed WPC core materials can be used in different applications.

Keywords: Wood-Plastic, Composites, Foamed Core Material, Sandwich Composite Structure

PP128

Evaluation fibreboard mechanical properties made of mixing cotton stalk and industrial wood fibers

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Medium density fiber (MDF) has suitable characteristic such as homogeneous structure, good finishing, acceptable mechanical strength ... it has special place in Iranian market. Therefore, the new numbers of factories are established in Iran annually for producing MDF. On the other hand, there is a limitation to harvest wood from Iranian forests. For this reason, most industries that consume wood as a raw material have a great concern about providing that. So it seems to be necessary to find a non-forest raw material to decrease depends on forests. Cotton is a plant that cultivate in large scale in north of Iran where most MDF factories were located. According to statistics provided by the Ministry of Agriculture, Cotton cultivation was more than 109000 hectares in 2009. Base on previous studies, each hectare produce approximately 3 ton cotton stalks and thus there are more than 300000 tons cotton stalks every year. Since a little cotton stalks use as a fuel and remaining is as a waste, so it seems these waste is a good candidate to producing MDF.

In this research, we investigated effect of cotton stalk fibers in mixed with industrial wood fibers for medium density fibreboard manufacture was studied. One layer laboratory panels with two variables of cotton stalk fibers content in four levels of 0/100, 15/85, 30/70, 45/55 by weight and press time of 5 and 7 minutes- were produced. The mechanical properties of panels including modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), were measured. The results showed that cotton stalk fibers had negative significant effect on MOR and MOE while IB improved as cotton stalk fibers increased. Furthermore, the result indicated that press time had positive significant influence on IB.

Keywords: medium density fibreboard, cotton stalk, physical and mechanical properties

PP129

Valorizing Wood Pulp Fiber Rejects into Cellulose Nanofibers: Preparation and Characterization

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In this study, various waste streams of wood pulp and paper production were considered for the preparation of cellulose nanofibers. Namely pulp fiber rejects such as fibers collected from the white water were collected characterized. These fibers were collected from both sulfite and kraft processes. The amenability of these fiber waste streams for conversion into cellulose nanofibers via traditional processes e.g. sulphuric acid hydrolysis, was investigated. After the acid hydrolysing of the pulps, the morphology and microstructure of the produced cellulose nanofibers were investigated by traditional techniques including transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FT-IR) and X-ray diffraction (XRD). This presentation will therefore highlight the challenges and possibilities for valorising pulp fiber waste streams into cellulose nanofibers, which are nowadays widely used for reinforceing polymer matrices.

Keywords: wood pulp; pulp fiber rejects; cellulose nanofibers; acid hydrolysis

PP130

Conventional particleboard made from coffee plant stem

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Several agricultural residues are widely generated in Brazil every year. The destination of such materials is not always adequate. This work aimed to verify the utilization of coffee plant stem in the production of conventional particleboard.

The basic density and chemical composition of the coffee stem were obtained. The residue was processed in hammer mill for generation of sliver particles. Particleboards were produced with urea-formaldehyde at 6, 9 and 12% and paraffin at 1%. For each treatment, 3 panels were produced. The nominal density of the panels was 0,600 g/cm^3. The pressing cycle used was: pressure of 0,32 MPa, temperature of 160°C and time of 8 minutes. Physical tests of water absorption and thickness swelling after 2 and 24 hours immersion and mechanical tests compression, static bending and internal bonding were made.

The different adhesive contents had significant influence on the properties water absorption after 24 hours, internal bonding and modulus of elasticity in static bending. Other properties were not affected.

Keywords: Coffea arabica L, agricultural residue, particleboard adhesive content.

PP131

Evaluation of permeability and its influence on physical and gluing properties of bagasse particleboards

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The permeability is a physical property of extreme importance for development of durable materials, since it can be associated with the resistance to penetration of environmental degradation agents. In this work, useful information and contribution to better understanding of the influence of permeability on the water uptake of post-pressed particleboards produced with sugarcane bagasse is presented. Moreover, the influence of permeability on the quality of glued joints of particleboards was analyzed.

The effects of mat type (1-layer and 3-layer), adhesive types (UF, MUF, UF/MUF/UF mixture and MUF/UF/MUF mixture), and adhesive contents (9 and 12wt.%) for both surface and middle layers were evaluated. The rotameter method with adaptations was used to obtain the permeability values, which means that the atmospheric air was used to determine the gas permeability of the panels. The glue line shear strength was obtained in panel samples glued together with PVA adhesive. The density and water absorption after 2 and 24 hours were determined according to American Society for Testing and Material - ASTM (1999).

The permeability means were adequately grouped to allow specific statistics contrasts. The linear correlations between permeability and the glue line shear strength and water absorption after 2 and 24 hours were verified. It was possible to conclude that: The mean permeability obtained for the panels was 5,62 $cm^3/cm*atm*s$; the permeability of particleboards may be affected by factors such as size of the particles in the surface and apparent density; in general, it was possible to observe that the type, content, position and combination of resins did not affect the permeability of particleboards; the particleboards exhibited decrease of glue line shear strength with permeability increase. Increases in the permeability values caused higher water absorptions after 2 and 24 hours.

Keywords: mat; water absorption; glue line shear strength; layer

PP132

Wood versus bagasse particleboards: evaluation of technological properties

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The large amount of wood consumption could mean a high worldwide deforestation rate that can cause environmental impacts. Non-wood lignocellulosic biomass such as grass, straw and agricultural residues present great potential for panels manufacturing, including particleboard. Among agricultural residues, sugarcane bagasse is considered the most promising substitute for wood in particleboard production due to its anatomic and chemical characteristics. This lignocellulosic residue is produced in large quantities by sugar crushing and extraction and its disposal on sugar industries causes economic and environmental problems. This work aimed to compare several technological properties of commercial particleboards made with different raw materials.

The following commercial products were compared: sugar cane bagasse particleboards from China; wood particleboards from Brazilian Industry A; and wood particleboards from Brazilian Industry B. The properties evaluated were: water absorption after 2 and 24 hours; thickness swelling after 2 and 24 hours; apparent density at 12% wt.; elastic modulus; rupture modulus; internal bonding; air permeability; glue line shear strength of glued joints (PVA adhesive); and resistance to dry wood termite attack.

For the physical properties, it was observed that commercial sugar cane particleboards presented higher apparent density, water absorption and thickness swelling both after 2 and 24 h immersion than wood particleboards. Mechanical properties values of bagasse particleboards were intermediate between wood particleboards from industry A and B. The highest resistance to termite attack was observed for sugar cane particleboards, since they presented the lowest average mass loss. Most samples obtained from bagasse particleboards were completely impermeable to air, while high values were observed for wood particleboards. This result was mainly attributed to high compression ratio of the bagasse during pressing. The average glue line shear strength values of the three particleboards were very similar.

Keywords: biodegradation; water resistance; mechanical properties; residue

PP133

Evaluation of the contact angle in two wood species chemically treated

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The market of OSB panels has recently increased and its high quality production needs a suitable gluing quality. Several papers that analyze the gluing process highlight the contact angle as a strong indicator of quality. This work aimed to verify the influence existent between strand particles and phenol-formaldehyde adhesive.

Pinus oocarpa and Eucalyptus grandis trees were used, for which basic density, chemical constitution, and anatomical characteristics were evaluated. Strand particles were generated in a hammer mill. They were treated by the following procedures during 24 hours: sodium hydroxide at 1,5%; acetic acid at 1,5%, and distilled water. Moreover, non-treated particles were evaluated as control. The con-

tact angle between phenol formaldehyde adhesive and wood surface was measured. Particles from sapwood and heartwood were selected for Eucalyptus grandis, while late wood and early wood were selected for Pinus oocarpa. The particles were submitted to superficial rugosity analysis, chemical constitution, elemental analysis and scanning electron microscopy.

For Pinus oocarpa species, the early wood presented smaller contact angle with adhesive, while for Eucalyptus grandis, smaller angles were found for sapwood. The chemical treatments made in the particles for both species studied, caused modification on the particle surface and reduced the contact angle. The acetic acid treatment and sodium hydroxide were the most efficient.

Keywords: particleboards; contact angle; chemical treatment; contact surface.

PP134

Incorporation of rice husk to *Cunninghamia Lanceolata* on the production of conventional particleboards

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The growth of the world population demands an increase in food production. The agricultural activity for food generation, also results in several residues which often do not have adequate destination. The inclusion of such materials in particleboard production may be an interesting alternative. This work aimed to verify the technical feasibility of rice husk inclusion in particleboard production.

Cunninghamia lanceolata wood was used and rice husk was applied at 25, 50 and 75%. The three urea-formaldehyde contents, paraffin content and apparent density for all panels were 6, 9 and 12% and 0,600 g/cm^3 respectively. The panels were produced with temperature of 180° C, pressure of 3,92 MPa and time of 8 minutes. The specimens were acclimatized before the conduction of the following tests: water absorption and thickness swelling after 2 and 24 h water immersion, perpendicular tension, static bending and compression. The experimental design was entirely randomized and disposed in a factorial scheme, being the evaluated the material mixture and adhesive content.

The results showed that the inclusion of a higher amount of residue resulted in decrease of mechanical properties and increase of physical properties. The opposite was observed for increases in adhesive content.

Keywords: particleboard; agricultural residue; sustainability; adhesive content.

PP135

Utilization of Candeia Wood Residue in Production of Wood Panels

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The candeia wood residue (Eremanthus erythropappus) after oil extraction is generated in great volume, because the oil has largest use in pharmaceutics and cosmetic industry. The objective of this work was to evaluate the viability of producing panels using wood residue generated after the extraction of candeia's oil.

Wood-cement, particleboard and wood-plastic panels were produced. In the wood-cement panels were evaluated association of Eucalyptus urophylla or Pinus oocarpa woods with candeia wood residue in substitution proportions of 25%, 50% and 75%. In production of particleboard were evaluated two contents of adhesive (8% and 12%), two different species of wood in association (E. urophylla and P. oocarpa) and three percentages of substitution the species of wood cited for candeia wood residue (25%, 50% e 75%). For wood-plastic panel were used three associations of polyethylene therephthalate plastic (25%, 50% and 75%) mixed with candeia wood residue.

In wood-cement panels the reduction in the percent 75% to 25% of association the candeia wood residue with eucalipto and pinus woods promoted the reduction in inhibition indexes curing time of cement. In particleboard, the specie wood in association with candeia wood residue didn't influence values of static bending (modulus of elasticity - MOE and modulus of rupture - MOR), but these properties were reduced with more addiction of candeia wood residue. The increase in content adhesive 8% to 12% contributed for better significantly only internal bond and parallel compression. In wood-plastic panels the increase of polyethylene therephthalate plastic (PET) promoted the reduction in properties mechanics values and better results only for water absorption.

Keywords: residue; Eremanthus erythropappus; wood panels

PP136

Effects of Oil Palm Empty Fruit Bunch (EFB) Treatments on Residual Oil Content and

Properties on Exterior Medium Density Fibreboard (MDF)

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The objective of this study was to investigate the effect of fibre treatment on residual oil content and some physical and mechanical properties of experimental medium density fibreboard (MDF) panels manufactured from empty fruit bunch (Elaeis guinnensis). Panels were made from the fibre treated with boiling water and sodium hydroxide (NaOH) by using phenol formaldehyde at three levels of

8; 10; and 12% based on oven dry weight of fibre. Mechanical and physical properties including modulus of elasticity (MOE), modulus of rupture (MOR), internal bond strength (IB), thickness swelling (TS) and water absorption (WA) of the samples was determined based on Malaysian Standards (MS 1781:2005). Based on the results of this work it seems that EFB can be used as raw material to manufacture value-added MDF with accepted properties based on MS standard. Soaking in NaOH was the most suitable treatment used to remove the residual oil in EFB fibre in order to get the best properties in exterior MDF produced. Panels made from fibres treated with NaOH with 12% adhesion resulted in the highest average MOR value of 31.4 MPa. It appears that boiling water treated fibres resulted in panels with reduced bending properties.

Keywords: Empty fruit bunches; Phenol formaldehyde; Mechanical properties; Dimensional stability; Fibre treatment

PP137

Formaldehyde content in fiberboards made with eucalypt fiber and sugarcane bagasse

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The use of alternative raw material for the confection of reconstituted panels, or different percentages of mixture with the wood, sheds new light on development of alternative uses of these materials. This process can leads to the manufacturing of new products, by adding science and technology in a particular fibrous raw material used for being a waste, or present easy logistics and distribution, such as the sugarcane bagasse in central and southeastern regions of Brazil.

However, the use of alternative raw materials implies an detailed characterization of the same ones. Therefore, it can have negative or positive characteristics to the processing or final utilization, such as the case of the formaldehyde content, because this component has been classified as a known human carcinogen (cancer-causing substance) by the International Agency for Research on Cancer (IARC).

In this work, panelboards made with different percents of eucalypt fibers and sugarcane bagasse particles, glued with urea resin, there are formaldehyde content determined and compared with specialized literature. As main result, the increase of the sugarcane percentage in the fibrous matrix of eucalypt promotes reduce on the formaldehyde content, with argued implications detailed in the present evaluation.

Keywords: formaldehyde, new products, fiberboards, MDF, MDP.

PP138

Anatomical characterization of sugarcane bagasse biomass for scanning electronic microscopy to wood panels

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The scanning electronic microscopy (SEM) is a practical tool and widely used for microscopical analysis of the wood and its products, as well as raw materials of agro-forest origin for wood panels production.

In the present study, sugarcane bagasse samples obtained from the industrial process of milling after classifying the particle size in a vibratory sieves with decreasing grading between 1,0 mm and < 0,297 mm, sputtered and later examined under FEI QUANTA 400 microscope, to obtain images of cellular components in diverse magnifyings, that best fit to the objective of study and visualization.Generally, high frequency of grouped cells of parenchyma was observed, as well as of staple fiber beams, representative of the original structure sugarcane, represented for fibro-vascular beams and epidermis.

The fractions of the restrained fibrous components in all the sieves had been indicative of the presence of (i) staple fiber beams, (ii) cells of parenchyma agglomerated e (iii) parts of epidermis, evidencing the longitudinal cut and the crushing cells in the industrial process of extration. So, the technique MEV proved to be very important to characterize details of this raw material and assist in the technical-scientific basis for the applicability of this biomass in wood panels.

Keywords: SEM, anatomy, microscopy, fibrous components, wood panels.

PP139

Alternative products to the wood for composites manufacture

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Brazil is admittedly an agricultural and forest country, characterized for the extensive busy area for a diversity of agricultural cultures and forest plantations with high productivity. These sectors have, in such a way, significant strategic importance for the country as generating, income and of verge. The agricultural and forest cultures are, also, characterized by the productin of high amount of biomass after-harvest or deriving of the industrial processing, which may be allocated to the recycling, the incorporation and enrichment of the ground, the primary burning for the energy generation, and others.

However, the diagnostic of the residues from production-use bio-

mass have demonstrated the excess existence, with perspective of application technology to develop new value-added products. The availability of agricultural biomass is large in some regions of the country, such as the sugarcane bagasse, following itself the agricultural and forest residues, as the rind of rice, the culture of the banana, bamboo, babaçu fibers, plastic-wood composites and cement-wood panels.

In the present work, the analysis of the potentiality of application of this kind of residues in composites is made, with emphasis in the biomasses from sugarcane, bamboo and cement-wood, presenting initial results that indicate its viability of uses. Local experiences and the advances in the research on the production and the quality of composites will be, in the same way, presented in the work.

Keywords: biomass, new products, panels, sugarcane bagasse, bamboo.

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Physical, Chemical and Preserving Properties of Short Rotation Willow Particle Board

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Short rotation willow is a woody crop biomass, cultivated for 3 to 5 years. In the previous study by a collaborative research group, 4 willow clones, KKD, HB471, FXM, and SEN, had been screened as having the highest yield. They contained a high biomass amount, compared with other plants grown in cold areas. Our group cultivated these 4 clones in Akita, northern Japan. In this study, we made particle boards with 1-year cropped willows, and check their physical, chemical, and preserving properties.

For materials, KKD clone and HB471 clone (Salix. pet-susu), SEN clone (Salix. sachalinensis) and FXM clone (Salix. pseudolinearis) were used for the particle board. They had been cultivated from April 2010 to April 2011. For comparison, Japanese cedar (Cryptomeria japonica) was also used. The materials were milled and sliced as particles, and pressed. The particle board-manufacturing condition was as below; p-MDI as adhesive; targeted density 0.4, 0.55, 0.7g/cm3; press temperature 160°C, initial pressure 25MPa. Anti-termite activity was determined by a termite feeding test using particle board pieces. Reticulitermes speratus and Coptotermes formosanus were used as test termites. Hot water extract was prepared for total sugar analysis by the phenol-sulphuric acid method. Ethanol benzene extract was prepared for gas chromatography-mass spectrum (GC/MS) analysis.

As a result of the physical properties of willow particle boards, all 4 clone boards at 0.65 densities revealed about 26MPa at MOR, and about 2.7GPa at MOE. These results satisfy the highest quality of Japanese Industrial Standards (JIS) for particle board. Regarding preservation properties, SEN showed high termiticidal activity for both R. speratus and C. formosanus. Regarding chemical properties, the total sugar content rates were as below; KKD 4.5%, HB471 2.4%, SEN 1.6%, and FXM 1.6%. Extract content rates of ethanol benzene were about 1.0% for all willow clones. GC/MS analysis is currently in progress.

Keywords: Short rotation energy crop; salix; willow; particle board; anti-termite

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Ecological lignocellulosic nanocomposite

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Classification of formaldehyde by the International Agency for Research on Cancer as a human carcinogen caused an intensification of research at minimization of this substance in wood-based panels and research on new solutions ensuring its exclusion from these materials.

In frame of the project, financed by the National Centre for Research and Development in Poland the new composite wood product has been worked out – an ecological lignocellulosic nanocomposite which does not contain formaldehyde. A special condensation type polysiloxane adhesive containing tin catalyst and nanosilica has been used as a binding agent. We have investigated the influence of different factors on composite properties, such as: molecular weight of binder, type of agents increasing adhesion to wood, type and amount of nanofillers, sort and form of wood, an amount of binder and catalyst, wood moisture content, density and structure of composite also parameters of its pressing.

The composite can be produced from different types of deciduous wood, including 2-year-old shoots of fast-growing willow (Salix viminalis L.). Its properties may be altered mainly by structure and density change, an amount of used binder and type of filler.

The obtained results showed that mechanical properties of a new composite tested according to European Standards for wood-based panels are as follows:

bending strength - 12 ÷ 35 N/mm2

tensile strength perpendicular to the surface - 0,6 ÷ 1,2 N/mm2

modulus of elasticity - 2800 ÷ 5400 N/mm2

Further investigation on composite properties such as: VOC emission, fire hazard properties, ageing tests is being continued.

Keywords: new composite; reduction of formaldehyde; ecology; silicone polymer; nanofillers

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Effect of density on stress relaxation of polypropylene/wood flour composites

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Stress relaxation is a time-dependent phenomenon similar to creep, which can serve as an indicator of the long-term dimensional stability and also the interface compatibility between the components in composite materials.

In this study, polypropylene (PP) /wood flour (WF) composites were prepared at three different target densities (1.0, 1.1, and 1.2 kg/m3) by using MAPP or silane as coupling agent at a WF content of 50%. The loading levels of coupling agent were set at 2.0 wt% based on the total weight of PP and WF. The compression stress relaxation curves of the composites were tested at three temperatures of 20, 40, and 60°C. The stress relaxation rates were calculated to show the effects of density on long-term dimensional stability at different temperatures. The apparent activation energy was further calculated to compare the interface compatibility between PP and WF in the composites with different density. The flexural modulus of rupture (MOR) and modulus of elasticity (MOE) were also tested to compare with the stress relaxation results. The results showed that: (1) with the increasing density, the rate of stress relaxation decreased for PP/WF composites either by using MAPP or silane as coupling agent at all three temperatures, suggesting a better long-term dimensional stability at higher density, which was consistent with the trend of flexural properties; (2) the apparent activation energy of the composites increased almost linearly with the density, which indicated that the internal compatibility between PP and WF could be improved corresponding to the increase of density; (3) the effect of temperature on stress relaxation highly depended on the type of coupling agent although stress always relaxed more rapidly at higher temperatures. MAPP modified PP/WF composites seem more temperature-tolerant by showing close relaxation curves at 20 and 40 °C, but silane modified composites are more temperature-sensitive with much faster stress relaxation at 40 °C than 20 °C. Therefore, at tropical areas MAPP would be a better choice than silane for application in PP/WF composites.

Keywords: polypropylene /wood flour composites, density, stress relaxation, coupling agent, temperature

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Tannin from grape pomace: extraction and utilization as adhesive for wood particleboard

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Grape is one of the most harvested fruit in the world, with more than 65 million of tons produced in 2009. A large part is used for the wine production which created a large amount of wastes. The pomace represents 20% of the bunch and is currently used as source of ethanol, tartaric acid and polyphenols in distilleries. However, huge quantities of materials still remain after those valorizations (about 700 000 tons per year of dry material just for France). The residue is generally used for animal feed or fertilization, without any economical interest and potential negative effects due to the high polyphenolic content.

Grape pomace is composed for an important part of condensed tannins, other polyphenols and free sugars. For many years, condensed tannins from barks of trees such as Mimosa or Pine are industrially extracted and used as adhesives for wood-based materials. The extraction process used for the grape pomace is inspired by the bark extraction: in warm water with sodium hydroxide, sodium carbonate or sodium hydrogenocarbonate in presence of sodium sulfite.

Since extracted tannins have shown a good reactivity toward formaldehyde, wood particleboard had been made in a laboratory scale with a resin composed by 80% of condensed tannin, 16% polymeric methylene diphenylene diisocyanate (pMDI) and 4% paraformaldehyde. Its internal bond value was good enough to pass the international standard specificationfor interior grade panel.

Keywords: Condensed tannins, adhesives, grape pomace, extraction

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Effect of Using Delignified Fibers on Mechanical Properties of High Density Polyethylene Composite Filled with Bagasse Before and After Accelerated Weathering

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There is great potential for wood plastic composites usage for outdoor applications in the markets. However these products contain natural fibers which go through degradation due to various environmental factors, and that also increase the photo-degradation of polymer matrix. Loss in mechanical properties is one of the undesirable effects of these degradation which by itself can limit structural application of WPCs. Lignin plays an important role in the field of wood weathering.

In this study, lignin was partially removed from non-wooden fibers of sugar cane (bagasse). These fibers were applied with high density polyethylene to produce natural fiber composites. Granule polyethylene based pigments were also added to half of the samples. To investigate the effects of delignification and pigments on mechanical properties of produced composites before and after 1440h accelerated weathering, three different mechanical tests were conducted: 3 points bending, vibration test and indentation. These tests were carried out on the samples to obtain the best index for measuring the effect of weathering on samples, and also assess to the changes in MOE, work of maximum load and ductility after exposure to weathering. As well, ATR-FTIR spectroscopy has been applied to explain the chemical changes according to the mechanical ones.

An undeniable loss in MOE was observed as the result of using delignified fibers in WPCs. Before any exposure to weathering, interaction of delignified fibres and pigments showed high reduction in MOE. After weathering, the MOE systematically decreased. However, for delignified samples containing pigments minimal change in the MOE was observed. By means of FTIR analysis, delignified samples showed increase in oxidation of surface and produced high amount of carbonyl group after weathering. Also, colored samples showed less decrease in lignin and carbonyl indexes, while they lost more hydroxyl and wood indexes compared to the control samples. These results indicate the role of pigments as reducer of oxidation. Cooperation of delignified fibres with pigments show interesting increase in crystallization of the product after weathering.

Keywords: Photo-degradation; 3 points bending; Vibration test; Indentation; FTIR spectroscopy; Pigment

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Relation between apparent density and mechanical properties of structural plywood panels

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Structural plywood panels present high mechanical resistance and water uptake resistance. Therefore, they are destined preferably to environments with high humidity variations. In order to evaluate the final quality of such products, it is necessary to determine their physical and mechanical properties and their possible relations. In this context, this work aimed to evaluate the properties of structural plywood panels, besides to obtain different correlation coefficients between their apparent density and mechanical properties.

5-veneers plywood panels were produced, glued by phenol-formaldehyde adhesive at 320 g/m^2 (double line). The pressing cycle used was temperature of 150 ºC, specific pressure of 8 kgf/cm^2, during 10 minutes. The experimental design was entirely randomized composed of four treatments, being the first two made with 4 and 18-years old Toona ciliata respectively. The other treatments were made by the combination of Toona ciliata wood (18-years old) with Pinus sp. wood (30-years old) with the veneers positioned in the faces and core respectively. The physical and mechanical tests apparent density, glue line shear strength, elastic and rupture modulus, both in parallel and perpendicular directions in relation to fiber orientation in the face of the panel, were performed according to specifications described in ABNT/CB-31 NBR (ABNT, 2001) standard.

The inclusion of Pinus sp. woods in the cores and faces of the panels resulted in increase of the apparent density, which consequently contributed to improvement of the properties evaluated. Positive correlations were found between apparent density and mechanical properties of the panels. The determination coefficients (R^2) varied between 0,68 and 0,83.

Keywords: Australian red cedar; Pinus sp.; determination coefficient; phenol formaldehyde.

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Creep behavior of Meduim Density fiberboard reinforced with metal and woven synthetic nets

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This research was planned to study the influence of reinforcement with metal and woven synthetic nets on the creep/recovery behavior of reinforced medium density fiberboard. Sample boards were manufactured according to common practice. However, reinforcements were placed in the boards at one fourth of their thicknesses. Urea formaldehyde resin was used in the boards. However, some metal nets were embedded in an epoxy resin prior to board manufacture.

Firstly, bending strength of samples were determined according to ASTM D 1037-99. Results revealed that bending properties (MOE and MOR), were significantly increased due to the reinforcment. Short term flexural creep tests at 10% of ultimate bending load were performed by using flexural creep equipment.

The results of creep test showed that Creep modulus and percent recovery in reinforced medium density fiberboard was higher than control specimens .fractional deflection and relative creep in reinforced medium density fiberboard with synthetic nets are higher than those of the metal nets and highest permanent deflection determined in these boards. Metal reinforcment resulted more improved creep/recovery behavior in medium density fiberboard.

Keywords: Medium Density Fiberboard (MDF), reinforcement, metal and synthetic nets, Creep

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Properties of Particleboard Manufactured from Kenaf as Function of Particle Geometry and Aspect Ratio

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Particleboard is one of the most important wood-based panel products in the market and it properties was influenced by many factors. Particle geometry, including shape and size, of the raw material is one of the main parameters that affect the properties of particleboard panels. The aim of this work was to evaluate the properties of particleboard panels made from kenaf (Hibiscus cannabinus L.) as fuction of particle geometry and aspect ratio of the raw material.

A stereo light microscope which connected to an image analyzer was used for studies of particle geometry and aspect ratio, respectively. The results showed that most of kenaf core particles were of rectangular or nearly rectangular shapes whilst kenaf bast was in the form of curl and kneel. The highest mean values of 1756 N/mm2, 17 N/mm2, and 0.90 N/mm2 for MOE, MOR and IB of samples made from 70% rubberwood and 30% kenaf, respectively was found. It seems that panels consists of combination rubberwood with kenaf particles had better mechanical and physical properties. Also, segregation of kenaf core and kenaf bast is necessary since both materials produced different particle geometries thus require different processing parameters

Keywords: kenaf; core; bast; particle geometry; wood composites

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Cloning, Expression and Characterization of Resilin in the Cell Wall of Tobacco Plants

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Resilin is a polymeric rubber-like protein secreted by insects to specialized cuticle regions, in areas where high resilience and low stiffness are required. Its unique mechanical properties allow the outstanding jumping ability of fleas, up to 30 cm high. The elastic properties of resilin are achieved by formation of di-tyrosine bridges within resilin monomers, generated by peroxidase enzymes, in the insect cuticles.

This highly resilience and elastic protein was optimized for expression in tobacco and was directed to the cell wall by a signal peptide. Cross-linking of resilin to the cell wall was enabled by utilizing the presence of natural plant cell wall peroxidases. Resilin was located in the cell wall by Immunohistochemistry and Increase in typical di-tyrosine blue florescence, of the cell wall, indicate resilin polymerization and cross-linking. The integration of resilin to the cell wall is expected to change and improve the mechanical properties of the plant and those of woody raw materials that are extracted from it. Moreover, changes in the formation of the plant cell wall, due to the cross-linking of resilin, improved sugars release from plant material, possibly by making cell wall cellulose more accessible for hydrolytic enzymes.

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Effect of heat treatment on mechanical properties of veneers glued pre-treatment with UF resins and post-treatment with MUF resins

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The heat treatment of wood results in changes in the material that can be considered as an improvement (lightening of the material, increasing of decay resistance, lowering of MC, shrinkage and swelling reduction) and in some others as a lack in the material (strength decreases and stiffness as well behind given threshold). Wood derivates are widely used in the automotive sector and in particular in the caravans sector were the lightweight is an essential requirement for the material used. An experimentation was undertaken in order to verify the effect of heat treatment on physical and mechanical properties of plywood panels. The tests were performed on poplar (I-214 clone) UF pre-glued plywood as well as on poplar and Ceiba (Ceiba pentandra Gaerth.) veneers glued post treatment by MUF adhesives. Veneers and panels were treated at 180°C for two different time periods, 23 hours (T1) and 33 hours (T2) with a dry mass lost going from 4 to 7 %. Two different pre-glued (UF adhesive) panel thicknesses were tested, 4.4 mm and 5.3 mm both with three layers. Two different post glued (MUF adhesive) panels were tested, one type made of 5 layers 7 mm thick fromager, the other made of 5 layers 9 mm thick poplar. Moisture content pre and post treatment (according to EN 322), density pre and post treatment (according to EN 323), MOE and MOR pre and post treatment (according to EN 310) and bonding quality pre and post treatment (according to EN 314) were assessed.

Keywords: poplar plywood, heat treatment, dry mass lost, strength, stiffness, EMC, bonding quality, MOE, MOR

PP150

Influences of checks on LVL mechanical properties

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INTRODUCTION

The LVL is an industrial material very popular in construction, is a material derived from wood popular in the wood-frame construction for the low dispersion of its outstanding mechanical properties, particularly in terms of axial stresses, which may go up twice a solid wood.

Keywords: lathe checks, veneer thickness, mechanical properties, LVL, peeling

PRESENTATION OF WORK DONE

In order to vary the parameter cracking, unwinding was carried out following several methods involving significant influences on the cyclic cracking (plating thickness, parboiling temperature and presence of bar pressure when peeling). Panels were glued and specimens were extracted. These were mechanically tested by several methods and types of solicitations.

MATERIALS AND METHODS

Sampling

This beech tree grew in the forest of Ponds, located in Saint Loup Ganges, Saone et Loire, Burgundy. The log (13m long and 0.45 m in diameter) which has been truncated in 19 raised beds of 0.6 m, numbered 1 to 19 starting from the ball of the foot.

Steaming

Before peeling, all the ridges were heated for 24 hours ± 1 hour, or 20 ° C or 70 ° C by immersion in hot water bottles thermostated to ± 1 ° C.

Peeling

Fixed cutting this was done on the lathe instrumented industrial automation LaboMap SEM (Cluny, France). The speed was 1.5 m / s and the clearance angle of 1 °. When the pressure bar is active, the horizontal and vertical ribs are respectively 90% and 30% of the thickness of veneer. We produced three veneer layers (1, 3 and 5 mm) and have added higher thicknesses (6 and 7 mm).

Table 1 – Peeling modalities

Bolt number	14	4	15	13	4	14	19	17	3	9	8	18	16	11	7
Veneer thickness [mm]	1	3	5	1	3	5	1	3	5	6	7	1	3	5	7
Boiling temperature	20°C						70°C								
Pressure bar (PB)	Wthout PB			With PB			Without PB					With PB			

Lathe checking

Several techniques for estimating the cracking of a veneer exist, as the ultrasonic method proposed by [TOMPPO_2008]. In our case, we chose the one developed by LaBoMap [PALUBICKI_2009]: the SMOF ® (Optical Measurement System for cracking). This tool detects cracks with a linear CCD camera (36KHz) and a laser displacement sensor (LDS) (Figure 1). The resulting image (Figure 2) is analyzed by a program developed in LabView.

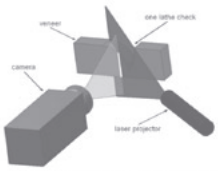


Figure 1 – Principal of the SMOF

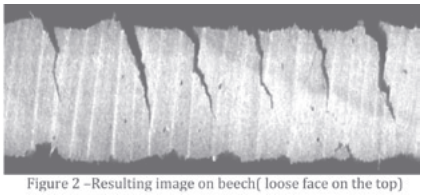


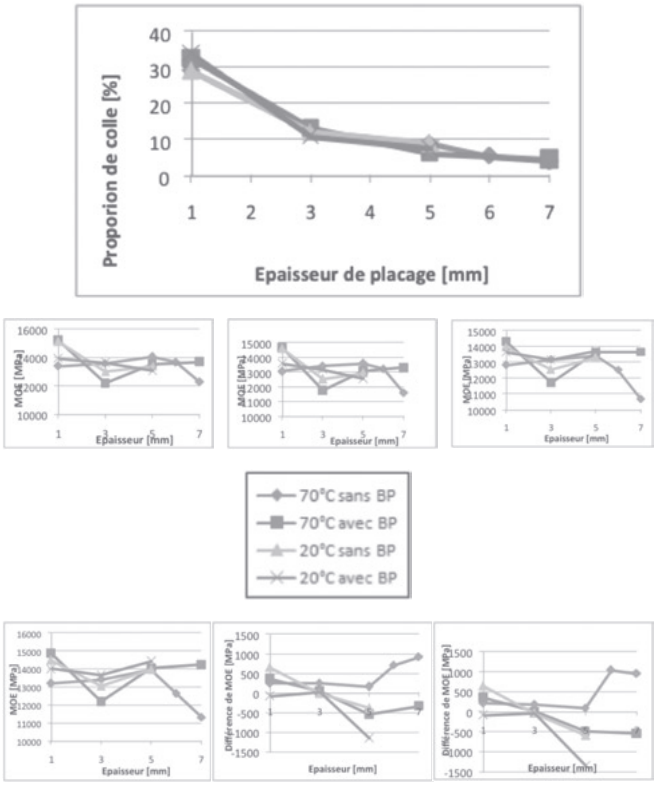
Figure 2 –Resulting image on beech(loose face on the top)

In the image, simply select the background of each crack (Figure 1) to get a. Xls including all positions (Figure 2). Thus, knowing the high position of the veneer, thickness and scale of the image, we calculate the average values of depth intervals and cracks.

RESULTS AND DISCUSSION

when plating has a surface very poor, we must increase the weight so that the glue penetrates into the roughness of wood can still cover a sufficient area to ensure proper bonding. Given that the quality of the surface state decreases when the thickness increases, it still manages to reduce significantly the overall proportion of glue in the panel (Figure 3) by reducing the number of folds (and therefore of glue joints).

Figure 3 - Evolution of the proportion of glue in the panel depending on the thickness of veneer



Differences de MOE Timoshenko & Bernoulli

CONCLUSION

Note that this study represents a first step in the optimization program of environmental performance of LVL which aims initially to try to reduce the use of glue and then use adhesive "green".

It has been drawn by increasing the thickness of veneer, we strongly decreases the overall proportion of adhesive per panel while maintaining the mechanical proper, subject to the use of optimum cutting conditions and a preliminary heat treatment billon.

The influence cracking, characteristics (frequency and depth) of these cracks can be improved by the cutting conditions by heating the wood and use a pressure bar during unwinding.

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Technology Evaluation in Iranian Particleboard Industry

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Iranian particleboard industry and market has been developing with a fast rate within past 50 years. Besides, the domestic particleboard industry is facing with new challenges mainly in five effective areas: raw material supply, production costs, product's characteristics and performance, new products and environmental issues. These factors are related to the technology of this industry in both hardware (machinery) and software (knowledge) sections. To be best adapted with the new and changing technology requirements, we should first evaluate the industry's current situation in the technology.

This study started by reviewing related literatures and extracting technology evaluation parameters in the industry. To evaluate the Iranian particleboard industry technologies, we selected 3 main manufacturing groups in Iranian particleboard market and using Khalil and UNIDO technology evaluation methods, we developed a new method to adapt with national and industry related challenges and requirements. We first extracted technology evaluation factors through literature study including Khalil's method, UNIDO method and using Delphi method to have industry experts' comments.

Extracted factors then screened and 33 factors classified in 10 groups in two levels. To use Analytical Hierarchy Process, a questionnaire designed and distributed within industry experts to evaluate the importance of each technology factor in overall technology effectiveness. Another questionnaire distributed within the same group to evaluate the technology level of each of 3 manufacturing groups in each of technology factors. Collected questionnaires analyzed using the "Expert Choice" software and AHP method and both of technology factors' importance and producers' level in each factor and in whole technology were evaluated, compared and discussed. Technology strategy factors were the most important factors and finally 3 particleboard producing groups ranked from the view point of technology factors.

Keywords: Technology evaluation; particleboard industry; Iran

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Influence of silane coupling on the fundamental properties of wood flour wood flour reinforced polypropylene composites

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Wood flour (WF) was chemically modified with silanes such as 3-aminopropyltriethoxysilane, 3-methacryloxypropyltrimethoxysilane, and vinyltrimethoxysilane. Polypropylene (PP) composites reinforced with the chemically modified WF were prepared by melt compounding and injection molding. The effects of the silane treatments on the fundamental properties of wood fiber-reinforced PP composites were investigated by the measurement of mechanical properties, water absorption (WA), thermal properties, and scanning electron microscope (SEM) analysis. The chemical modification of the WF with three types of silanes significantly increased the mechanical properties of the composites as the WF loading increased by the increased compatibility between immisible PP through the reduction of interfacial tension. Second, the improved mechanical properties of the composites may be related to the removal of hemicellulose and extractives of the WF by the NaOH pretreatment. APTES showed the lowest WA among the treated PP/WF composites. The high polar characteristic of APTES may increase the hydrolysis by fast dissolution, resulting in the improved reactivity of the silanol and the hydroxyl groups of WF. Silane treatments provided the decreased WA of the composites. From thermogravimetric analysis, the effect of the silane treatments on the thermal properties of the composites was not observed. From differential scanning calorimetric analysis, crystallization temperature and crystallization enthalpy were increased by the silane treatments, and crystallinity was decreased by the treatments. SEM photomicrographs show the evidence of the improved mechanical and WA properties of the PP/WF composites by the silane coupling treatments.

Keywords: silane, polypropylene, wood flour, polymer composites, mechanical properties, thermal properties

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Characterization and performance of β-cyclodextrin based resin in the adsorption of Cu(II)

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β-Cyclodextrin (β-CD) is a cyclic oligosaccharide formed from seven glucose molecules by α-1-4-glucosidase linkages, which has a micro-environment of a chiral, hydrophilic outside and a hydrophobic interior cavity. Currently its main uses are in the adsorption of organic chemicals, controlled drug release, environmental protection and cosmetics. Chemical modification of β-cyclodextrin through etherification, esterification and oxidation reactions and cross-linking of hydroxyls outside the cave use cyclodextrin molecules to produce new adsorbents, which may have strong interactions between hydroxyl groups and metal ions. As an adsorbent for metal ions, β-cyclodextrin and its derivatives have the advantages of being renewable, biodegradable, and have a large number of active hydroxyl groups, which can selectively contain and slowly release some substances.

A novel β-cyclodextrin-based adsorbent with high metal ion adsorption capacity was synthesized. The chemical characteristics of the adsorbent were characterized by FTIR and solid-state 13CNMR. Cu2+ was used as model pollutant for to test the heavy metal ion adsorption capacity from the aqueous phase. The adsorption equilibrium data were analyzed using the Langmuir, Freundlich and Temkin isotherm equations. The equilibrium data fit the Freundlich isotherm well. The adsorption kinetics were tested using a quasi-first order equation, quasi-second order equation, the Elovich equation and the intraparticle diffusion equation. The results indicate that the maximum adsorption capacity of the adsorbent for Cu2+ is 107.37 mg/g. The kinetic equations showed that the adsorption of Cu2+ on the adsorbent fit different equations for different concentrations of Cu2+. These results indicate that adsorption occurred via ion exchange and chemical interaction mechanisms.

Keywords: β-Cyclodextrin; Adsorbent; Adsorption mechanism; Cu(II); Kinetics

PP154

Evaluation of thermally treated OSB panels

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This study aimed to evaluate the effect of time and temperature of thermal treatment on the properties of OSB panels (oriented strand board). The experimental design consisted of five treatments: a control (no treatment) and two temperatures (200 and 250° C) in combination with two exposure times (10 and 15 min). For each treatment were used three industrials panels produced with pine wood. The physical-mechanical properties were evaluated according to ASTM D1037 (2006), and it was also performed nondestructive evaluation of the panels with a stress wave timer (SWT) equipment. Results were evaluated by the analysis of variance, arranged in a factorial 2 x 2 (two temperatures – 200 and 250 °C, and two treatment times - 10 and 15 min) with a control (no treatment), and subsequent testing of averages by Tukey ($\alpha = 0.05$). It was also performed a Pearson correlation and regression analysis between the destructive and nondestructive method (SWT).

The thermal treatment applied at a temperature of 250°C in the two treatment times promoted significant improvements in almost all physical properties, while the temperature of 200°C led to a significant improvement of water absorption only when it was applied at the time of 15 min. For the mechanical properties it was observed a significant reduction only for the modulus of rupture in the thermal treatment applied at 250°C. In general, the temperature had greater influence on the physical-mechanical properties of OSB panels than the time treatment. By Pearson correlation (r^2=0.9792) it was observed a high correlation between the values obtained for the dynamic modulus of elasticity (MOED) obtained by the method of

stress wave timer with the values obtained for the elastic modulus of bending (MOE), and also significant by linear regression analysis MOE=2,4643*MOED - 4469,8 (r^2=0,957).

Keywords: OSB; thermal treatment; physical and mechanical properties; stress wave

PP155

Characterization of the physical and mechanical properties of *Hevea brasiliensis* wood

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The rubber wood (Hevea brasiliensis) is originally from the Amazon and has several plantations in Brazil and in countries of the Asia. Its purpose is the exploitation of latex, but over the years this activity becomes uneconomical. Thus these plantations are cut down and the wood, in most times, is discarded or used as firewood.

For an environmentally sound use of wood in structures, furniture and domestic use in homes, is important that their physical and mechanical properties be known. Thus, the aim of this study was to evaluate the basic density, compression strength parallel to the grain, modulus of elasticity and modulus of rupture from internal and external positions of the stem of Hevea brasiliensis.

To carry out this study, 10 trees of clone RRIM 600 with eleven years-old were used. The base logs were sawing and removed the central plank for the preparation of the samples in the internal and external positions along the ray. The static bending and compression parallel to the grain were determined according to the technical standard BS 373. The basic density was determined according to NBR 11941 (ABNT, 1997).

The results showed that the internal and external positions does not differ significantly among themselves for basic density, modulus of elasticity in static bending, modulus of rupture and compressive strength parallel to the grain. The results are satisfactory for use in structures and furniture.

Keywords: Modulus of elasticity, modulus of rupture, compression strength parallel to the grain, basic density, rubber wood.

PP156

Evaluation Of Selected Physical And Mechanical Properties Of *Chrysophyllum Albidum*: A Lesser Used Species

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Declining availability of the prime economic species in timber market has led to the introduction of Lesser-Used-Species (LUS). Their acceptability demands information on their wood technical properties. This study investigates wood properties of Chrysophyllum albidum to determine its potential for timber in Nigeria.

The test samples were obtained from tree at breast height and were prepared according to BS 373 standard. Hatt-Tumer impact machine and Hounsfied Tensometer were used to determine mechanical properties. Results of test on Chrysophyllum albidum showed the mean specific gravity 0.66 ± 0.13 was significantly lower at the corewood and decreased from base (25%) to the top (75%). Mean moisture content (MC) of 64.73% was significantly higher in the wood nearest to the pith and decreased upward along the tree. Wood wet density of 1258kg/m3 heavier nearer the outerwood (1292kg/m3) than the corewood (1230kg/m3) and with the base (25%) having the higher density. Tangential shrinkage (44.4%) was higher at the outerwood the corewood and higher at the top (75%) than the base of the tree. The Linear shrinkage (39.3%) decreased from the corewood to the middlewood and increased from the middle wood to the outerwood with the corewood having the highest shrinkage value.

Mean impact bending was 1.08m which increased from the corewood to the outerwood and remained constant upward along the tree. The MOE and MOR were higher (40409.65, 157.53N/mm2) at the outerwood than the corewood (36303.84, 151.46N/mm2). The mean maximum compression strength parallel to the grain was 45.55N/mm2, the highest value was obtained at the middlewood and decrease from the base (25%, 46.91N/mm2) to the top (75%, 43.95N/mm2) of the wood.

A comparison of the strength values with other economic tree species shows that Chrysophyllum albidum wood has high strength properties. Generally, strength values obtained were almost the same with those of the economic tree species such as Milicia excels, Khaya species and Mansonia altissima etc.

Keywords: Chrysophyllum albidum; Lesser Used Species; physical properties; mechanical properties

PP158

Applicability of Laminated Veneer Cylinder to Sustainable Production of Woodwind Instruments

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Granadilla or African Blackwood (Dalbergia melanoxylon) is widely used to make the pipes of woodwind instruments such as clarinets and oboes. It grows very slowly; hence, its harvestable size is reached only after ~70 years. Further, quality lumber with suitable dimensions is difficult to obtain because granadilla trees often grow in very gnarled and twisted shapes. Recently, some clarinets were made using synthetic polymers and wood fiber–plastic composites. However, professional players find these "new" materials unacceptable because their mechanical and acoustic properties are completely different from those of granadilla wood. Therefore, we need to find or develop a performance substitute that has properties closer to those of granadilla.

The most serious problem in granadilla-made instruments is the development of unpredictable cracks and splits at tone holes or

at the end of the pipe due to irregular shrinkage during drying. Therefore, the minimum requirement for the material of woodwind instruments is excellent dimensional stability against frequent wetting and drying. Sufficient density and hardness are also required because many holes are drilled into the pipe. In addition, the pipe should have sufficient shearing rigidity to withstand the strong torsional force induced during assembling separated pipes.

To try to match these requirements, we developed a laminated veneer cylinder (LVC) in which fine veneers are helically wound. The density and dimensional stability of an LVC can be easily controlled by pre-compression, resin-impregnation, and chemical modification of veneers. Excellent torsional rigidity is achieved in interlocked veneers i.e. from their plywood-like structure. Further, LVC may support a bamboo-like intelligent "gradient structure" providing excellent hardness and stiffness with light weight. As LVC is a dimension-free material, it is applicable to large instruments such as bassoons and contrabass-clarinets. The described features make the LVC a potential sustainable material for woodwind instruments.

Keywords: Engineered wood; laminated veneer cylinder; woodwind instruments; chemical modification

PP159

Evaluation of Oil Palm Stems Wood Extractives in Non-Successive and Successive Extraction

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Extractives are amongst the diversified features of wood, both in their nature and their amounts. Wood extractives cover various compounds in wood other than the major wood constituents such as cellulose, hemicellulose and lignin, which include fatty acids, lipids, terpenoids, phenolic compounds and glycosides mostly soluble in water and various organic solvents. The values are varied at different parts of the tree and it also influences the physical and mechanical properties of wood such as permeability, diffusion, density, drying etc. The objective of this study was to determine the overlapping dissolved of the extractive content of oil palm stem (OPS) by using two different methods which were non-successive and successive extraction followed by Technical Association of the Pulp and Paper Industry (TAPPI) standard. To achieve this objective three oil palm trees were harvested and divided into three parts along the height and categorized as; bottom (B), middle (M), and top (T). Each part was further divided into three sections; outer (O), center (C), and inner. In overall, the yield was determined highest at top-inner in both methods for hot water solubility, followed by middle-inner for cold water and acetone extractives. As a comparing the methods, there was a great different between both of the methods tested. Successive gave lower yield of extractives compared with the non-successive method by 52.0% and 90.4% in hot water and acetone extractives, respectively. In addition of the test, extractives yield from parenchyma cells were much higher compared with vascular bundles of oil palm stem ranged from 52.6-70.6 % in three different solvents.

Keywords: Oil palm, extractive, successive, non-successive, cold water, acetone

PP160

Variation in wood density and correlation with tree growth in different clones of *Hevea brasiliensis* MUELL ARG

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Variation in wood density and its correlation with tree growth were investigated at 9 year-old trail rubber tree plantation. Increment cores were taken from 1.30 m height of two trees at four different planting density (500, 1000, 1500 and 2000 trha-1) of two clones (RRIM 2020 and RRIM 2025) in North-east of Malaysia. The wood density and diameter at breast height were obtained using water displacement method and diameter tape, respectively.

The results showed that there was a decreasing pattern in wood density from lower planting density to higher planting density. As the highest value, 0.59 and 0.64 gr cm-3, were pronounced in planting density 500 trees per hectare and lowest values, 0.54 and 0.54 gr cm-3, were evidenced in planting density of 2000 trees per hectare of both clones, respectively. Competition between trees is an effective determinant of tree growth. This reveals a direct effect of planting density on density of wood. Positive correlation between wood density and tree growth was found.

The findings imply that higher planting densities have higher values of biomass production. For commercial production, therefore, the most wood is produced at the highest planting density per hectare. Even though trees grown at the low planting density are larger and heavier, they are not large enough to exceed the total wood volume produced per hectare in the high tree population. Differences between wood qualities of different planting densities of both clones suggest that wood properties of plantation-grown trees in the wider spacings are noticeably more valuable than lower spacings. These considerable differences were recognized in most anatomical and physic-mechanical properties

Keywords: Variation; wood density; tree growth; rubber tree; wood production

PP161

The Effect of Cemara Udang *(Casuarina equisetifolia var. incana)* as Windbreak in Addressing Local People Economy

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A windbreak is generally defined as a structure that reduces wind velocity. It can be a single element or a system of elements that through its presence can provide protection to area behind it from

the wind by filtering and reducing the speed but does not stop the wind entirely. Coastal area in Kebumen regency and most of beach in southern Java are wide sandy land that front directly to the ocean. Sand dune is unproductive land because it is dynamic, does not have aggregate, has low of fertility and organic matter, easy to be dry, and has high salinity. Strong wind from the ocean can create critical land and also threaten the area behind.

Wind barrier has been established using Cemara Udang (Casuarina equisetifolia var. incana) to reduce the critical land and change it to productive one at Samas Beach and along Bantul Regency coastal land in Yogyakarta. Casuarina has many objectives in its planting such as reclaiming sand beach, utilizing it as sources of drugs, tannins, pulp raw materials, and timber production. This plant is well adapted and able to grow on sand dune which is infertile. Having that ability, Casuarina can be used as windbreaker and soil stabilizer in coastal sandy region. The success of Casuarina establishment as windbreak in Southern Yogyakarta coastal land, can be used as a pioneer to windbreak establishment in other region especially in southern Java Beach.

Windbreak establishment at the beach is one of way to cope with local people economy. Those who live around and near the beach area can make a living not only by using sea resources but also utilizing productive land. They can do agriculture in the productive land to support their daily needs. This can be a solution to solve economy problem in local level which have been critical problem for local people. Improvement of local people economy needs to be done in order to improve their life quality.

Keywords: Windbreak; sand dune; Casuarina; local economy

PP162

Evaluation of wood of standing teak trees (*Tectona grandis*) by impulse tomography in Brazil

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The impulse tomography, as a non-destructive method, constitutes an alternative to analyse standing trees and to provide information on their wood quality. The impulse tomography equipment is based on the measuring the transmission of mechanical waves through the wood, evaluated by sensors attached on the trees trunk. Some equipment allowed to determine the speed of mechanical waves and, also, generate an image of wood cross-section, applying a specific software. This image of the internal wood structure of standing trees can be correlated with their physical-mechanical properties (i.g. density, moisture and modulus of elasticity). In this study, the trunk of 18 standing teak trees with 52 years-old from a plantation established in Piracicaba city, Brazil were analyzed using the equipment Arbotom. The results allowed to determine the mean speed value of mechanical waves of 1,087 m/s through the teak trees trunk, decreasing toward the pith and correlated with the trunk diameter, and also internal wood defects were delimitated by the difference of colour on the tomography images. The applicability of impulse tomography as a non-destructive to wood characterization of standing teak trees is discussed.

Keywords: non-destructive method, wood quality, impulse tomography.

PP163

Evaluation of the radial wood density profile of teak trees (*Tectona grandis*) by X-ray densitometry in Brazil

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The X-ray densitometry is a classic methodology to analyse tree-rings and obtaining the radial wood density profile, as well as, the intra and inter-annual tree-rings density variation. The wood densitometric analyses can be applied to studies related to wood quality of trees and genetics, management practices, etc. In this study, 5 mm-diameter wood samples were extracted of the trunk of 18 standing teak trees with 52 years-old by increment borer. The radial wood density of 2 mm thickness-wood samples were taken by directly X-ray scanning, using the equipment QTRS-01X. The results allowed to obtain the wood densitometric density profile of adult teak trees showing a increase of wood density in the radial direction, the juvenile-mature wood differentiation, as well as, the distinctiveness of early-late wood and false tree-rings. The teak trees were grouped into 6 classes by the variability of wood density applying the Scott-Knott test statistic. In this paper the applicability of X-ray densitometry as a non-destructive to wood characterization of teak tree is discussed.

Keywords: X-ray densitometry, wood quality, tree-rings

PP164

Soil influence on the fluctuation of macro and oligoelements in two contiguous plots of *Populus*

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In the experimental plots of Populus (Populus sp.) located in Soto de Cerrato (Palencia, Spain) initially two different populations of poplars, in a apparently sandy loam soil, were detected. Both populations belong to the same species (Populus sp.) and were planted on the same date. Since these two populations share the same 10 ha registered property the climate variables such as temperature and rainfall are the same as well.

Therefore, soil is the only variable able to cause these two populations to be different.

In order to determinate the characteristics of the two different kinds of soil geophysics measures were developed by using a Geonics EM-31 instrument and a Syscal Resistivity meter all over the poplar grove.

Besides this, several soil samples were analyzed according to Standard Methods and results have been used as GIS (Geographic Information System) data input.

Moreover, every single tree has been geo-referred by GPS and measured to achieve a dasometric characterization (height and diameter) and thus to determinate the ecologic features of the different poplar populations in the study area.

Additionally, foliar analyses have been carried out as well as sap flux measures of a sample of trees of the plot with SF1 Dynagage and SV1 TDP sensors.

Later, soil data and ecological characteristics (dasometric, foliar and sap-flux data) have been spatially correlated and as a result it shows a high correlation between the two different kinds of soil and the two different types of Populus sp. populations in the same registered plot. Consequently we can infer that the only environmental parameter that may produce two different populations in the same area is soil.

Poplar culture is increasing due to its fast growth and profitability as a source of quality wood and as a carbon sink to mitigate climate change via carbon uptake

Keywords: Populus sp, forest soil, forestry production, geophysics, macro and oligoelements, ecological parameters, GIS

PP165

Evaluation of wood characteristics in the first phase of selection of a willow (*Salix* spp) breeding program in Argentina

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Willow wood is suitable for a broader range of forest products, including furniture components and veneer for plywood. In Argentina willows are used in the pulp and paper industry and for production of particleboard; secondarily, for saw-timber. To improve the quality of the willow plantations, INTA is developing a breeding program that has reached different phases of selection, with over 3000 genotypes. Selection criteria include fast growth, resistance diseases, stem form and wood quality.

This paper reports results of the first selection of new 1800 genotypes of seven families of Salix alba L., S. amygdaloides Anderss., S. babylonica L., S. matsudana Koidtz and S. nigra Marsh, that were obtained by inter- and intra-specific hybridisation in 2008. Six of them were originated by means controlled crossings (CC) in greenhouse and the other one, by open pollination (OP). All genotypes obtained were put in forest plant pots until the age of 10 months; after that, progenies were planted at field. A completely randomized design is utilized, with plots of 10 plants. At 34 months all survived plants (1674) have measured (high and diameter); symptoms of diseases and stem form of the plants were registered. Studies of wood density and characteristics of fibers were carried out.

ANOVA showed that high growth differed significantly between families and genotypes within families. The highest were the family 09 (OP of an individual originated in the cross S. matsudana x S. nigra), 7.20 m (±1.24 m) and family 05 (S. amygdaloides x S. alba), 6.35 m (±1.25 m). The family was a significant source of variation for basic density and fiber length. Families that include S. matsudana (01- 07 and 09) had the longest fibers (836-864-812 um respectively) and high densities (0.403-0.397 g.cm-3, 01 and 07 respectively). The family 09 despite being a cross x S.matsudana had lower density (0.35 g.cm-3). The families 05 and 09 showed the best diameter growth (6 cm) but had low densities (0.35 g.cm-3). As result of this first selection, 200 genotypes or experimental clones were selected.

Keywords: Willow breeding program; growth; wood characteristics; density; fiber; selected clones

PP166

Mechanical properties of *Eucalyptus* wood clones cultivated in Cerrado region in Brazil

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Eucalyptus, which in Brazil, has been selected and traditionally cultivated for the production of pulp and charcoal, is now being designed also to the production of solids, where the technological requirements of the wood are not exactly the same. Among these, mechanical properties suitable for use as sawn timber stand out as one of the most important to be scientifically investigated. The objective of this research was to evaluate the mechanical properties of wood from seven clones of Eucalyptus and correlate them. The methods used were three trees of each of these clones planted experimentally in Paraopeba, Minas Gerais State, Brazil. The trees were measured in the field and also had their longitudinal residual strain (LRS), the strain associated with growth, measured by an extensometer. From each tree, basal logs were cut, from which wood samples were extracted from various radial and longitudinal positions. Tests of Janka hardness (JH), compression strength parallel to grain (CS), modulus of elasticity in compression parallel to grain (MOEc) and modulus of rupture (MOR) were carried out The results showed that i) the mechanical properties of wood varied among the clones, but the same clone showed no major differences between the longitudinal positions of sampling within the log, however between the radial positions the differences were high, reaching variations above 50%, depending on the clone and the mechanical characteristic in question. Comparing the mechanical properties of wood of the seven clones with the same properties of tropical timbers for commercial use in Brazil, it can be seen that most of the clones has high compressive strength, flexural strength and medium hardness; ii) the mechanical properties were significantly correlated when they were directly correlated with each other, but only compression strength was significantly correlated with LRS.

Keywords: Eucalyptus; wood; mechanical property; growth stresses

PP167

Basic density of wood of clones of *Eucalyptus* related to the productivity of the plantation site

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One question that always disturbs producers and wood researchers is the influence that the environmental conditions for tree growth have on the quality of the wood. In Eucalyptus, rare is the information on this relationship, especially when comparing wood from identical genetic material, planted in different sites. The objective of this study was to compare the wood density of seven clones of the same age, planted at two sites with different productivity conditions. For this, three trees were collected from each of seven clones of Eucalyptus, with seven years of age, planted simultaneously in Paraopeba (site of higher productivity) and Bocaiuva (site of lower productivity), both located in Minas Gerais State, Brazil. Discs were cut at the base, the DBH and 25%, 50%, 75% and 100% of commercial height of each stem. The basic density were determined in each disc, checked their variations along the stem and made comparisons of the average densities of clones according to the site. From the results, it was concluded that all the trees that grew in Paraopeba showed larger than those grown in Bocaiúva. The study also found that clones from Paraopeba, site with the highest productivity, showed higher basic density than the same clones from Bocaiúva.

Keywords: Eucalyptus; wood; basic density; site

PP168

Perspectives for biological control of the Eucalyptus Snout Beetle, *Gonipterus platensis* (Coleoptera: Curculionidae)

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In the Iberian Peninsula, Eucalyptus forests represent an important land use with multipurpose economic value, mainly for pulp and biomass. Yet, invasive insect pests originated from Australia compromises its sustainable use.

The Australian weevil Gonipterus platensis is the most important pest affecting eucalypt plantations in Portugal. Classical biological control using the wasp egg parasitoid Anaphes nitens has been the main strategy to reduce weevil outbreaks since 1997, but it fails in some regions, mainly in mountainous areas where low temperatures seem to affect parasitoid effectiveness.

Because G. platensis appears to occur naturally only in Tasmania, it is expected that more effective natural enemies of the weevil may be found there. Therefore, in 2008 we searched for natural enemies in Tasmania, especially for egg parasitoids, in regions presenting climatic conditions similar to the ones in Portugal where G. platensis remains a serious pest. During this survey, two egg parasitoids Anaphes tasmaniae and Anaphes inexpectatus were found associated with the eggs of Gonipterus spp.. During 2009 and 2010 we imported both species to Portugal in order to perform laboratory studies on their potential as biocontrol agents. Here we present and discuss the available results from those studies.

PP169

Mill variation in bending strength and stiffness of in-grade Douglas-fir No. 2 lumber

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Visually graded lumber has wide variability within each grade, because different defects will reduce the strength differently. For Douglas-fir, variability within grade for 2x4 lumber has increased because it is often harvested from intensively managed plantation forests where trees contain a large percentage of juvenile wood. To investigate resource variability, 744 samples of in-grade, commercially dried and graded No. 2, nominal 2x4 Douglas-fir lumber from six mills was destructively tested in bending. Average stiffness ranged from 1.40 to 1.92 psi x 106, 2 mills did not meet the stiffness required for the grade (1.6 psi x 106). Bending strength (Fb) ranged from 800 to 1,650 psi, 3 mills did not meet the bending strength required for the grade (1,350 psi). Actual bending strength grade ranged from No. 3 to No. 1 & Better. Analysis of variance of stiffness and bending strength showed significant differences using Tukey's studentized range test at the 0.05 significance level. Stiffness explained a wide range of the variability in strength, with a range of 50% to 78%.

Keywords: Lumber; Douglas-fir; Design Values; Wood

PP170

Overview of *Quercus faginea* characteristics and growth tendency

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Quercus faginea Lam. (Portuguese oak) is an endogenous oak species in Portugal, presently without commercial value for timber. To evaluate its potential for high quality end uses, the wood species was characterized in relation to anatomical, structural, chemical and physical properties. Measurements were made in stem discs collected from 10 trees with 34-65 years of age at different height levels along the stem.

The trees showed a relatively high heartwood proportion in the cross-sectional area: 35.0 % at tree base and 37.1 % at 1.30 m, and then decreasing to 11.3 % at 5.60 m of tree height. Sapwood width was relatively constant along the stem showing 47.6 mm at tree base and 37.2 mm at 5.6 m of height. The amount of heartwood was strongly correlated with stem cross-sectional area.

Tree ring width at 1.30 m increased 1.3 mm in the first 10 rings, decreasing gradually afterwards from 3.1 mm until an average of 1.3 mm at around 40 years of age. The between-tree variability of ring width was high. The differences were statistically significant during the first 30 years of cambial age but decreased with tree aging.

The wood showed distinct rings and ring-porosity. Earlywood vessels diameter increased from pith to periphery reaching in average 223 µm. Fibre length increased towards periphery from an average of 969 µm to 1195 µm. The fibre wall was thick maintaining relatively constant. Multiseriate ray size increased from pith to bark and showed high variability.

Basic density was in average 0.70 g/cm3 in heartwood and 0.58 g/cm3 in sapwood. Heart and sapwood density were significantly different and variability within tree and between trees was also observed.

The wood dimensional behaviour and water content were studied at 40ºC, 30ºC and 20ºC. The volumetric shrinkage varied between 14.7% and 16.1%. The shrinkage anisotropy measured by the T/R ratio varied between 2.2 and 2.4.

The wood chemical average composition was: ash 0.6%, total extractives 15.1%, total lignin 24.0% and polysaccharides 54.7%. Heartwood showed less ash content when compared to sapwood (0.5% and 1.0%, respectively) and a higher content of total extractives (19.3% and 10.8%, respectively). Lignin content and polysaccharides was quite similar in heart and sapwood.

Quercus faginea wood showed similar features to oaks in general which reinforce its capacity and potential as technological wood product.

Keywords: Quercus faginea, wood quality, growth, variability, heartwood

PP171

Physical Properties of Wood *Tectona grandis*

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Tectona grandis (teak) is an arboreal species of the family Verbenaceae, native to the wetlands of the Indian subcontinent and Southeast Asia, and today is cultived in almost all tropical regions. The importance and value of teak is due to the desirable physical and mechanical properties of wood, such as: durability, stability, ease of pre-treatment, natural resistence of fungi, insects, pests and borers. Besides these, important qualitative aspects makes it a most valuable hardwood species in the word. This paper presents a study on the physucal properties of the wood of T. grandis L. f. from three planting densities of plantings in Cárceres, Mato Grosso (Brazil).

Were used six trees, two of each planting density, randomly selected with good features and phytosanitary representative height and diameter of the settlement, from the pantation ehit three different spacings of 30 years in Cárceres. Was determined the following properties: basic and apparent density, volumetric contraction, thermal transfer and saturation point of the wood fibers.

The overall average for the basic density of the samples was 0,48 g/cm3 , and 0,55 g/cm3 for apparent density. The average volumetric contraction in the longitudinal direction of wood teak was 8,57%. With the decrease in wood moisture content is also a loss in volume and the effects of panting were not signigicant at 5% probability. The thermal transfer averaged 7,3h/cm and saturation point of the wood fibers was 17,25%, below the range found in literature and there was no influence of planting density for this property. According to our results, was concluded that the planting density significantly influenced the basic density of wood, the same effecr does not occur for the others physical properties and considering the thermal transfer, the wood was considered as a difficult drying.

Keywords: Wood material science; behavior of wood; Tectona grandis; drying of wood.

PP172

Wood quality of eucalyptus plantation in Brazil

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The area of eucalyptus plantations in Brazil is 4,3 million ha, as a result of the fiscal incentives policies implanted in the 60's. That significant area concentrated mainly in the states of Minas Gerais, Sao Paulo and Bahia seeks to supply the demand of the Brazilian forest industries, with strong expansion to attend the national and international market. Actually, the possibility of a wood shortage in the next decade has been stimulating an inversion in the decreasing tendency in the annual reforestation rates.

Also, investments have been applied to genetic improvement, nutrition, soil preparation and, recently, with the experimental practice of fertilization associated with the irrigation. For example, the Project Brazil Eucalyptus Potential Productivity, initiated in 2000, demonstrated that the eucalyptus clone plantation presents a mean productivity of 49 m^3/ha/year applying the traditional technique, that includes the fertilization. Without the fertilization the wood productivity is reduced to 34 m^3 ha-1 year. The introduction of the irrigation increase the wood productivity to 63 m^3 ha-1 year and with the irrigation plus fertilization the productivity reaches 68 m^3 ha-1 year, representing an increase of 38% in relation to the usual silvicultural practices. While the irrigation and fertilization treatments increase the eucalyptus trees growth rate considerably, the information on the effects on the wood properties are scarce.

The knowledge of the wood property alterations due to the stimulus in the volumetric growth is essential to define the strategy for future research. According to the forest managers and wood technologists it is fundamental to consider the wood properties, even if the main objective is the increase of the wood volume of the eucalyptus trees on plantations. The lack of alterations in the wood characteristics, or even, the improvement of the quality for specific applications are considered desirable. This work has the aim to present the wood quality variation of the main eucalyptus tree species from fast-growing plantations established in Brazil.

Keywords: wood quality, fast-growing eucalyptus trees, wood properties.

PP173

Mass and carbon accumulation in trees of *Tectona grandis* L.F. by X-ray densitometry

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The CO2 removed from the atmosphere, along with the availability of light and water to produce sugar-rich substances that are vital to the development and growth of plants. Knowing how the CO2 builds up inside the tree, the amount that is embedded in the wood annually, and the carbon that is exported in the form of wood for paper production, pulp, furniture, which can be interpreted as carbon retained and stored biomass has been investigated and questions of many researchers. So based on that context, this research aims to quantify the stock of carbon in mass and radial sections of the trunk of trees of Tectona grandis from homogeneous stands located in the city of Cáceres / MT. Were selected 15 trees under different planting densities (6x2 m, 5x2m and 4x2m), in which of the base position were removed radial sections that were used to determine the accumulation of mass from the wood density data obtained by technique of X-ray densitometry and measured the area of each ring by Software "Cell ^ F" and thickness of the sample. The accumulated carbon for each growth ring was determined based on 50% of the accumulated mass. The results showed no significant differences at 5% significance level of carbon stocks and mass as a function of tree ring growth and spacing.

Keywords: wood density, carbon and mass quantification

PP174

Wood density and growth of several native open-pollinated *Eucalyptus globulus* families and some control seedlots from a progeny trial located central-coastal Portugal.

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Mean performances are given for wood density and stem volume over-bark at 9½ years for 138 native open-pollinated Eucalyptus globulus families and some control seedlots-Indicate which seedlots were used as control?? in a provenance trial located at Óbidos, central-coastal Portugal. This trial was planted in 1989 using 402 open-pollinated families collected as seed from native stands across the range of E. globulus in Australia. Of these 402 families originally planted, the faster growing 138 have been felled and measured at 9½ years. Stem dry weight has been estimated as the product of volume (cubic meters over-bark per stem) and basic density (kg/m3).

Jeeralang and St. Pauls River-Royal George had the highest wood basic density of the native E. globulus populations studied. The Henty River and Scamander populations had the lowest wood density. Portuguese landrace E. globulus as represented by the Altri Florestal improved full-sib families and the unimproved control had substantially higher mean densities than the Jeeralang and St. Pauls River-Royal George material.

Many of the best native open-pollinated families for stem dry weight are of Cape Otway origin; highlighting the importance of this source of E. globulus.

There is no serious negative genetic correlation between growth and density. It is clearly possible to simultaneously improve both growth and wood density.

Keywords: Eucalyptus globulus, native populations, progeny trial, growth, density, dry weight.

PP175

The anatomical characteristics and physical properties of *Cordia dodecandra* wood from commercial plantations

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In this study, we determined the anatomical characteristics, and the mechanical and other physical properties of siricote (Cordia dodecandra A. DC) wood in 10-year old trees from a commercial plantation in southeast Mexico.

Five trees were collected from Campeche, Mexico, and cut to 0.30 m-long discs for transportation. Macroscopic anatomical characteristic were obtained from 7 x 15 x 1 cm wood specimens, while the microscopic anatomical characteristics were determined from microtomed fixed sections and from macerated wood, following standard methods of the Wood Anatomy Laboratory of Chapingo University. Lateral and transversal Janka hardness and the next physical properties were determined according to ASTM standards: green moisture content; normal and basic densities; and linear and volumetric shrinkage.

Siricote wood has pale yellow sapwood, while the heartwood is reddish-brown; it has diffuse -porous. Vessel elements are classified as medium and short, with simple perforation plate. Predominant axial parenchyma is paratracheal aliform confluent in bands, although there is scanty paratraqueal vasicentric parenchyma. Rays are heterogeneous, multiseriate, and classified as very numerous, high, and moderately broad. Fibers are slender, with thin walls and medium length. Based on the Runkel Ratio, the quality index for pulp production was deemed as fair. The proportion of xylem elements can be broken down into 10.0% vessel elements, 48.3% of fibers, 32.8% of rays, and 8.8% of axial parenchyma.

Mean green moisture content in siricote wood was 123%. Basic and normal densities were classified as low, and the linear shrinkage were classified as high and very high in the tangential and radial directions, respectively, while the volumetric shrinkage was classified as medium. Lateral and transversal hardness were both classified as medium.

Keywords: Wood anatomy, Basic density, Shrinkage , Janka hardness, Xylem

PP176

Quality And Energetic Potential Of The Wood Of *Eucalyptus* Sp. Clones

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ABSTRACT: Wood is a very versatile material due to the variations of your intrinsic characteristics. Several use forms can be attributed to the wood that depending on your quality. Quality is a term that should be always associated to the use of the wood and it depends on your properties. In the studies of evaluation of the wood quality, they are usually certain the most important characteristics to have given use. This study aimed to evaluate the wood quality of Eucalyptus sp. clones to your bioenergy use. For this research four clones of Eucalyptus sp. were used. The clones were selected in a commercial planting with spacing 3.5 m x 2.5 m and 78 month years old, located in the State of Minas Gerais, Brazil. Wood characteristics as the basic density, elementary chemical analysis (CHN-O), extractive, Klason lignin (soluble, insoluble and total), ash content and calorific value (gross, inferior and net) were measurement. The used sampling was in obtained disks in five relative longitudinal positions (2%, 10%, 30%, 50% and 70%) of the commercial height of the tree, considered until a diameter of 5 cm. All the disks had about 2.5 cm of thickness. The chemical analyses and to gross calorific value was accomplished with a composed sample considering all the longitudinal positions. The results indicate that differentiates significant among the available genetic materials. All the clones present potential for bioenergy production. The clone 3281 presented higher ash content, lower basic density, lignin content and volumetric caloric value. The gross calorific value didn't differ significantly among the genetic materials.

Keywords: Bioenergy, Genetic Materials, Wood Quality

PP177

Technological study from *Matudaea trinervia* wood from Puebla State, Mexico

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In this study, we determined the anatomical characteristics, the mechanical and other physical properties, as well as the machining properties of quebracho (Matudaea trinervia Lundell) wood from Puebla State, central Mexico. Two trees 27 m high, with DBH of 65 cm and 55 cm were collected from Tatahuicapan, Puebla, and cut to 1.30 m-long logs for transportation. Macroscopic anatomical characteristic in the three typical planes (radial, tangential and transversal) were obtained from 7 x 15 x 1 cm wood specimens, while the microscopic anatomical characteristics were determined from microtomed sections and from macerated tissue, following standard methods of the Wood Anatomy Laboratory of Chapingo University. Lateral and transversal Janka hardness and the next physical properties were determined according to ASTM standards: green moisture content; green, normal and basic densities; and linear and volumetric shrinkage. Machining properties was evaluated according to ASTM Standard D-1666-87.

Quebracho wood shows pale pink sapwood, while the heartwood is solid pink. Interlocked grain, fine texture, and diffuse- porous were also found. Vessel elements are classified as small, short and very numerous, with scalariform perforation plate at both ends. Axial parenchyma is apotracheal difuse, and scanty paratraqueal. Rays are heterogeneous, mostly biseriate, with presence of a few uniseriate rays, and classified as extremely numerous, high, and moderately broad. Fibers have thick walls, and are medium in diameter, and long in length. Based on the Runkel Ratio, the quality index for pulp production was deemed as fair.

Mean green moisture content in quebracho wood was 86%. Basic density was classified as high, and the linear shrinkage were classified as high and very high in the radial and tangential directions, respectively, while the volumetric shrinkage was classified as high. Lateral and transversal hardness were both classified as very high.

As far as machining properties is concerned, planning of quebracho wood was found to be fair to good, sanding as excellent, boring as poor to fair, molding from very poor to fair, and turning as fair.

Keywords: Wood anatomy, Basic density, shrinkage, Janka hardness, machining properties

PP178

Influence of Particle Size and Blending Ratio on the Physical and Combustion Properties of Fuel Briquettes Produced from Wheat Offal

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This study focused on the production of fuel briquettes from wheat offal. The variables investigated are particle size and blending ratio. The wheat offal used was sourced from Maiduguri Flour Mill (MFM). The material was sieved into fine, medium and coarse particle sizes using 1mm and 2mm wire mesh. Each particle size was thoroughly mixed with gelatinous cassava starch in ratios; 90:10, 85:15, 80:20 and 75:25 by weight. The blended material was then hand-fed into a 3.11cm x 40.50cm cylindrical mould and compressed at a pressure of 10.76kg.cm-2. In order to have enough briquettes for material testing, each production batch was replicated 10 times. The physi-

cal properties in terms of stability of the briquettes was evaluated as a function of compressed and relaxed density, relaxation ratio, moisture content and while the combustion properties in terms of %volatile matter, %ash content, %fixed carbon and heat value were also evaluated for each production

The physical properties in terms of stability of the briquettes was evaluated as a function of (compressed and relaxed density, relaxation ratio, moisture content while the combustion properties in terms of (%volatile matter, %ash content, %fixed carbon and heat value) were also evaluated for each production. The result shows that all the physical properties of the briquette were greatly influenced by particle size ($p<0.001$).In the density of the briquette, there is no significant effect of the binder level on the briquette produced but gives the highest result when medium particles size was used with the valued of 1.06g/cm3 and lowest in coarse particle 0.46g/cm3, binder level had no significant effect on briquette produced ($p= 0.281$).The EMC was best in medium particle size with the value 131.25% at 25% binder level with the value 135.63%, EMC was significantly affected by binder level. Volatile matter was not influenced by particle size and binder level at ($p=0.581$) and ($p=0.980$) respectively but has better performance in medium particle size of 4.30% at 15% with the value of 4.14%. Ash content was not significantly influenced by particle size at ($p=0.0069$) but significantly influenced by binder level at ($p<0.002$) and was preferable in medium particles of 2.40% at 10% binder level with the value 2.08%. Fixed carbon was not influenced by particle size at ($p=0.150$), also better in medium particle of 93.84% at 20% binder level with value 94.01%, while Heat value was influenced by particle size and binder level at($p=0.005$) and ($p=0.0021$) respectively, highest with medium particles of 33.52mj/kg at 20% level of binder with the value 33.59mj/kg.

It was observed that better and combustible briquette can be obtained from medium particles of wheat offal at low quantity of binder.

Keywords: Wheat offal, particle size, binder, combustion properties, physical properties, blending ratio.

PP179

Modeling Sheanut Renewable Energy Potential In Ghana

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This paper has assessed shea renewable energy potential regarded as net electrical energy generated due specified processing throughput referenced to standardized agro-process cogeneration CHP configuration. This has been done through an aggregate energy model formulation with incorporation of shea biomass material-ratios, thermochemical energy conversion efficiencies, steam generation efficiencies and typical parameters of the shea supply chain, inclusive total sheanut capacity, distribution of shea biomass and standard cogen shea process CHP data.

Results of the modeling and simulation indicates the CHP-line model, for discussed industrial shea process configuration, indicates Ghana's renewable energy potential in orders 33.93MW based on current 200000ton per annum shea-nut production; however available industrial data indicates 0% of this potential. From this model the impact of exclusion of Wshell from industrial renewable energy integration, reveals, only process heating (-11.738MW) and not CHP can be achieved. This impact is further indicated by approximately 5.66 times reduction in renewable energy potential (MW) per unit milling throughput (Kgs-1) from 8748.5MW/Kgs-1.From the CHP-line modeling, the threshold milling throughput for complete and partial shea-biomass integrating processes are respectively 8.9t/h and 50.2t/h for realization of renewable energy potential(net electrical power output).

The summary outcome of this model is the importance to reform current shea supply chain with focus on co-locating Plantations and millers with throughputs greater than 8.9t/h to facilitate full or partial realization of the country's 33.93MW shea renewable energy potential.

PP180

Anti-inflammatory Activities of Extracts from *Taiwania cryptomerioides* Hayata

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In this study, we evaluated the anti-inflammatory activities of the ethanolic extracts from six plant parts of Taiwania (Taiwania cryptomerioides Hayata) using ultrasound-assisted extraction. Results revealed the heartwood extract has the best performance to suppress nitric oxide production in lipopolysaccharide-activated RAW 264.7 macrophages, with an IC50 value of 27.8 μg/mL. Among all fractions derived from heartwood extract, n-hexane and ethyl acetate soluble fractions had the best inhibitory activity. By following the bioassay-guided fractionation procedure, eight compounds were isolated from active subfractions. Among them, taiwanin A, helioxanthin and hinokione were proven to have the best inhibitory performance on nitric oxide production, with an IC50 value of 9.80, 48.49 and 63.77 μM, respectively. These results demonstrated that taiwanin A from T. cryptomerioides has excellent anti-inflammatory activities and thus has great potential to act as an inhibitor to prevent overproduction of nitric oxide in inflammation.

Keywords: Taiwania cryptomerioides; anti-inflammatory activity; taiwanin A; helioxanthin

PP181

Recent Trends In Biomass Gasification And Gas Cleaning Technology

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Gasification of biomass is one of promising energy production technologies and the gas product contains quantities of particulates,

tars, and other constituents that may exceed the specified limits for intending purposes. The research and development on effective and efficient gas cleaning processes for removal of these contaminants as well as high efficient reliable gasifiers is essential for home and industrial applications especially in developing countries. It is imperative to know that principles of gasification along with gasifier designs will play important roles on the quality of product gases. The review provides in-depth information on the various designs of gasifiers and principles of gasification as a major factor in determining the calorific value of product gas. This paper also focuses on the recent trend in gas cleaning technologies. Applications of wet scrubbing technology, hot gas cleanup technology, catalysts and activated adsorbents to remove tar, ammonia and other contaminants are discussed.

Keywords: Biomass, gasification, gasifier, gas cleaning technology, tar

PP182

Thermochemical properties of several Portuguese and exotic woods and shrubs

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n recent years it has been attended in Portugal a constant increase in demand for forest biomass for energy purposes, which may lead to an overexploitation of these resources. Only an efficient management of biomass can ensure the sustainability of the Portuguese Forest. This can be achieved by the use of biomass resources yet unexplored (shrub component) or by producing more biomass (energy crops). The aim of this study was to evaluate the thermochemical properties of various national wood species, exotic species, and shrubs, most representative of Portugal.

With regard to the tree species, the study assessed the following national softwoods: Pinus pinaster, Pseudotsuga menziesii, and Cedrus atlantica; in the national hardwoods: Eucalyptus globulus, Populus euro-americana (cl. I-214), Salix alba, Quercus robur, Castanea sativa, Acer pseudoplatanus, Fraxinus angustifolia, Prunus avium, and Fagus sylvatica; and in the tropical hardwoods: Chlorophora excelsa, Entandrophragma cylindricum, Gossweilerodendron balsamiferum, Bowdichia nítida, and Hymenaea courbaril. As regards the shrub species (bushes), have been studied the Ulex europaeus, Cytisus striatus, Pterospartum tridentatum, Erica arborea, Erica sp., and Hakea sericea. For each species it was determined the gross calorific value-GCV (or higher heating value-HHV) and the following chemical properties: ash content, chemical composition (C, H, O, N, S), Micro and Macroelements (Na, K, Ca, Mg, Mn, Fe, Zn, Ni, Cr, Cd, Cu, P) and halogens (F, Br, Cl).

For the Calorific Value, the tropical hardwoods, national softwoods and shrubs have higher calorific value than the national hardwoods. In general it was found that tree species have low ash content (0.1% - 0.5%). The shrubs have much higher values (1.5% - 2.8%) as well as the Acer p. (1.0%), Entandrophragma c. (1.0%), and the Chlorophora e. (2.8%).

Concerning the elementary chemical composition, the different species present very similar chemical compositions. The only exceptions are the national hardwoods with lower levels of C, compared to the tropical hardwoods and the softwoods. The national hardwoods also present higher levels of O comparatively the tropical hardwoods. The fact that hardwoods have less C and more O, can explain its lower calorific value, in relation to other species. For micro and macro elements, the shrubs present levels of Na, Ca, Mg, Mn, Fe, Cr, Cd and Cu much higher than woods (sometimes more than 40X). In turn the K, P, Zn, Ni are identical between shrubs and woods. As regards the halogens, it is clear that shrubs present levels of F and Cl much higher than woods, but identical values of Br.

It should be noted that although the shrubs show high calorific value, its use as an energy source can give rise to corrosion and accumulation of ash in burning equipment, as well as the emission of toxic compounds.

Keywords: Utilization, Forestry biomass, energy, chemical properties.

PP183

Solvent Extraction of Oil from Bani (*Pongamia pinnata* (l.) Pierre) seeds

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Pongamia pinnata (L.) Pierre seeds were extracted using Soxhlet apparatus to determine which among hexane, cyclohexane, and petroleum ether would be practical to use for solvent extraction of pongam oil. The effects of seed moisture content, seed coat and grinding on oil yield were evaluated. Hexane proved to be a practical solvent choice with its high yield and lower cost per liter for sun-dried uncoated ground seeds. Hexane provided an average of 56% oil yield. An increasing trend in %oil yield with time was observed until such a point where further increase in the soaking time resulted to insignificant changes in the %oil yield. The favorable soaking time was 8 hours for hexane extraction (corresponding to 22% oil yield). Oil yield increased as the amount of solvent increased until equilibrium was reached at a seed (mass) to solvent (volume) ratio of about 1:6 beyond which changes in oil yield were insignificant. The physico-chemical properties of the solvent-extracted oil, such as specific gravity, saponification number, iodine value, and acid value were determined, showing a specific gravity of 0.92764 ± 0.0052 at 250C, saponification value of 441.8316 mg KOH/g oil, iodine value of 151.4766 mg I/g oil, and an acid value of 80.7292.

Keywords: biodiesel, Pongamia pinnata, solvent extraction

PP185

Heterologous Expression of Endo-beta-1, 4-xylanase A from *Schizophyllum commune* in *Pichia pastoris* and Functional Characterization of Recombinant Enzyme

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The Endo-1, 4-β-xylanase A, XynA, from Schizophyllum commune was cloned in to the pPCZαA and expressed in Pichia pastoris GS115. The open reading frame of xynA gene is composed 684 bp encoding 278 amino acids with a molecular weight of approximately 26 kDa. The base on the sequence similarity and predicted tree-dimensional structure, XynA belong to glycoside hydrolase family 11. The XynA was purified by Ni-NTA agarose affinity chromatography. The optimum activity of XynA was confirmed at pH 5 and 50 C on beechwood xylan, respectively. The stability of XynA was kept at pH 8 for overnight and 40 C for 1h, respectively. In this condition, the specific activity, Km and Vmax of the XynA was 5768 U/mg, 4 mg/ml and 9000 μmol min-1 mg-1, respectively. The activity of XynA was enhanced in presence of cation, such as Cd2+, K+, Na+, Li2+ and Co2+. But, in presence of EDTA, Hg2+ and Fe3+, xylanase activity was significantly inhibited. This is the first report on the heterologous expression of a S. commune XynA in P. pastoris.

Keywords: Endo-1, 4-β-xylanase; Schizophyllum commune; Pichia pastoris; Purification

PP186

Evaluation of lignocellulosic residues as bioenergy source

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Currently, the global warming takes part in the political reality and international economy and influences several knowledge areas, demanding scientific and technological development that minimizes this problem. In order to achieve this goal, the possibilities are capture, keeping, and decrease of CO2 emissions, main gas that causes greenhouse effect. It is known that the world energetic matrix is highly dependent on fossil fuels (non-renewable). Therefore, there is a need for implementation of new alternative energy sources in the energetic matrix of the countries. In this context, Brazil is highlighted for presenting nearly 50% of its energetic matrix from renewable sources, being 15,2% correspondent to hydroelectricity and 32% from several types of biomass.

This work aimed to analyze the viability of utilizing lignocellulosic residues for the production of bioenergy based on the chemical elemental analysis and to divide the biomasses in groups by the multivariate analysis techniques of principle components and grouping, besides univariate analysis. Eight types of biomass were used: Australian red cedar wood shavings (Toona ciliata M. Roem – 18 years old), pinus wood shavings (Pinus sp. - 35 years old), rice husk, sugar cane bagasse, residues from coffee process (husk and parchment), residues from maize harvesting (cob, straw, branches and leaves) and residual cellulosic pulp of bamboo (Bambusa vulgaris Schrad. ex J.C. Wendl).

The rice husk presented the lowest potential for bioenergy production due to low hydrogen and carbon content, high ash content, and low higher heating value. Although the higher heating value was statistically equal to the observed for eucalyptus shavings, the coffee husk presented high nitrogen content. This result indicates that this residue should be used for energy generation by techniques that prevent nitrogen release in the atmosphere. The other residues lignocellulosic residues presented similar energetic potential based on multivariate analysis and considering the elemental and mineral components. The grouping of the lignocellulosic residues obtained by the principle components analysis was similar to the one obtained by grouping analysis. Both multivariate techniques may be used for the selection of lignocellulosic residues for bioenergy generation.

Keywords: lignocellulosic residues; elemental analysis; higher heating value; biomass energy.

PP187

Densification of residual plant biomass

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Due to the increasing world worry about the use of renewable sources of energy, residues from several processes are pointed as interesting energetic alternatives. In Brazil there is a great production of plant biomass residues, since the country is a major forestry and agriculture producer. Therefore, there is a possibility of utilizing such residues for bioenergy generation. However, the low energetic density of residues from plant biomass makes difficulty their use. In this context, the briquetting process may contribute for the development of more homogeneous and high density energetic solid biofuels.

Therefore, this work aimed to evaluate briquettes made with coffee husk, eucalyptus sawdust and residues from maize harvesting. Moreover, the influence of time after compression on some of the properties of the briquettes was evaluated. The biomass was previously dried in a kiln and the briquettes were produced in a laboratorial briquetting machine at 120±5ºC and 15 MPa. The bulk density and higher heating value of the raw biomass were determined. After compression, the influence of time on the moisture content, volumetric expansion and apparent density of the briquettes was evaluated.

From the results obtained, it was possible to observe that the milled coffee husk presented the highest average value of bulk density. There was no significant difference in higher heating value among the biomass analyzed. Time effect after biomass compression was significant for the dry basis moisture content and apparent density for all the briquettes produced. The briquettes made with maize

harvesting residues presented great volumetric expansion. For the tension resistance by diametric compression, the lowest value was observed for coffee husk. The results found show the great potential of energetic utilizing of the briquettes made with coffee husk.

Keywords: briquettes; energetic density; volumetric variation; higher heating value.

PP188

Optimization of Galactoglucomannans and Acidic Arabinans Recovery in Softwood

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The pulp and paper industry is currently in a transition situation and needs to produce additional products which can increase both the mill profitability and the overall mill energy efficiency in order to convert mills into biorefineries. Autohydrolysis of softwood chips, used as raw material in a paper mill, was studied to simulate one of the aspects of industrial hydrolytic steps of a thermomechanical pulping process. Based on industrial process steam conditions, the operations were performed at laboratory scale. Both compositions of pulps and hydrolysates were determined as a function of the residence time and the severity of the treatment. It was found that the amount of glucans and Klason lignin in solid residues showed moderate cellulose and lignin degradation caused by hydrothermal treatment and that acidic arabinogalactans were largely affected and depolymerized, even at low severity ($\log(R0) < 2$). The percentage of residual arabinans in the pulp after hydrolysis seemed to be a good indicator of the severity of the treatment and can provide an effective guide for an industrial process optimization. A hydrolytic step performed at a severity of $\log(R0) = 1.8$ resulted in the extraction of 100% of the water-soluble acidic arabinogalactans. These polysaccharides are released and accumulated into process waters. They constitute the main part of the "anionic trash" released in mechanical pulping, which can form complexes with various cationic polymers used by the paper industry.

Keywords: Autohydrolysis; hemicellulose; thermomechanical pulping

PP189

Seed Oil and Defatted Cake Proximate Composition of Non Timber Product *Annona squamosa* (Annonaceae) Grown in Benin

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Annona squamosa L. is a small tree which grows wild in many places in the tropical regions and locally called "xwingle" in Benin. Its produces edible fruits, typically globular or heart-shaped which are highly appreciated and the seeds are much neglected. Recently, our works have started to be greatly concerned about identifying new oil sources from a large number of oil bearing seeds grown in Benin.

We report here on the chemical composition of seed oil (ASSO) and defatted cake (ASDC) of A. squamosa. Fatty acid composition, chemical properties of oil, unsaponifiable fraction, amino acids, lignocellulose and carbohydrates were analyzed by standard analytical procedures. Our objective is to update and to widen available data in order to check and confirm the interest of the seeds as a readily available by-product resulting of the consumption of the fruit pulp for human food.

The extracted lipids (33.7%) were examined for fatty acid composition by gas chromatography. Linoleic (25.4%) and oleic (47.4%) acids were the predominant unsaturated fatty acids, while palmitic acid (12.6%) and stearic acid (11.6%) were the major saturated acids. The iodine value of 92g/100g indicates that the seed oil is a non-drying type. The unsaponifiable fraction (1.0wt-%) whose composition was not investigated previously especially for the sterol fraction, the major sterol is β-sitosterol (68.7wt-%) and tocols (143ppm) show α- and γ-tocopherol as major components (26.5 and 73.5wt-%). The defatted cake is rich in proteins (25.5g/100 g), potassium, and fibers (Van Soest; NDL 60.1%, ADF 34.7% and ADL 7.4%).

This work is part of a study aiming at adding value to underused forest biomass. Next step will deal with anti-termite properties of A. squamosa cake.

Keywords: Non timber product, Annona squamosa, seed oil, defatted cake, chemical composition, Benin.

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PP190

Experimental TGA device for the determination of cellulose pyrolysis behaviour at elevated pressure

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Forestry lignocellulosic biomass is a major renewable energy sources in the world. Carbon generated by Nature through photosynthesis process, could potentially be considered as a neutral energy carrier in term of the greenhouse gas emissions, if it is produced is assured through sustainable plantations use. Cellulose is the main component of biomass (50% in weight on a dry basis in average) and its conversion into high density energy carrier like charcoal, gives relatively low charcoal yield (< 15%).

The development of more efficient conversion technologies in terms of yield of charcoal is of primary importance for both developing countries than for industrialized countries. In the first case, the firewood and charcoal are the main sources of energy to the people. In the second case, the development of sustainable energy sources

from biomass for biorefinery applications are of primary importance.

The work aims to present our first results of the cellulose pyrolysis kinetic study at Elevated Pressure by specific Thermogravimetric Analysis (TGA-EP). The aims are (i) to assess the influence of pressure on the pyrolysis reaction kinetics and, (ii) to determine charcoal yield benefit.

After a brief presentation of the TGA-EP equipment developed in the laboratory, a more detailed discussion is done about the treatment of the technical constraints like weigh measurement at elevated pressure (buoyancy). Advantage and limitation of the detailed equipment in term of result and potential studied are discussed.

A preliminary study on cellulose pyrolyis at elevated pressure is presented. The work was done with commercial microcrystalline Sigmacell cellulose type 50 (30 mg) provided by Sigma-Aldrich, for pressure conditions between 0.1 MPa and 1 MPa, and at a constant heating rate up to 1000 °C. The inert atmosphere conditions were performed by carrying in constant nitrogen gas flow rate (30ml/min). The results indicate a significant increase of the charcoal yield (>60%) compared to atmospheric condition results and suggest a significant involvement of secondary pyrolysis reactions.

Keywords: Engineered wood; wood composites; material selection; wood material science

PP191

Comparison Of Energy Value And Proximate Analysis From Raw And Pyrolysed Wood Biomass And Palm Kernel Shells

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Palm Oil processing yield a considerable quantity of palm kernel shell (PKS), which has been predominantly used as fuel through direct combustion. This form of combustion does not effectively utilize the energy potential of PKS. Likewise, the wood processing industries in Nigeria operates with efficiency of about 45%, turning out a large quantity of wood residues which are burnt off, causing environmental pollution. Therefore, this study examines the energy value and proximate analysis of raw biomass and bio-char produced from selected sawmill residues Apa (Afzelia africana) and Palm kernel shells (Elaeis guineensis) in slow pyrolysis with a view to establish the variation in their energy level and the possibility of using them as biofuel on commercial scale in Nigeria. Sawmill residues and Palm kernel shells collected in Akure Ondo State Nigeria, were converted to bio char in a fixed-bed reactor at 400o C, 600o C, and 800o C. The energy derivable at each temperature was measured viz ; Heating value and proximate value for both raw and combusted residues using AOAC 1975.The Energy value for non combusted Afzelia africana and Palm kernel shell were found to be 33.31MJ/Kg and 32.90 MJ/Kg, Ash content of 1.08% and 2.23%, Volatile matter 77.86 % and 79.32% and Fixed carbon21.06% and18.45% respectively. The proximate for combusted Fixed Carbon ranged from73.65±0.51 to 92.32±0.91 for Palm kernel shell and 56.38±0.23 to95.36±0.53 for Apa. The Volatile matter ranged from 1.29±0.52 to 22.28±0.11 for Palm kernel shell and 2.05±0.04 to 42.31 ±0.22 for Apa. The Ash content ranged from 4.07± 0.17 to 6.39±0.02 for Palm kernel shell and 1.31± 0.52 to 2.59± for Apa. The gross energy recorded for Palm kernel shells ranged from 59.72 MJ/Kg ± 1.18 to 118.53 MJ/Kg ± 1.69 and 52,52 MJ/Kg ± 1.69 to 98.39±0.41 MJ/Kg for Apa .

The higher Gross energy and Fixed Carbon recorded for Palm kernel bio-char, makes it a potential substitute fuel for domestic and industrial use where energy from wood is required to power their boilers. Also, Low Sulphur content reported for PKS by various researchers makes it an environmental friendly source of energy.

Keywords: Gross Energy, Proximate, Bio char, Palm kernel shell

PP192

Fractionation of wood by LGF organosolv cooking

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A novel Lignofibre (LGF) organosolv process has recently been developed at VTT. In this sulphur-free process, both alcohols and organic acids can be used as solvents in the presence of phosphinic acid (H3PO2). By proper selection of the cooking parameters, the LGF process is suitable for the fractionation of hardwood and softwood species, and also annual plants. Besides the cellulosic fibres, also lignin and hemicellulose fractions may be recovered. The potential target products are biobased materials as well as bioethanol and other chemicals obtained via biotechnical routes.

The yield and recovery of wood components is largely affected by the selection of solvent. LGF cooking of birch (Betula pendula) in acetic acid produces xylan-poor pulp, and only lignin can be recovered by alkaline extraction of the fibers. Acetic acid is a suitable solvent for softwood, but for hardwoods also ethanol is well applicable. In this case, less xylan degradation takes place, and also hemicellulose fraction can be recovered.

The LGF organosolv process in ethanol has been studied as pretreatment technique for bioethanol production using various Eucalyptus species as raw materials. The cooking conditions have been varied, including phosphinic acid charge, temperature and cooking time, and glucose yield in enzymatic hydrolysis has been evaluated. The cooking was followed by alkaline extraction of the fiber fraction to produce hemicellulose free fibers for more efficient bioethanol production. The LGF cooking in acetic acid has been applied to Eucalyptus, birch and pine (Pinus silvestris). In this case, the main aim was in the fractionation of the wood to recover biopolymers for material applications. The paper summarizes results obtained in two EU projects: LignoDeco (EU/Brazil, FP7-KBBE-2009-3-244362) and Afore (FP7- NMP-2008-4.0-6).

Keywords: organosolv, fractionation, fiber, cellulose, lignin, bioethanol

PP193

BISYPLAN: The Bioenergy System Planners Handbook

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One main challenge to promote a change from fossil-based energy production is to promote the development and diffusion of bioenergy systems, using available and well proven conversion technologies in combination with the abundant biomass resources.

The BISYPLAN project aims to produce a handbook which can be used as a reference and resource by those seeking to develop bioenergy projects in their regions. The handbook aims to be a guidance for anyone who needs not understand all the fundamental aspects of biomass-based energy systems but who needs a conceptual and over-all understanding. Target groups are those who are involved in planning, who take strategic decisions and who are involved in the procurement process, but who feels inferior to the consultants and suppliers during the process. The handbook aims to explain the underlying logics and properties that make biomass-based energy systems different from fossil-fuel based energy systems. The handbook aims to remove some of the most common misunderstandings still prevalent among many people who have no extensive experience of biomass-for-energy and hence to promote the installation of new biomass-based energy installations worldwide.

The project team have started content development and this should be completed by early 2012 with a plan to release the final handbook in mid 2012. The handbook will be made available on-line and will be available in English, Swedish, Italian, Estonian and Greek. It is expected that the existence of such a handbook will increase the quality of biomass system commissioning and procurement so that more planned projects get carried out.

Keywords: biomass-for-energy; handbook; bioresources

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BISYPLAN: The Bioenergy System Planners Handbook

PP194

Composition of epicuticular wax from *Eucalyptus globulus* and *Quercus suber* leaves

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Leaves of higher plants are covered by a cuticle, i.e.an extracellular membrane consisting of a polymeric cutin matrix and soluble cuticular waxes. Intra- and epicuticular waxes are embedded and deposited in this polymeric framework. In many plant species, an amorphous film of epicuticular material forms a smooth wax surface. In contrast, wax crystals protruding from the film create a microscopically rough surface on other species. The epicuticular wax forms the outermost surface of the plant, and is thus of special importance in interactions with the biotic and abiotic environment.

In contrast to cutin, the surface lipid components are soluble in organic solvents, and are called soluble cuticular lipids (SCL), cuticular waxes or surface lipids. The main fraction of these solvent-extractable waxes contains very-long-chain aliphatics, i.e. fatty acids, aldehydes, primary and secondary alcohols, ketones, and alkanes of chain lengths C20–C36, as well as C38–C70 alkyl esters. Unsaturated fatty acids, terpenoids, steroids, flavonoids and many other compounds have been also reported as minor components in waxes.

The extractable wax layer of the cuticle ranged from 0.7 to 4.5 mg/cm2 in Eucalyptus species leaves and about 125 mg/cm2 in Q. suber leaves. Wax layer in Eucalyptus leaves had previously been reported to contained β-diketones (24.7-83.0%) as major wax constituent, followed by wax esters (6.4-26.5%), n-alkanes (3.5-26.5%), fatty acids (3-15.9%), n-alcohols (0.6-11.1%) and aldehydes (0-9.2%). The main classes encountered in Q. suber leaves were n-alkanes (4–27%) and amphiphilic compounds. The major classes of amphiphilic compounds are n-alkan-1-ols (18–50%), n-alkanals (25%), n-alkanoic acids (<5%) and n-alkyl esters (25–45%).

This work quantifies, characterises and compares the chemical composition of the epicuticular wax from leaves of Eucalyptus globulus and Quercus suber. The epicuticular wax from Eucalyptus globulus and Quercus suber were extracted into dichloromethane and quantified. Their constituents were analysed, after derivatization, by gas chromatography coupled with a mass spectrometer.

Keywords: Quercus suber, Eucalyptus globulus, epicuticular wax, chemical analysis, surface composition

PP195

Potential For Energy Production From Biomass Of Alien Fast Growing Tree Species Under Mediterranean Climate

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Most short rotation energy crops used in Europe (e. g. willows and poplars) may be of limited usefulness under Mediterranean summer drought conditions. Exotic trees well adapted to summer stress, such as eucalyptus and acacias, may be more promising as biomass producers in Portugal. The area of eucalypt plantations in Portugal significantly increased over the last decades, but changes in the international pulp markets may compromise its use and economic value. A reasonable knowledge on biomass production and management options in eucalypt coppices is already available and may become a key factor on their conversion to bio-energy production. Acacias are an environmental problem in several areas of Portugal due to the invasive character of some species. These species are not allowed in plantations and the restrictive law recommends their

control through large scale plans. The use of their wood for energy may be an alternative to reduce the costs of eradication.

The aim of this research consists in the improvement of knowledge on the potential of woody species well adapted to Portuguese summer drought as energy crops under Mediterranean climate. Seedlings of Eucalyptus globulus clones with high biomass production will be acquired and used as a reference. Acacia melanoxylon, A. pycnantha and A. dealbata, frequent invaders of abandoned fields and coastal sand dunes, will be privileged as target invader species, based on literature referring their biomass production performance and, in the case of A. melanoxylon, owing to its ability fort fast growth and high dimension at maturity. Aiming the establishment of a controlled experiment, these species were propagated in nursery from seeds collected in existing Portuguese stands.

We will present the first results of above-ground biomass production, energy yield and energy balance for each species in field trials for biomass-for-energy installed in BionergISA - the bioenergy field installed in Instituto Superior de Agronomia.

Keywords: Acacia; biomass; energy; Eucalyptus globulus

PP196

Effect Of Summer Drought In The Potential Of Native Tree Species For Energy Production From Biomass Under Mediterranean Climate

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Bioenergy is an important renewable energy source for Europe and a key choice to mitigate greenhouse gas emissions and replace fossil fuels, but little work has been published on energy investment in crop management and harvesting processes. Commercial use of short rotation woody crops for energy is still low in EU, because using available wastes is less expensive per unit of energy produced. Nonetheless, due to the limited potential of residues and wastes, the use of large scale energy crops should be developed and knowledge on its characteristics and limitations improved. Under Mediterranean climate, the characteristic summer drought may be one limitation to the usefulness of most EU woody crops. The aim of this experiment is therefore to assess the potential to biomass-for-energy production of some native species and their crop energy balance under the Portuguese Mediterranean climate with and without irrigation during summer drought.

Common species of poplar (Populus alba) and willow (Salix atrocinerea) will be compared with i) the traditional Miscanthus giganteus energy crop, ii) Retama sphaerocarpa, an endemic legume shrub well adapted to summer drought, iii) coppices of Eucalyptus globulus, a fast growing tree species widely cultivated in Portugal for pulp and a possible alternative for bioenergy, allowing to the dependence of its economic value on international pulp markets.

Plants of willow and poplar were produced in nursery from stem cuttings obtained in natural communities, and Miscanthus giganteus was established from root cuttings from experimental plots already installed in BioenergISA – the bioenergy field installed at the campus of the School of Agricultural Sciences of the Technical University of Lisbon. Seeds of Retama sphaerocarpa were collected in the wild within the same campus and methods to break seed coat dormancy were applied, aiming to optimize seedling production in nursery, both in quantity and vitality of plants. Seedlings of Eucalyptus globulus clones with high biomass production were acquired in the Portuguese seedling market for the species.

We will present the first results of different methods used for optimizing seed germination and cutting sprouting in nursery, and on early above-ground biomass production of each species in field trials for biomass-for-energy installed in BionergISA, both irrigated and rain fed.

Keywords: biomass; Eucalyptus globulus; Miscanthus giganteus; Populus alba; propagation; Retama sphaerocarpa; Salix atrocinerea

PP197

Eucalypt residual stumps as fibre raw-material for pulp in biorefinery context

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Nowadays the discussions about integrated biorefineries in pulps mills considers pre-extraction of hemicelluloses before the traditional pulping process. Currently, tree stumps are emerging as woodfuels feedstock for energy production. The stump is the basal part of the tree, including the near-the-ground stem portion and the woody roots that remain after stem felling. It is the oldest part of the tree, therefore enriched in heartwood reaction wood and cicatricial tissues, with a higher content in extractives and polysaccharides. E. globulus in Europe plantations are managed as a short-rotation coppice system, with 3-4 rotations of about 9-12 years. The belowground biomass represents 25% of the stand aboveground biomass, being on average 40-60 ton.ha-1 of stumps biomass in commercial stand of E. globulus. Most of the available stumps come from commercial plantations with high biomass growth, frequently managed in coppice systems, and reforested when productivity achieves its economical limit. In the past, the stumps were uprooted and destroyed, and the biomass spread or incorporated in the soil. Today, the process sequences involves: in the field (cleaning and grinding) and in the conversion plant (chipping and cleaning), in order to prepare and convert the stumps in chips with the necessary quality for energetic conversion. Research for new applications, in particular those more economically advantageous, is still a demand in order to exploit this source of forest residues.

In this study it was investigated the use of E. globulus biomass stumps (harvested in six different sites) as raw-material for pulping integrated in biorefinery context. Different pulping process Kraft and ASAM with autohydrolysis as pre-treatment were studied in order to release the hemicelluloses that becomes available for others biorefineries applications. The determination of total yield, intrinsic viscosity, kappa number and chemical composition of the autohydrolysis liquor was also performed.

The value of the total yield of the stumps biomass collected in different sites ranged between 40-45% for kraft pulps and 46-51% for ASAM pulps. The chemical analyses of pulps, in particular the kappa number of the stumps pulps presented values ranging from 9 to17

and 30 to35, respectively kraft and ASAM process. The autohydrolysis liquor was characterized by an average of 16 % in xylose and 1.4 % in furfural.

Keywords: E. globulus; stumps; biomass; biorefineries; kraft; ASAM

PP198

Optimization of forest biomass use in reducing green house gas emission: a life cycle analysis

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In this study, we discuss the greenhouse gas emission reduction from sustainable harvest and utilization of forest residues and stumps. Forest production, harvest, and use of forest residues and stumps to replace fossil fuels are considered for greenhouse gas emissions accounting in northern Sweden.

A system-based approach to life cycle assessment is adopted to calculate greenhouse gas emission reduction benefits. Amount of forest biomass production and harvest for one hectare of forest land in northern Sweden are obtained from DT model. Amount of wood processing residues recovery is obtained from the wood processing in the wood industries. Greenhouse emissions during silvicultural activities and transportation of products are considered in calculation. At the same time the greenhouse gas reductions in terms of carbon sequestration in biomass and soil, stocks in forest products, and reductions by substituting fossil fuel and non-wood materials are accounted. System boundary is expanded to replace fossil fuel use by the use of forest biomass as feedstock for bioenergy production. Sensitivity analysis for biomass recovery is performed to see the implications in greenhouse gas emission reductions.

The results of the study have shown that the use of forest residues for energy has increased during the past two decades and further increase is expected in future. Harvest of forest residue does not significantly decrease the soil carbon pool if the forest is regenerated subsequently. Use of forest residues to replace fossil fuel will provide significant greenhouse gas emission reductions compared to the soil carbon development if it is left in the forest. Allocating some biomass to be used for pulp and paper production does not significantly change the overall carbon balance in this study. However the results may depend on the forest biomass production rate and forest biomass harvest rate.

Keywords: Forest production, DT model, harvest, bioenergy, substitution.

PP199

Lignocellulosic Resources Uses for Savings of Fossil Fuels

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Lignocellulosic biomass makes up the main part of the biomass produced in the world (12.1011 ton per year); relatively speaking, saccharose and starch make up a lower part (108t). Wood (from secondary-growth species) and related biomaterial from primary-growth species (palms, coconut, bamboo) make up nearly 80% of lignocellulosic biomass produced in the world.

The remaining part mainly comes from co-products of food plants (straw and co-products from cereals and oleaginous plants, bagasse…) and also annual plants produced for fibre (cotton, flax, hemp).

A part of these fibres is used for other various applications than energy: pulp, biomaterial, and bioproducts. The wide range of celluloses-lignin-hemicelluloses distribution and structure of these biopolymers sometimes limit their applications.

The development of these applications is also limited by two factors: (1) the collection and the transport of the fibres are not well organized; (2) the fibres must be frequently left on the ground after harvesting in order to maintain the soil fertility. Lignocellulosic materials play a major role to save fossil fuels for three main reasons: (1) their elaboration and their use need a low quantity of energy, by comparison with other materials; (2) lignocellulosic materials capture carbon during plant growth and store it during the life cycle of the manufactured products; (3) savings of energy are also possible when the biomaterials are used on the spot instead of imported materials, without long transport distances.

It is economically interesting to produce energy from lignocellulosic biomass only if a part of this biomass is used as far as possible for higher added value applications, i.e. plant materials.

Co-products and by-products used for energy are then obtained at lower cost.

Lignocellulosic materials and energy applications are directly linked due to carbon storage in biomass that is used for energy at the end of life cycle.

Keywords: Lignocelluloses; Energy; Carbon storage; Plant Materials

PP200

Characteristics of Bi-functional Acidic Endoglucanase (Cel5B) from *Gloeophyllum trabeum*

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The endoglucanase (Cel5B) from the filamentous fungus Gloeophyllum trabeum was cloned and expressed in Pichia pastoris GS115.

The DNA sequence of Cel5B had an open reading frame of 1077bp, encoding a protein of 359 amino acid residues. The recombinant Cel5B protein displayed a molecular mass of approximately 47 kDa on SDS-PAGE analysis. The Cel5B protein was acidic and mesophilic in nature. Cel5B was efficient under acidic conditions of pH 3.5 at 55°C, and showed the characteristic of both endo- and exo- type cellulases, acting on carboxymethylcellulose (CMC) and β-glucan as well as filter paper. A comparison with other endoglucanases and cellobiohydrolase at optimal conditions, the purified recombinant Cel5B showed very high specific activity, about 80–1000 times and 20–50 times on CMC and filter paper, respectively. Based on the mutational analysis, Glu175 and Glu287 represented active-site residues. Both residues lost full hydrolytic activity when replaced with other amino acid.

Keywords: Gloeophyllum trabeum; Endoglucanase (Cel5B); Pichia pastoris

PP201

Import demand function for writing and printing paper in Iran

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Writing and printing paper is primarily used for publication of magazines, catalogues and books (textbooks, notebooks and exercise-books). Therefore the growth in demand for this grade of paper is highly influential on overall economic situation, especially the performance of advertising, and commercial printing and educational writing and printing. Due to the lack of suitable raw material and consequently undesirable investment in Iran, this industrial sector has not been able to satisfy the growing domestic demands and therefore considerable volume of writing and printing paper was supplied through imports. Total domestic consumption for writing and printing paper in Iran has grown since 1981 to 2008 at a rate of annual 8.5%. During the past three decades writing and printing production has grown the least, but import of this Product has grown at a strong rate .The average annual growth rate of import demand is 11.8. it is obvious that the trends of consumption and import of writing and printing paper is similar for the period 1981-2008%, Therefore, from the economic point of view, studying the country's demand for import and monitoring its evolution over the time, is an important issue that merits careful examination. This study investigated the factors that affect the import demand for writing and printing paper in Iran. Data used in the time series analysis covered a period of 28 years from 1981 to 2008.Double-log linear function was used to analyze the import model and the coefficients were evaluated using ordinary least squares model(OLS). Prior to estimation, Augmented Dickey Fuller (ADF) test was applied to investigate the stationary character of the data. Five categories of explanatory variables were hypothesized to determine import demand: domestic and imported prices, consumption and production quantities of writing and printing paper ,Iran's national income. All of the variables were in the first lagged form .The results indicate that the lagged domestic and imported prices of writing and printing paper are completely effective on its import demand .Demand for import of writing and printing paper is a function of lagged consumption and production quantities of this product .National income of Iran does not affect on demand for import of writing and printing paper. Writing and printing paper is an essential good for its consumer and consequently with respect to shortage of domestic production, the consumers with any level of income apply for acquiring this product .So, writing and printing paper imported plays main role in satisfaction of consumers' requirements and consumption structure and the dependence of Iran's writing and printing paper is very high. The impact of explanatory variables on import demand for writing and printing paper are consistent with economic theories.

Keywords: Writing and printing paper, production, import, function, demand, consumption ,OLS

PP202

Green Jobs in the Forest Sector Supply Chain

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The term "green job" is a relatively new definition that defines employment activities that are likely to have occurred since the beginning of human existence. The push to identify, to quantify and to drive the growth of these jobs has recently been brought on by climate change and the depletion of Earth's natural resources. For the purposes of this study, seven "green job categories" were used: 1) Education, Public Awareness, and Compliance, 2) Energy Efficiency, 3) Green Certification, 4) Greenhouse Gas Reduction, 5) Pollution Reduction and Cleanup, 6) Recycling and Waste Reduction and; 7) Renewable Energy.

In order to obtain information on green jobs in the Louisiana forest sector, a mail survey was administered to the known population of the Louisiana forest sector supply chain. Member sectors included loggers, primary producers (e.g. lumber, plywood, paper), secondary manufacturers (e.g. furniture, flooring, millwork), and brokers/distributors. The study did not include forest landowners or small retailers. The main objectives of the study were to classify and quantify current and future green jobs in the Louisiana forest sector and to develop an understanding of supply chain member attitudes and behaviors in the context of green jobs.

Results indicate that a wide array of green jobs exist in the industry. Each green category is well represented and overall, respondents consider 13% of employment in the sector to be green. Additionally, respondents forecast that 17% percent of employment in the forest sector supply chain will be green in five years. Increased profits, government incentives and regulations and public perception were reported to be likely drivers of green job creation. Respondents claimed to have a clear understanding of the term "sustainability" while there were misconceptions about the term "green jobs" and their potential impacts on the industry. Study results suggest that education and, potentially training would benefit forest sector members that wish to continue or increase participation in the green jobs arena.

Keywords: Green jobs, forest sector, Louisiana

PP203

Economic Impacts of Forest-based Energy Production

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The long term success of bio-based facilities and subsequent markets is dependent, in part, on the level of commitment of feedstock from the forest industry. The forest industry offers a variety of feedstock ranging from in-woods, pre-merchantable roundwood or harvest residues to sawmill residues such as bark and sawdust capable of sustainably supplying the emerging biomass industry and its markets. This inherent demand for a sustainable supply of biomass feedstock will challenge forest landowners to adopt innovative practices and commit some of the abundant endowment of natural resources to a multitude of possible revenue streams. They will also be asked to embrace government programs in support of bio-based production. On the supply side, it is important to understand forest landowner knowledge and attitudes towards biomass technologies and initiatives and on the demand side energy producers need to ascertain supply availability.

In addition, economic development planners, lawmakers and other policymakers need to evaluate the economic impacts of different business proposals that are brought before them. We examined the economic impacts of using wood for electricity generation and pellet manufacturing in Louisiana and Mississippi, part of the "Wood Basket of the South." For this study we first estimated the direct expenditures on constructing the plants and plant operations. However, the total impact on the economy is not only limited to the direct expenditures. When workers at the plant or construction site receive wages, they spend a portion of those wages in the local economy. Likewise, local business will directly receive additional sales from the plant's construction and later operations. In turn, additional rounds of businesses and workers will benefit from this injection in the economy. Like a rock dropped in a pond, an economic injection ripples throughout the economy to create additional rounds of spending. Input-output analysis provided a method of quantifying the total economic impact of an economic injection on the local economy.

Keywords: Forest biomass, energy, pellets, electricity, economic impacts

PP204

Consumer perspectives on perceived environmental and social responsibility of wood products and suppliers in Finnish markets

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Previous literature indicates that today's consumers often perceive an additional benefit associated with responsible business practices and sustainability of purchased products. Regarding wood products, the environmental quality has been found in a previous study to be a part of the total product quality. Despite that over 40% of the production of the Finnish sawmilling industry is consumed domestically, there is still lacking knowledge on consumers' attitudes towards socially and environmentally friendly product attributes. To fill the gap, we address in this paper two questions: first, what does consumers' perceived environmental and social friendliness of wood products consist of, and, second, do identified dimensions in environmental and social responsibility help to explain consumers' self-declared willingness to pay for environmentally and socially responsible product features? In discussion section, we explore from the managerial perspective, how the detected importance of wood products' environmental and social features be used in developing marketing these products. Our data consists of interviews with 227 Finnish adult consumers during 2004-2007 as exit data from home retail centers selling building materials. Perceived environmental and social responsibility of wood products was found using exploratory factor analysis to be a two-dimensional construct consisting of (1) general issues within environmental and social responsibility and (2) specific issues reflecting consumer needs for product safety. These dimensions were also found in logistic regression analysis to explain consumers' self-declared willingness to pay. The results also indicate that the environmentally most conscious group can be profiled with gender (female), older age and summer cottage ownership, while the level of education, forest ownership, professional status or housing type do not seem profile consumers with higher sensitivity to environmental and social product characteristics. Since perceived supplier characteristics associated with environmental friendliness were found to be linked with both domestic origin of wood and company ownership, there seems to be some scope for strengthening wood products marketing based on the concept "Made in Finland".

Keywords: wood products, consumer, environmental and social responsibility, market segmentation, Finland

PP205

Barriers and Opportunities of Service Innovation in the Finnish Forestry

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Previous research on Finnish forestry service markets has heavily focused on the challenges arising from the external market environment, as well as modeling and forecasting timber selling behaviour of non-industrial forest owners (NIPFs), that the industry is dependent on. In this research we aim to create better understanding of marketing of forestry services covering the whole array of service assortment offered for the NIPFs . Since these services hold a substantial potential in the development of new service businesses, they are of core interest to the creation of new dynamics in the Finnish forestry. The broader theoretical objective is to examine and systematize the processes of service innovation in the context of Finnish forest cluster and its service activities. Based on the concepts of service-

dominant logic and dynamic capabilities, the empirical objective of the project is to describe existing and potential service business models. This research contributes to an improved service dominant logic based system, where customer value is created broadly at the level of whole network of actors. Using qualitative approach and 13 + 9 thematic expert interviews in service organizations, we will be able to analyse the main barriers and opportunities for creating new service innovations in the market.

According to our results, the ongoing structural changes would offer an excellent opportunity to change traditional mindsets in the established organizations. However, established organizations want to dominantly secure their current field of services as driven by timber procurement needs. Lack of medium-sized companies creates a hole in the market and has evidently made it difficult for small companies to grow. Although many services are already supplied by networks of service organizations, it seems that all the potential within value networks has not be utilized. In the Finnish forestry, a great deal of public resources has been devoted for activating passive forest owners to increase their propensity to sell timber. While the share of these passive forest owners is on the rise due, it makes it difficult to optimize industrial raw material flows, keeps the transaction costs high and is inefficient in transmitting quality based customer information through the value chain. From institutional perspective, the new business opportunities are therefore heavily dependent on the foreseen EUs requirements for free competition which may likely change the financing base of public organizations in the Finnish forestry services. While the emerging market-based organizations could partly fill the gap by developing more extensive service offerings, the smallest NIPFs constitute the least lucrative market segment, consequently being served with the least developed service offerings and neglecting their specific needs. From managerial perspective, focusing on them could facilitate also fostering new business start-ups as well as enhance strategic capabilities and competitiveness of the established firms.

Keywords: value-chain; forestry; service innovations; service dominant logic, value co-creation

PP206

Shocks of oil price and exchange rate (USA$) on the Iranian point of paper and paper products

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Iran is second largest producer within the OPEC (Organization of the Petroleum Exporting Countries). Paper products are strategic commodity in Iran. Paper products ply important roles in the structure of countries economy. Therefore, the basic of questions as fallow: What is the effect of Shocks of oil price and exchange rate (USA$) on the Iranian point of paper and paper products? Since, the research methodologies are analytical and estimation and Vector Auto Regressive (VAR) and Impulse Response Functions (IRF) were used.

Econometric criteria were showed that point of paper and paper products had related to USA dollar price and then OPEC reference basket price. If crude oil price is increase, point of paper and paper products will increase in next year. Shocks of OPEC crude oil price on the point of paper and paper products were diverged, but the shock of USA dollar price hadn't effected on the paper point.

Keywords: point of paper products; VAR; IRF; price of OPEC crude oil; USA$ exchange rate.

PP207

Implications of the 2008 Lacey Act amendments: Insights from the Wood Products Industry

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Export-oriented illegal logging has been recognized as a major global problem in environmental, social, and economic terms. It does not benefit the community or government that should be benefited by its own natural resources. The emergence of policy initiatives targeting illegal logging are considered to have the potential to increase the competitiveness of legally sourced tropical timber products by removing cheap illegal products from the market of the consuming country. The US Lacey Act amendments of 2008 were put in place to set a precedent for the global trade in plants and plant products by putting in place powerful incentives for US wood products importing companies to demand legally sourced and traded wood.

This research addresses how the 2008 Lacey Act amendments have been utilized by the US wood industry, and how those affected by the amendments view the future of environmental policy and global illegal logging as impacted by the amendments. According to this research, most US wood importers have made small changes to their operational practices, and many suggestions for change regarding policy implementation. These suggestions include an increase in communication between the US government and US wood products companies.

Keywords: environmental policy, US wood imports, the Lacey Act, US forest products industry, global illegal logging

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PP208

Perceived Benefits and Constraints of Forest Certification: A Comparative Study between FSC and PEFC Holders in China

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Forest certification is widely perceived as a market-based tool to promote sustainable forestry and has far-reaching impacts in transforming land-use practices, business practices and consumer be-

haviour. In China, both certified forestland area and the number of chain-of-custody companies have been growing fast over the past decade. It is estimated that at least 2% of forests in China will have been certified by the end of 2011. This compares to less than 1% as of 2010. The total number of chain-of-custody companies increased by 10 fold between 2006 and 2011 to reach 2,000.

In terms of market share, Forest Stewardship Council (FSC) is the leading scheme thanks in large part to support from international NGOs and global retailers. However, many challenges, including, supply bottlenecks, low market incentives, as well as looming institutional barriers, may limit FSC's future growth potential in the country. By comparison, the other two schemes - the Programme for the Endorsement of Forest Certification (PEFC) and the Chinese Forest Certification Council (CFCC) standards, which are supported by different interest groups, are increasingly popular with many perceived advantages such as low cost, relatively sufficient raw material supplies and government support which are key success factors for doing business in China. It is expected by many that PEFC's future endorsement of CFCC will provide further synergies for both schemes to grow in China and internationally.

Building on a previous study on FSC in China, this study is further developed to investigate perceived benefits and constraints of forest certification by comparing current FSC-CoC companies and PEFC-CoC certified companies in China, with data to be collected from expert interviews and a structured survey. Managerial implications will be discussed.

Keywords: China, forest certification, FSC, PEFC, CFCC, market, benefits, constraints

PP209

Market Impacts of the European Union's Forest Law Enforcement, Governance and Trade Actions

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The EU established the Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan in 2003 in order to eliminate the trade of illegal forest products with the EU Member States, and to reduce illegal logging and its subsequent impacts on deforestation. Voluntary Partnership Agreements with tropical timber producing and exporting countries are in place and more are being developed to create new trade channels into the EU for timber licensed for legality. The EU Timber Regulation is scheduled to be mandatory in 2013 and will require EU timber trades to ensure the legal source of their wood and paper products. The EU established the EU FLEGT Facility at the European Forest Institute, and within the Facility, market and trade analyses are conducted to prepare the Action Plan activities. This presentation will focus on the current and anticipated marketplace impacts of the Action Plan.

Keywords: forest products, forest products markets, forest products trade, FLEGT, illegal logging, illegal trade, wood and paper products, FLEGT, Voluntary Partnership Agreements, EU Timber Regulation.

PP210

Communicating with environmental performance measures: qualitative study on the perspectives of the Nordic wood industry

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Since the 1990s, the availability and use of environmental performance measures (EPMs) on wood products and production processes have become increasingly common in marketing products in environmentally sensitive European markets. The key role of environmental issues is more generally recognised, but there have been no studies analysing the use of EPMs from a multi-country perspective. The purpose of this study is to fill this gap by examining how companies in the Finnish, Swedish and Norwegian wood products industry currently employ EPMs; what are the driving forces to the use of EPMs; what communication channels are used to address which target groups; and by proposing new ways to develop environmental communication in the future. Other issues addressed are identifying customer segments or stakeholder groups with opportunities for use of EPMs in the marketing of products; and whether the growing pressure towards environmental performance is driven by customers, competitors or other stakeholder groups?

The primary data for this study of Finland, Sweden, and Norway was collected by conducting 41 thematic interviews in 2011 with professionals and experts in the wood product value chain, mainly sawmills and their business-to-business customers. The data was processed using content analysis and theory driven thematisation.

According to our results, the most useful environmental performance indicators in the wood industry were thought to be forest certificates (PEFC, occasionally FSC) and the Nordic Swan Ecolabel. The bigger companies have also in many cases implemented environmental management systems (ISO 14001). By contrast, the use of environmental product declarations (EPDs) was relatively uncommon. Within the domain of environmental communication, ecological aspects, recyclability of wood, sustainability of forest management practices, and the origin of wood were most commonly emphasized, uniformly towards all identified customer groups. The main drivers for use of EPMs were customer requirements (particularly in certain export markets), internal information needs, and strategic decisions to act responsibly. There are also increasing information needs from e.g. institutional builders in certain markets, chiefly the UK. Competitive pressures from producers of wooden or other products play a minor role. In the future, companies expected a growing use of product specific Life Cycle Assessment (LCA) tools and EPDs, as driven by the requirements of green building systems currently being implemented in the Nordic countries.

PP211

Business and environmental performance in wood product industries

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Evaluation of an organisation's performance is generally based on four main areas: cost, quality, time and service, but environmental performance (EP) has been suggested as a new dimension of operations performance. Environmental considerations have also filtered into marketing and supply chain management. However, the actual content of EP is usually unclear. In this paper we discuss on different definitions of EP and provide our understanding of the relevant typologies and uses of EP measures in wood product industries. Analysis is based on scholarly literature on EP measures as well as on observations form state-of-the-art in use of EP in wood product industries.

Business literature on EP classifies measures in process/output and internal/external dimensions. Multi industry studies also rely on resource based theory and get some support to use of EP in a proactive manner for the capability of a firm. The gains of those strategies are usually obvious compared to reactive ones, that usually present obedience of legislation or standards. The studied measures are usually process oriented; either end of pipe or managerial tools, whereas the product related, usually reactive, environmental measures have gained less attention. However, wood has an inherent environmental property that makes it easier for the industry to apply reactive measures like Sustainable Forest Management (SFM) certificates and negative foot printing. Consequently, environmental labels are used in wood product consumer markets to show sustainable origin of the material and positive climate impact but also introduced as a CoC measures in B2B markets.

Information passed to the stakeholders is conditional to companies' selections for their environmental strategy. Thus environmental communication closes the loop between stakeholders and operations management of the firm. Previous studies have concluded that willingness to pay a premium for the forest certification is low. Also, SFM certificates are "wood only" measures, not comparable with other materials. To gain comparability, some SFM certificates have already taken actions toward better integration with more general eco labeling schemes. In B2B markets, the construction value chain appears critical and generally underutilized opportunity. Industry should contribute actively to development of green building certificates, to take account fully the negative footprint of wood in construction.

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PP212

Readership Survey of the UNECE – Forest Products Annual Market Review

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The Forest Products Annual Market Review (FPAMR) has recently seen its 100th edition in print, remaining a priority publication for the Timber Section of the United Nations Economic Commission for Europe and the Food and Agriculture Organization.

Between August 01 and September 15, 2011, the Markets & Economics Group at FPInnovations carried out a web-based survey with the e-mail list maintained by the Timber Section. To quote Ján Kubiš, Executive Secretary, United Nations Economic Commission for Europe, the objective of the Review is to "provide factual, up-to-date and neutral analysis of market and policy developments and providing stimulus for meaningful policy discussion in international forums". The intent of this survey is to help ensure that this objective continues to be met, and to offer recommendations for improvement.

355 usable responses were collected, yielding a response rate of 14%. Virtually every UNECE country was represented, with 35.1% of the respondents from research and development institutes (including universities), 26.1% government, 12.3% industry, 11.2% non-government organizations, , 0.7% students and 14.5% other.

Valuable feedback was obtained around the nature and quality of the existing FPAMR content, including thoughts around creating on-line, interactive interfaces for more detailed information sources / discussion forums.

Keywords: UNECE; FAO; Forest Products Annual Market Review; market trends; softwood and hardwood lumber; structural and non-structural wood-based panels; engineered wood products; value added wood products; pulp and paper; bio-products; forest policy.

Gaston and Robichaud, FPInnovations

PP213

Global Forest Certification – A Spatiotemporal Assessment of its Future Potential

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By 2011 almost 10% of the global forest area has been certified by one of the major schemes. During the past 2 decades, forest management certification developed from a pure marketing tool towards an instrument that might help fighting illegal logging and hence contribute to REDD activities. Moreover, forest certification serves meanwhile as a template for a couple of other certification efforts for commodities such as sustainable biofuels or palmoil. However, the increase of certification slowed from exponential to linear growth during the past decade and from a global point of view we find a rather uneven split of the total certified area. In contrary to the original idea of forest certification, the majority of certified forest area did not develop in the tropics or the southern part of the hemisphere. Only 11% of the globally certified forest area can be found in the southern hemisphere and 89% is located on the northern half of the globe. This article aims at providing a detailed spatiotemporal overview of the development of forest certification and chain of custody certification. GIS methodology is used to analyze and visualize original as well as meta data from the certification schemes over the past 2 decades in order to identify drivers of certification and derive an outlook on a potential future development including the assessment of the potential of forest certification to contribute to avoiding deforestation. First results indicate that key parameters for the future development are seen in the governance of i.e. tropical countries as well as in supporting activities such as the European FLEGT initiative or on the legislative side the LACEY Act of the US. On the other hand the consumer in developed and especially in the BRICS countries will have a strong influence on the future success and increase rate of forest certification.

Keywords: Forest Management Certification, Chain of Custody Certification, Spatiotemporal Analysis, GIS, Global Data Analysis;

PP214

The effect of price volatility of OPEC crude oil and USA dollar on Iranian point of wood products

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OPEC (Organization of the Petroleum Exporting Countries) reference basket price and USA dollar exchange rate to Rial affected Iranian economic growth. Their price volatility can have an effect on the wood industries prosperity or depression. Therefore, the basic of questions as fallow: What is the price volatility of OPEC crude oil and USA dollar on Iranian point of wood products? Since,

Econometric methods such as; estimating equations, Vector Auto Regressive (VAR) and Impulse Response Functions (IRF) were used.

Our results were showed that relate between points of wood product with USA$ exchange rate to Rial better than OPEC reference basket price. Results of Vector Auto Regressive revealed that if OPEC reference basket price is increase, point of wood product will increase in next year. Response of wood product point to oil price impulse was divergence and their relationship was positive. Result of exchange rate volatile cause was not increasing of wood product point. Volatile of wood product point from exchange rate will disappear in ten next years.

Keywords: point of wood product; VAR; IRF; OPEC reference basket price; USA$ exchange rate.

PP215

Roundwood Pricing Mechanism for Higher Quality and Value

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Roundwood trade in Finland is based on unit prices for harvested timber assortment; most often these timber assortments are saw logs and pulpwood, from which the former is the higher value product. However, added value of saw logs is greatly dependent on the dimensions and quality of the logs; thicker and longer logs produce higher quality sawn goods with lower production costs. The pricing of timber assortments offers incentive to produce saw logs rather than pulpwood, but it does not encourage producing higher added value saw logs.

Roundwood pricing mechanism based on timber assortments leads to several drawbacks. Harvesting companies are expected to maximize the volume of saw logs even though this would compromise the desired distribution of log lengths and diameters. One unit price for all saw logs leads to shorten optimum rotation age leading to lowered ability to pay from rawmaterial. Several buying bids with different dimension and quality requirements are impossible to compare.

The optimal pricing mechanism is related to sale type (standing sales, roadside sales or delivered sales), but in general, the optimal pricing mechanism should include the following aspects: It should not restrict the optimization of raw material usage, it should be transparent and easy to understand and it should offer incentives to grow higher quality raw material.

In the study, five pricing mechanisms for clear-cutting stands were tested: timber assortment pricing, weighted timber assortment pricing, stem pricing, fractional stem pricing and log length/diameter based price list pricing. The pricing mechanisms were analyzed by their flexibility in different marketing states, by their transparency and understandability and by their ability to reflect value added in to stumpage prices.

Keywords: Roundwood; pricing mechanisms; quality

PP216

Dynamics of Lac Market in India: II. Lac Prices at Growers Level

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Sustainable development leads to social sustainability, and is one of the multi-faceted dimensions of sustainable forest management. Lac cultivation is an age old occupation in tribal dominated states of India. Lac products provide all the coloring materials for dyeing textiles, preparation of cosmetics, paints and foodstuffs and is produced by an insect Laccifer lacca (Synonym: Kerria lacca; super family Coccoidea). There are about 160 tree species that serve as host but mainly reared on Zizipus mauritiana, Schleichera oleosa and Butea monosperma in India. Two strains- kusumi and rangeeni are prominently cultivated in India and both differ in their seasonal cycle. Many thousands of people are dependent on lac cultivation in India for the sustenance. Therefore, the prices of sticklac in local markets that farmers are getting and its dynamics are important considerations for sustainable development of forestry. Lac is produced by farmers on their own land or in forests and brings to local markets for selling. Periodical surveys were made for local prices in such 41 major lac markets in four tribal dominated states viz. Jharkhand, Chattisgarh, West Bengal, Maharastra and one district in Uttar Pradesh from 2006-07 to 2009-2010 and the data was analyzed statistically. Much of the variation observed in bimonthly prices was ascribed to seasonal harvesting rather than prices themselves. Prediction of price movement of mean sticklac prices was carried out for next five years by regression method on linearity between export performance and current market dynamics which indicates steady prices for sticklac in local markets. However, there was a slight decrease in prices at later stages and the coefficient of determination suggested the robustness of the prediction model (R2= 0.53). Similarly, prediction of local market fluctuations on current trend scenario suggest that they will remain in future also (R2= 0.44). Regression of exported lac products from 2003-04 to 2009-10 predicted a steady export performance for next five years assuring retention of current domestic price trend. The demand in international markets for lac products will remain steady and may slightly increase due to awareness of consumers to use natural products in place of synthetic products due to their non-hazardous nature on human health and environment. Therefore, there is a need to enhance and refine lac management techniques including pests, diseases and predators by development of integrated pest management program since use of excessive pesticides may affect the quality of sticklac. Mean time cultivation of lac in plantations is proposed which highly economically viable. In the meantime, fluctuations in prices at the local markets must be minimized through proper market interventions to ensure better prices for growers.

Keywords: Local market prices, Export of lac products, natural products

PP217

The market power in the log and lumber import in Japan

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Japan is purely an importing country of forest products, and it does not export, although it has plenty of forestry resources. Moreover, the leading forest products exporting companies are often demand-oligopolistic in the factor market and supply-oligopolistic in the product market and therefore, these oligopolistic companies may have a strong market power in the trade market. The possibility of incomplete competition in the Japanese wood import market can be also observed from the fact that the structure of imports of logs and lumber in the past 10 years is unchanged, although the shrinking of the domestic market has reduced the entire imports. However, there is limited empirical economic analysis of the timber trade market to support the abovementioned aspect.

In this study, by employing the Residual Demand Model, we use the import data between 1988 and 2010 to measure the market power of the primary export countries such as the United States and Canada for every main item exported to the Japanese log and lumber market. The measurement targets are softwood logs, other logs, lumbers, and the lauan. The items of softwood logs include the import item of Sitka spruce, abies and picea, white cedar and yellow cedar, hemlock, and Douglas-fir; the items of lumbers include Sitka spruce, white cedar and yellow cedar, hemlock, and Douglas-fir.

On the basis of the estimations, it is clear that Canada has the market power on most kinds of import logs in the Japanese import market. With regard to the lumber market, the estimations show that the main export countries have the market power on some import items. The study clarified that an imperfect competition exists in the Japanese timber import market, and the Japanese timber price levels can be determined by exporting countries partially. The policy implication is to address effectively and fairly in trade negotiations with exporting countries and increase the competitiveness of the domestic timber industry to improve the Japanese domestic wood industries.

Keywords: Japanese import, log and lumber trade; market power; residual demand model

PP218

Impact of Wood Market Fluctuations on Plantation Trend of *Populus deltoides* in India

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Agroforestry is being promoted and popularized in India by the government and wood-based industries so that the requirement of fuel wood, fodder and timber wood for industries are met from the farmers field itself and the pressure on forests are reduced. Selection of trees for agroforestry is of paramount importance from the viewpoint of promoting tree cultivation on farmer's fields. Poplar (Populus deltoides), a native tree of the USA introduced in India during 1950, is widely grown in northern India as an agroforestry tree because of its fast growth, straight growing stem, short rotation, quality wood production and less adverse effect on associated agricultural crops. Deciduous nature of poplar allows agricultural crops to grow under poplar without much adversely affecting yield. Average production potential of poplar plantation is 35-40 m3/ha/year whereas maximum production potential is up to 65 m3/ha/year.

Commercial-scale plantations of poplar have been expanding since

the WIMCO-sponsored Farm Forestry Project was launched in 1984. WIMCO-sponsored Farm Forestry Project promoted the poplar based agroforestry plantations by providing technical know-how for planting and care of poplar trees and buy back guarantee with a minimum support price. Poplar replaced Eucalyptus tereticornis when the latter's market prices declined in the 1990s. Market prices for poplar wood were reached at highest in 1994-95 and as a result farmers sold their wood in open market deviating from minimum buy back support price of the promoting company. The poplar based agroforestry plantations had been increasing at a very faster rate all over northern India upto year 2000. Ten million trees used to be planted annually in 0.02 million ha with an average density of 400-500. But poplar was no more popular among farmers during 2001-2004 because the prices of their produce touching an all time low. Farmers were forced to sell their produce at throwaway prices anywhere between Rs.700 (14 US$) and Rs.1550 (31 US$) as compared to Rs.3500-5500 (70.0-110.0 US$) per ton. Farmers were compelled for pre-mature felling of poplar. Sale price of 6-8 years old poplar tree with a girth of 1 m was lower down to about Rs.500-600 (10.0-12.0 US$) per tree in 2004. The low market price of poplar wood discouraged the farmers with the result the farmers were compelled to deviate from poplar based agroforestry plantations. Accordingly nursery growers also reduced the production of poplar saplings in their nursery. Rates and demand of poplar wood were start increasing by the end of 2004 and the farmers were again attracted towards poplar based agroforestry plantations.

Presently the sale price of poplar wood is up Rs 10000 (200 US$) per ton depending upon girth and quality of wood. Timely pruning is very important for the production of excellent quality knot free wood. The tree attains a girth of 1 m at breast height (1.37 m) after an average age of 6-7 years and such a tree fetches an average of Rs.3500 (70 US$). The net income from poplar plantation would be about Rs.200000 (4000 US$) per hectare per year (three times in comparison to crops alone).

Keywords: Agroforestry, poplar, Populus deltoides, commercial plantations, market prices, quality of wood

PP219¬

Forest Certification updates in Argentina

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The definition of "Forest Certification" appeared during the nineties and was considered an instrument which contributes to the conservation of forests, through a good management and also with other benefits which are connected with a positive environmental and social impact in the community.

This Certification is a tool which verifies formally and willingly that the forest management developed by the owner of a "unit of management" complies with several Standards and functions as the "Eco labelling".

The Certification entities are responsible for the preparation of independent audits (according to the IRAM 39.803 Regulation), the concession, suspension and modification of the certificate, to inform CERFOAR, (Civil Association for the Argentine Forests Certification Administration) control of the granted certification´s use and also about the trademark PEFC (Programme for the Endorsement of Forest Certification).

The Argentine Accreditation Organization (OAA) established in 2011 the documents and general proceedings for the evaluation and accreditation of entities that certificate these organizations should comply with the IRAM 352 Regulation is equivalent to the ISO/IEC Guide Nº 65 and also with other specific requirements. In this sense, the auditing groups should have the necessary technical competence with economic, social and environmental issues in connection with the forest management of the requiring entity, and also the forest certification judgement. Each one of this should have a "Leader" qualified forest auditor.It is important to say that the validity period of the "Sustainable Forest Management Certification" is of five (5) years, and it is renewable.

As a conclusion we can add that in our country (Argentina) several organizations worked following the "Sustainable Forest Management Principles", and there is a big interest from the producers to achieve a good qualification which may allow them to compete in more demanding markets.

Keywords: Forest, Sustainability, Certification, Markets, Quality.

PP220

The effects of wood industry in the economical development of Kosovo

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Kosovo is a relatively small country with 10870 km2 where 42% of its territory is covered with trees. To date, Kosovo has passed through three important phases of economic development: the emergency phase after the recent war, the second phase with the privatization of social enterprises and the present third phase of sustainable development.

The after war period was very important for the forest sector as it led to its reconstruction, privatization and development aiming at the internal and foreign markets. Positive developments in the field of wood industry led to a marked increase in the number of work places offered and consequent requirement for a specialized and qualified workforce.

These developments have been sustained by higher education programs addressing these issues. One of the study programs is offered by the Faculty of Applied Technical Sciences, in Ferizaj, within the University of Prishtina. This is the only higher education institution in Kosovo, which for 35 years has been offering opportunity to study in wood industry and cooperates with wood processing enterprises and with the Kosovo Wood Processing Association.

Curriculum projects are focused in a way that the study process should be more closely related with industrial practices and scientific analyses of all practical parts in the economical context. The

large proportion of forests in Kosovo represents a relatively good potential for development of this sector both for the domestic market, and for exports of wood products. This sector can also be very attractive for foreign investments and can generated new jobs.

It is therefore essential to have scientific and technical knowledge on the national forests as well as on the species' quality for wood processing.

Keywords: Forest, wood industry, development, qualification, curriculum

PP221

Development of Hardwood Flooring Quality Certification Program

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The forest based-sector is very important to Brazil in the social, economic and environmental areas. However, considering the Brazilian forest vocation, the wood products trade with higher value added is low. One of the reasons is related to the lack of procedures about quality of products. Hardwood flooring production is losing field and has been disbelieved by consumers because manufactures that search for high quality are facing a market competition of products of poor quality and low prices.

In several productive sectors and services, the adoption of quality system programs has provided significant benefits involving reduction of production cost, improvement of human resources training and increasing in quality of products and its sales. This way the National Hardwood Flooring Association – Brazil (ANPM) developed the Quality Certification Program (QP) to attend the demands of customers and ensure the quality of the products.

The purpose of this work is to show the phases of QP implementation for hardwood flooring which include the development of technical specification, audit procedures and management to use Quality Trademark.

This work was carried out by ANPM and associated companies (18 in total). The main focus was on hardwood flooring with 19mm thick including tongue and groove. The QP developments involved the survey of technical standards and models of certification programs, the consulting of the manufactures and consumers. The final step was the formalization and establishment of the standards. In addition, a preliminary quality products analysis was conducted applying the audit procedures to verify the adequacy.

The results showed that QP for hardwood flooring production allowed the development of four technical standards (Terminology, Standardization / Classification, Audit Procedures and Management), and two of them were made official by Brazilian official regulatory agency. Moreover the QP actions provide quality programs improvement along audit, so the flooring defects, thickness and width were easier to be controlled and the moisture content was the most difficult one.

Keywords: Hardwood flooring, technical specifications, flooring defects, ANPM

PP222

Economic Panorama of the Brazilian Wood Flooring Segment

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In Brazil, the economic information related to wood flooring segment are few when compared to other segments of the Brazilian economy.

In this way, this research aimed to collect up dated economical information from wood flooring industries; obtained through personal interviews, local visit and oriented questionnaire application.

Based on the results it was possible to demonstrate that the most part of wood flooring industries are located in North region of Brazil and have till 50 formal employees. The sector shows a small economic participation in comparison with other productive chains in the forest products segment. Its more expressive contribution is related to export values and generation of job positions. In 2010 the Brazilian wood flooring industries produced around 11.6 millions of square meters, which represents a sales value of US$ 567 million. During the last three years the industries redirected the products market, decreasing the quantity sold in the international market and increasing the sales to domestic consumers; although wood flooring have a very small participation in the domestic flooring market when compared to the most used product (ceramic flooring).

The main conclusion is that the sector needs initiatives to foster its development, mainly due the fact that, among the wood based products, wood flooring can be considered as a high added value product.

Keywords: Forest product market, economic analysis, wood flooring.

PP223

Forest Management Certification as strategic positioning on the market

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Forest certification is designed as a market-linked mechanism to assure consumers that the wood products they purchase come from responsibly managed forests. To apply for forest management and chain of custody certification is frequently a decision of strategic positioning. The certificate of the Forest Stewardship Council (FSC) with its support from environmental and social organizations is regarded as a strong incentive to improve forest management practices. Certification can serve as risk management tool in helping to reduce social conflict in and around certified forests; and the impacts of certification are among others described as improving the image of the forestry locally and in associated markets; providing greater access to premium timber markets where they exist; and promoting forestry more generally through dialogue between the private sector, government bodies, non-governmental organizations and civil society. FSC certification also helps attract long-term investments, as it has robust feedback mechanisms in place to provide potential investors with a set of

indicators about a company that would otherwise be hidden. In this paper the complex example of the certification of cork as an NTFP will be used to demonstrate the various tools and impacts of certification. More general research needs will be highlighted in the area of market access and market price development, synergies of government tax incentives and promotion of forestry.

Keywords: Forest management certification, chain of custody certification, FSC, NTFP

PP224

Improvement of the chlorine-free bleaching of hardwood kraft pulp

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The complete elimination of the chlorinated reagents in pulp bleaching has been a subject of investigation for more than 20 years, with limited success. The major drawback of this change is the lower viscosity of the pulp due to the oxidation of cellulose, which is reflected in the lower strength resistance of the pulp. As a result the number of mills having shifted to these new bleaching sequences has remained marginal and most of them are sulphite mills producing pulp for other uses than paper.

New sequences containing oxygen, ozone and peroxide stages have been studied in the case of the bleaching of hardwood kraft pulps. It was shown that very different results were obtained depending on the way the bleaching chemicals were applied to the pulp. Moreover a preliminary treatment with an A stage in the presence of a chelating agent appeared to be a key step to successful bleaching.

Some bleaching sequences leading to high viscosity pulp are proposed. Their design was based on the knowledge of the chemistry of pulp components with acids, ozone and hydrogen peroxide under varying operating conditions. A new in situ free-phenol analysis method was applied and lignin models were used to explain the results.

Keywords: bleaching process, bleaching chemistry, sulphuric acid, oxygen, ozone, hydrogen peroxide

PP225

Research report and inventory valuation of the Goeritz Manor House (Brandenburg) before its termination

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The diploma work of Jens Putz involves the razing of the Goeritz manor house in Brandenburg, Germany. Associated with the termination of this building is the loss of an important piece of history in the life story of Goeritz village. The Brandenburg architectural conservation Code of Law required a detailed documentation of the manor house before its razing.

This presentation provides a detailed examination of the contents and history of the Goeritz manor house. The appearance, structure, construction, and equipment of the manor house are evaluated and discussed in detail. From both hands-on experience and reference to historical literature, the importance and historical significance of the Goeritz manor house is described in detail.

Keywords: construction, architectural conservation, historical

PP226

The Interaction of Rainfall, Tree Diameter and Ethrel Treatments on Resin Yield of Pili (Canarium ovatum Engl.)

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The effect of tapping length, ehtrel concentration and rainfall on resin yield was determined by tapping 36 pili trees growing in Calomagon, Bulan, Sorsogon. Three tapping lengths were used (15cm, 20 cm, 30 cm) at the same width (2 cm) and same depth (enough not to reach the cambium) and four levels of ethrel application; 0%; 0.5%; 1.5%; 2.5%. Retapping after the weekly resin harvest was done immediately above the previous cut. Each treatment was replicated thrice.

Increasing tapping length increased resin yield with 30 cm giving the highest yield. Ethrel concentration affected resin yield which was highest at 2.5%, while monthly rainfall had no significant effect on resin yield except at ethrel concentration of 1.5% and tapping lengths of 20 and 30 cm.

Resin yield of trees with ethrel application increase by 37.5%, which means resin tapping can be a source of additional income for farmers and resin tappers.

Keywords: resin, ethrel, tapping, rainfall

PP227

Bark Fibre Dimensions in *Quercus cerris* var. *cerris*

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Tree bark is among the most important non-wood forest products. Until recently bark has been considered as a waste-product of forestry activities and used predominantly as an energy source. Apart from this utilization bark has also been used to a lesser extent for different purposes i.e., in the production of materials, chemicals, natural dyes and mulching, as well as nutritional and medicinal purposes by local people.

Bark fibres may be important in their utilization. Historically, some barks have been utilized for making ropes and baskets; others have been used for pulp and paper and in composites. The potential ap-

plication possibilities are determined by the anatomical properties of fibres, namely by the fibre dimensions which are among the most important properties to indicate utilization areas for fibres.

In the present study, twelve Quercus cerris var cerris trees were sampled at breast height (DBH) in four different locations of Andırın province (Turkey). Fibre dimensions (length, diameter and wall thickness) were measured from bark samples, cut from the cambium towards the periderm. Specimens were macerated and from each tree sample 40 fibres were measured by a semi-automatic image analyser.

The mean length, diameter and wall thickness of phloem fibres varied between 1.06 to 1.16 mm, 21 to 22 µm and 2 to 3 µm in the four sites respectively. An analysis of variance showed significant difference ($P<0.05$) between the sites for fibre biometric characteristics.

This study is the part of the on-going research work on the characterization of Quercus cerris var. cerris bark in order to contribute to find reasonable uses to bark material.

Keywords: Bark fiber; Quercus cerris; bark utilization; non wood forest products

PP228

Effect of heat treatment on physical and mechanical properties of moso bamboo (*Phyllosachys edulis*)

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Moso bamboo (Phyllosachys edulis) is an important forest resource with great potential in subtropical Taiwan. It is used for various applications, such as light building materials, scaffolding, mats, fencing, handicrafts, toys and musical instruments. In 3~5 years, the mechanical strength, utilization properties, and anatomical characteristics of bamboo become stable and mature, making it suitable for various uses. However, bamboo is easily susceptible to fungal or insect attack. The physical and mechanical properties of bamboo will deteriorate rapidly if the material is not treated with preservatives.

One method that has been studied recently to improve the properties and durability of bamboo is thermally modified. In fact, the heat treated wood has been investigated since the middle of the last century and is nowadays produced industrially in many European countries, and some of the products developed by heat treatment include thermowood in Finland, torrefaction in France and PLATOwood in the Netherlands. Heat treatment of wood at relatively high temperatures ranging from 150 to 260°C is an effective method to improve dimensional stability and durability. Studies on heat treatment of bamboo reported reduction in mechanical properties but with marked improvement in dimensional stability and durability.

In this study, the heat treatment of moso bamboo is used steel kiln under air atmosphere. The parameters of heat treated conditions at four temperatures (150, 170, 190 and 210°C) and three durations (2, 6, and 10 h). The effects of heat treatment on physical and mechanical properties of moso bamboo were examined.

The results indicated that the bending strength (MOR and MOE) values decreased with increasing heat treatment temperature and treatment times. The MOR and MOE retention were 85.7% and 77% respectively. Improved anti shrink efficiencies (ASE) and lower hygroscopicities occurred only for the high temperature treatments, and at a temperature of 210°C for 10 h has the maximum values (60~69%). On the other hand, the colour and surface roughness decreased in the bamboo samples that was affected by temperature and duration of heat treatment, L* value decreased from 79.71 to 30.98 in CIE Lab method, and roughness Ra vale decreased from 3.92 to 2.15 µm, respectively.

Based on the results of these experiments, the heat-treatment process greatly enhanced the dimensional stability and durability of bamboo, however there was a reduction in mechanical properties as indicated by bending strength, modulus of elasticity in bending. Therefore, the optimized heat treatment process is needed to select for end used purpose.

Keywords: Heat treatment; Moso bamboo; Physical properties; Mechanical properties; Dimensional stability

PP229

Selected Properties Of Malaysian Bamboo – *Schizostachyum Bracycladum* (Buluh Lemang)

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Schizostachyum brachycladum or locally known as buluh lemang is indigenous to Malaysia. This species is one of the most popular tropical bamboo species for plantation. The culms are commonly used for cooking glutinous rice called 'lemang' and also used for crafting basket and mats. The objectives of the study were to determine the fibre morphology, physical and strength properties of S.brachycladum. The study of fibre morphology were investigated due to relationship with strength, preservative absorption and end product especially pulp and paper. The moisture content, density and shrinkage are considered to be important factors in determining the suitability of bamboo for various application and chemical treatment. Determination of strength properties which is modulus of rupture (MOR) and modulus of elasticity (MOE) is very important since these properties are closely related for industrial uses and structural application.

Study on the selected properties of S.bracycladum was carried out on 4-year-old bamboo culms. The selected properties were fibre length, width, thickness, lumen diameter, moisture content, density, shrinkage from green to air dry, MOR and MOE. The average value for fibre length, width, thickness and lumen diameter were 2840 µm, 23 µm, 9µm and 6.4 µm respectively. Whilst the result for moisture content, density and shrinkage from green to air dry were 93 %, 589 kg/m3, 0.22 % (longitudinal shrinkage), 3.05 % (radial shrinkage) and 2.25% (tangential shrinkage) respectively. MOR gives the result of 145 N/mm2 and 27325 N/mm2 for MOE. From the result it shows decreased trend from bottom towards the top of the culm for fibre morphology, moisture content and shrinkage. On the other hand the density, MOR and MOE show the reversed trend.

From the result obtain, S.brachycladum could be potential for commercial product such as furniture, plybamboo and flooring. Base on the basic properties from this recent study, it is believe that this species has a higher potential for wide scope of usage. However, further research need to be done to explore more potential usage and suitable product from this species.

Keywords: Schizostachyum brachycladum; fibre morphology; physical properties; modulus of rupture; modulus of elasticity

PP230

Authenticated Refference Of Bamboo Species Occuring In Malaysia

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Malaysia is endowed with more than 50 species of bamboo, 25 of them are indigenous, while the rest are known exotics. All the bamboo species are grouped under 11 genera namely Bambusa, Dendrocalamus, Gigantochloa, Chusquea, Dinochloa, Melocanna, Phyllostachys, Racemobambos, Schizostachyum, Thyrsostachys and Yushania. Of the total species, only about 14 are commercially utilised while the rest are left idle in their habitat with lack of knowledge on their properties and potential usage. With bamboo is now seen as potential alternative to forest timber, collecting and documenting all the bamboo species and its properties is now of significant important. Effort has been initiated by establishing a bamboo authenticated reference centre at the Forest Research Institute Malaysia (FRIM) with samples collected within Malaysia. The reference centre would create a database on authenticated bamboo with complete information made available to scientists and bamboo related individuals. Initially, the study began with bamboo species collected within FRIM campus and this would later be extended to the whole of Malaysia as and when funds are made available. The bamboo would be scientifically identify based on existing plant taxonomy method and protocol and would later be cross-checked and verified with other established centre. However, continues improvement is being sought and made to expedite efficient collection of bamboo samples and documentation in compliance to established standards. The study would also include establishing the morphology and anatomical structure of the bamboo as well as the physical and mechanical properties of these authenticated samples. This study which began in Jun 2011, as to date has seven bamboo species with their complete database being documented. It is hope that this project would provide a complete portfolio of each bamboo species found in Malaysia and in long term would benefit the bamboo community and the bamboo manufacturing industry in Malaysia.

Keywords: Malaysian bamboo-Authenticated reference-Morphology-Properties-Taxonomy

PP231

Extrafloral nectary and nectar in *Acacia mangium*

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Our microscopy studies describe the anatomy of extrafloral nectaries on the abaxial side of the basal part of every leaf stalks of Acacia mangium. The lens-like nectary expands with the development of the leafstalk, peaks at the stage at which the leafstalk itself has reached its mature size. The nectary is composed of numerous small parenchyma cells and a nectar cavity in which the nectar is pooled. Those small parenchyma cells are divided into nectariferous tissue and epithelial cells, which line the lumen of the nectar cavity, and secretes the nectar into the same. Each nectary is surrounded by several vascular bundles, which probably afford the nectar.

Secretory behavior of nectaries in a humid atmosphere (75%) is longer than that of those in a dry atmosphere. Nectaries under lower soil moisture conditions shorten their secretion period. It is presumed that water shortage affects the amount of photosynthetic products, resulting in a shortage in sugar sap supply to the nectaries. In addition, the chemical constituents of the nectar are analyzed by NMR, and it mainly consists of sugars with 60% sucrose, 25% glucose and 15% fructose.

Keywords: Extrafloral nectary; nectar; Acacia mangium; nectariferous tissue; epithelial cells; secretion

PP232

Effects of Seedling Density on Turkish mahaleb (Prunus mahaleb L.), as a Non-Wood Forest Product Seedling Morphological Properties

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Turkey has an important potential in terms of non-wood forest products due to the geographical location with varied climatic regions and richness of biological diversity. Although the country has a rich plant diversity on non-wood forest products, these resources are not utilized sufficiently. For this reason, in recent years some medicinal and aromatic plants, which have a significant share in the foreign sales, has been cultuvated in order to meet the growing demand for herbal products.

Flora of medicinal and aromatic plants grown in Turkey up to 3000 has the potential to export some 200 of them are exported to much of 70-100. Seeds of the Turkish mahaleb (Prunus mahaleb L.), one of the non-wood forest products which grow naturally in Turkey, are collected and exported on a large scale. In FAO recordings Turkish mahaleb producing land has been reported at about 18375 ha.

Turkish mahalep (Prunus mahaleb L.) is included in the genus of Prunus, and its fruit and seeds are assessed, also tree wood is used in the furniture making. Fruit jelly, fruit pulp, candied done, and the pharmaceutical industry, and the seeds into a powder by bringing cookies and cream pasta is used in perfume.

Turkish mahaleb was used alone as the boundary of the North Anatolian Region, in recent years, both in the domestic consumption, and as a result of increased exports and production have increased rapidly, especially the establishment of the gardens close. In order to increase the production of Turkish mahaleb in the country, in addition to their natural habitats, there is a need new plantations consist of high quality seedlings in the suitable ecosystems. High levels of economic revenue will be provided in this way. It will be possible the production of quality seedlings if appropriate seeding density will be determined in the nurseries.

Subject to the lack of sufficient knowledge of the literature revealed the importance of this topic. The main objective of this study was to determine the effects of seedling density on seedling morphology for Turkish mahaleb which is suitable native species for Non-wood forest products. Study was carried out in experimental sites established in Eğridir Forest Nursery. There were five treatments as seeding density (0 (control), 3 cm, 6 cm, 9 cm and 12 cm) applied in experiment. At the end of the growing season, seedling height, seedling diameter at collar, number of thin roots (longer than 5 cm), fresh and dry weight of seedling and ratio of height and diameter at collar were measured.

Keywords: Non-wood forest products; Prunus mahaleb L.; seeding density; seedling

PP233

Sex Identification for More Production of Seeds in Pistacia atlantica (Northwest of Iran)

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Pistacia atlantica is the most important tree species for the economy of many rural areas in west of Iran. The resin of wild pistachio, called Saqez, is used for a variety of industrial and traditional uses, including food and medicine. P. atlantica is also used as a rootstock for edible pistachio tree (P. vera). As well as adaptation of Pistacia trees to harsh desert conditions, their longevity also make them ideal candidates for reforestation in arid zones.

All Pistacia species (Anacardiaceae) are dioecious and sex determination mechanisms in this species are unknown. This problem is exacerbated in dioecious species where the sex of an individual is revealed only after flowering which may take from a few months (papaya) to several years (pistachio, nutmeg and jojoba). Thus the development of a reliable method of sex determination for pistachio would be considerably advantageous in cases where plants are cultivated for the seeds borne on the female plants, which are of commercial importance.

In this study we tried to find a relationship between gender and morphological characteristics. Trees of known gender (n = 105) were randomly selected from three wild populations of P. atlantica in north-west of Iran. For each individual tree the micro-morphological features of leaves including the number of stomata and chloroplast were measured. ANOVA and mean comparison revealed a significant diversity among the populations, showed significant differences between genders for number of chloroplast and it was higher in females than in males. Because female trees invest more resources for future generation, this may be expected to affect their photosynthetic performance. As a consequence this could be reflected on different photosynthetic characteristics such as the number of chloroplast.

Also tree dimension has been measured and a significant difference between sexes was found in Salmas population at 0.01 probability level. This difference can cause unfavorable conditions because male trees are more vigorous than female trees in stressful environments.

Keywords: chloroplast; micro-morphology; Pistacia atlantica; stomata

PP234

Socioeconomic aspects of an extractivist community in Brazilian Amazon

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Although the sustainable harvesting of NTFPs is touted as a means of sustainable development, much still needs to be better known and discussed. In order to better understand people and their forest interaction, in November 2009, an agroextractivist riverside community composed of 31 families was visited in Rio das Minas, in the state of Acre, Brazilian's Amazon. In the community, the main income generator are plant fibers used in the manufacture of broom. These fibers are extracted from three plant species: piaçava (Aphandra natalia (Balslev & Henderson) Barfod), the titica vine (roots of epiphytic Heteropsis flexuosa, Araceae) and timbo vine (the roots of hemi-epiphytic Thoracocarpus sp., Cyclanthaceae). Each family produces 350 brooms a year on average. All brooms are sold to middlemen traders. The average price paid by the middleman for the broom is $1.18 (PPP 2009), so the families have an average annual income of $413.00 (PPP 2009). Families also extract food from the forest. On average, each household consumes approximately 1385kg per year in palm fruits, which were açaí (Euterpe precatoria Mart.), patauá (Jessenia bataua (Mart.) Burret), buriti (Mauritia flexuosa L.) and bacaba (Oenocarpus mapora H. Karsten). The harvest work of vines and production of brooms is carried out throughout the year. It was found that açaí is consumed almost exclusively from January to June. The bacaba is consumed throughout the year, and in greater quantities during the months January to September. The harvest of buriti focuses October to December and although patauá consumed throughout the year has increased consumption between February and September.

Keywords: NTFP, extractivism, Amazônia.

PP235

Optimal plot size for inventory of Amazonian non-wood species

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Forest inventory is the first step for natural resources research and decisions related to land use. On large Amazonian forest areas, resources are measured frequently by sampling techniques, which enable a fast and inexpensive data recording. The estimate accuracy of population parameters and inventory costs are directly related to plot size and shape. These methods cannot be a standard for all species, because it depends on: ecological characteristics of each species and site; aims

of the study; financial resources available and the allowable error. Various plot sizes have been used in inventories of non-wood species. The aim of this study is to determine optimal plot sizes for inventories of non-wood species, to improve the accuracy of non-wood forest products (NWFP) stock estimates in Amazon region.

This study was carried out at ZF-2 Tropical Forestry Experimental Station of the National Institute for Research in the Amazon (INPA). We used forest inventory data from a 30 ha (500x600m permanent plot) continuous forest area divided on 10x10m (100m2) subplots. All trees and palm trees with DBH ≥ 5 cm were measured and mature and immature roots of Heteropsis spp. a commercial fibre from Amazon region were counted. We selected 5 tree species [1] Geissospermum sericeum (Sagot) Benth., [2] Minquartia guianensis Aubl., [3] Protium heptaphyllum (Aubl.) March., [4] P. apiculatum Swart, [5] Aspidospermum oblogum A.D. and 3 palm trees [6] Euterpe precatoria, [7] Oenocarpus bacaba, [8] O. minor with certain potential of NWFP production. The trees [1 to 4] and the palms [6, 7] were divided on 2 diameter classes (i) 5 ≤ DBH < 10 cm and (ii) DBH ≥ 10 cm, representing regeneration and adult trees. For [5] and [8] species were considered all individuals within the diameter class of DBH ≥ 5 cm. Seventy forest inventory simulations were performed for each of the 19 plot sizes (0.01 to 1.5 ha). We randomly selected 20 plots on each forest inventory simulation. Confidence interval in percentage unit (CI at 95% level of probability) was calculated to rank optimal plot sizes. We considered "basal area" as parameter for trees, "individual abundance" for palm-trees, and "root abundance" and "number of trees with roots" for Heteropsis spp..

Analyses indicate that the use of large plot sizes result in narrower CIs, but not necessarily the largest was considered the optimal plot size. The abundance and spatial distribution were the main cause of high variability on CIs, for example, species [5] (scarce) and species [4] (abundant): sample units of 10x600m results a CI of 40% and 6.3%, respectively. Another example is the species [6] that due to the preference for valleys, the lowest value of CI was 31%.

Including all trees and all Heteropsis spp. parameters, the optimal plot size was 50x150m, which result CI from 8% on species [4] to 28% on [5] and [2]. For palm tree species the optimal plot size was 10x600m, which result in CI from 23% on species [7] at class (ii) to 45% for the same species in other class (i). To improve estimates, we will need to increase the size of plots and/or number of samples; however, it will increase the inventory costs. Another choice is to change sampling design, which is the next step of this research.

Keywords: Forest inventory; non-wood forest product; plot size; confidence intervals

PP236

Potentials of medicinal plants productions in Iran

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Climatic and ecological condition differences are the main cause of high diversity of medical plants and genetic reserves in Iran natural resources. Usage of eight thousands medicinal plant species is always the relief character of Iranian traditional medical profession. At present, agricultural lands are be cultured with medical plants are about 66 thousand hectares areas in the country with 65 thousand tones production and 63 million dollars value. The related studies were showed that to use about 90 medical plant species to produce medicine (4 percent of total requirement medicine for the country) in spite of existence of about 1500 medical species in the natural resources areas that some of them are exclusive and high value. General plans for medical plants can lead to reach sustainable developing management in this section aspect of economic, environment, hygiene, occupation, food security and genetic reserves in national and world levels and also foreign funds for the country.

Keywords: Medical plant, production, Wood production, Growth.

PP237

Forest native community of cocoa (*theobroma cacao* l.) in the Varzea Purus: sustainable economic development experience, Amazonas – Brazil

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This essay has the purpose to present a synthesis of the major studies for the development of Community Forest Management Plans of native cocoa (Theobroma cacao L.) in the Purus River's floodplains at the Amazonas State. It still has detailed the studies of forest inventory, satellite mapping occurrence, logistics and socioeconomic aspects of extractive population and how these studies can be used to subsidize decisions about native cocoa forest management by extractive producers associated in Mapiá and Middle Purus River Agro-Extractive Cooperative (COOPERAR). The main objective of this work is to serve as a technical reference to improve productivity and quality of native cocoa management getting as a result better life conditions for extractive population and socio-environmental sustainability.

Keywords: Management Plan, Community, Cocoa native.

PP238

Forests and climate: How do harvested wood products help?

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In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change on Forestry, scientists stated that "a sustainable forest management strategy aimed at maintaining or increasing

forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit". Under the current system, forest fellings are counted as emissions of CO2, despite the fact that the majority of the carbon remains stored in the wood or the materials derived from it. Including harvested wood products in the scheme would lead to an accounting of this carbon storage benefit and give a more prominent role to wood and wood products.

An ad hoc working group of the Standing Forestry Committee of the European Union has dealt with the issue of forestry and climate change and discussed, in particular, the specific role of harvested wood products and their contribution to mitigating climate change either by cutting CO2 emissions by substitution, or by storing sequestered carbon in wood products (extending carbon sinks).

In this context, it is worthwhile noting that:

- Europe's forests provide a carbon store of 150-200 billion tonnes CO2, grow each year by 661 000 ha sequestering a further 0,5 billion tonnes CO2
- Europe's stock of wood products stores an estimated 220 million tonnes CO2. Annually, the stock increases, storing a further 20 million tonnes CO2
- Substituting materials typically used in construction by wood products leads to a saving of between 0,7 and 1,1 tonnes CO2/m^3
- Wood is a carbon-neutral fuel which can be used as a substitute for fossil fuels

Keywords: Climate change, Harvested Wood Products (HWP), carbon storage, substitution

PP239

Global Warming: Impact in the Sundarbans and Coastal Region of Bangladesh.

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Global warming and climate change in general and in its consequences are among the pressing issues today. The changes have been attributed to the rise of concentration of green house gases in the earth's atmosphere. The GHGs like carbon dioxaide, methane, nitrous oxide and clorofluro carbons absorb thermal reaction emitted by the surface. Thus the global average surface temperature has automatically increased over the last century. Climate change is one of the define factors in the vegetation distribution, changes and conservation. Global warming impacts on the constant region and the Sundarbans of Bangladesh. The threat of accelerated sea level rise exacerbate the already existing high risk of storm surges, severe waves, river bank erosion, tsunami and other disaster. Climatic hazards, including extremes like floods, cyclones, tornado, storm surge, tidal bore, etc are not new to Bangladesh. The country has a scarred history claiming many lives and resulting in losses of assets and belongings. The life of living organisms, crops and vegetation production would be severely affected by the consequences of climate change.

It also impacts and aggravate long term biochemical effects like sea level rise, shore line and river bank erosion, sedimental deficits, salt water intrusion into coastal aquifers and the loss of coastal wetlands and the Sundarbans. Loss of Sundarbans means loss of wide variety of heritage, its biodiversity, fisheries resources, life and livelihood of people and after all loss of very productive ecosystem and environment. The sea level rise, insufficient fresh water flow in upstream river in winter, resulting increasing water and soil salinity in the current area and the Sundarbans. It is threatening the conservation of the Sundarbans mangroves.

Sea level rise can activate two important mechanisms that result in the loss of land erosion and inundation. Erosion represents the physical removal of sediment by wave and current action. Inundation is the permanent submergence of low lying land. Land loss resulting from inundation is a function of slope. The survival coastal wetland is dependent upon sediment availability and local biomass production. Coastal adaptation requires more data and information on coastal characteristics and dynamics, as well as ecosystems for understanding the potential consequences. Need to be considered for applying appropriate plan and programe to conserved the coastal ecosystem of the Sundarbans, the world largest mangrove forest for millennium development.

Keywords: Coastal ecosystem, global warming; green house gases, disorders; global warming; sundarbans; sea level rise.

PP240

Climate Vulnerable Species in the Sundarbans of Bangladesh

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Sundarbans is the largest single tract mangrove Forest of the whole world. It is one of the most important and productive ecosystems of great ecological and economic resources of the Sundarbans and along with the coastal areas of Bangladesh. The forest occupies the south-west corner of Bangladesh between longitudes 89°00"E and 89°55"E and latitudes 21°30"N and 22°30"N. The forest cover an area of 6017 km2, of which 4143 km2 are landmass and remaining 1874 km2 are under water bodies. The Sundarbans has a high biodiversity value in which is tidally inundated twice a day. It was reported 334 floral species belonging to 245 genera of spermatophytes and pteridophytes. The Sundarbans also constutes 66 species. More recently it was listed 130 and 215 species which are not all the mangroves.

Sundri (Heritiera fomes) and gewa (Excoecaria agallocha) are the major tree species in the forest. The other important species are pasur (Xylocarpus mekongensis), goran (Ceriops decandra), keora (Sonneratia apetala), amur (Amoora cucullata), baen (Avicennia officinalis), kankra (Bruguiera sp.), shingra (Cynometra ramiflora), khalshi (Aegiceras corniculatum), kirpa (Lumnitzera racemosa), golpata (Nypa fruticans), garjan (Rhizophora mucronata), dhundul (X. granatum). Now the major tree species in the Sundarbans are climate vulnerable.The major important timber species are facing different diseases and disorders. Sundri is affected by top dying disorder. Pasur is faced with heart rot disease. Holing problem is well known problem for baen in the Sundarbans. Some other species are also climate vulnerable.

Global warming, ozone layer depletion, marine pollution, insufficient upstream water flash and tidal inundation, increasing soil and water salinity, sedimentation, river bank erosion, different hazard-

ous waste materials are some of the major ecological and environmental concern theme. Fungal pathogens and are other bioms are also resposible for the degradation of the mangrove forest. However, such long-term studies are needed to document impacts of its biodiversity. In the short-term studies of competition in impacted areas are valuable substitutes for long-term studies.The researchers, forest personnel, planners and related think tanks have to realise, assess and manage the future of the vulnerability of the Sundarbans mangrove foerest of Bangladesh.

Keywords: Climate vurnerable; diseases and disorders; global warming; sundarbans; mangrove forest.

PP241

An All Lands Framework for Conservation of Ecosystem Services

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Ecosystem services has emerged as a way of framing and describing the comprehensive set of benefits that people receive from forests and landscapes. These include commonly recognized goods like timber and fresh water, as well as processes like climate regulation and water purification, and aesthetic, spiritual and cultural values. The USDA Forest Service has been exploring use of the framework of ecosystem services as a way to describe benefits provided by public lands and to attract and build partnerships with stakeholders and nongovernment organizations to implement projects. More recently, the agency has sought placed-based applications of this ecosystem service framework to explore its possible use as a management tool on national forests and to better illustrate the concept for policymakers, managers, and potential national forest partners. The Forest Service is also working with a variety of private forest landowners to broadly conserve and integrate management of habitat to enhance wildlife and fisheries habitat, joint production of forest products and watershed management. To test this framework, the Deschutes and Willamette National Forests and the Forest Service's Pacific Northwest Research Station are collaborating to explore how an ecosystem services approach can enhance forest stewardship in Oregon. This framework includes (1) describing the ecosystem services provided by the forest; (2) examining the potential tradeoffs among services associated with proposed management activities; and (3) attracting and building partnerships with stakeholders who benefit from particular services the forest provides. This paper will synthesize this collaborative effort and defines ecosystem services from a management perspective, describes how management actions support the provision of those services, and identifies partners with potential to plan, fund, or implement projects to enhance ecosystem services.

Keywords: Ecosystem services; forest products; water, private and public lands; tradeoffs

PP242

Fast Growing Lesser-Known Species from Secondary Tropical Forest in Colombia: Wood Properties and Product Options

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In Colombia, the Caribbean area has one of the most relevant wood markets in the country. Due to the depletion of the most commercial species in the region, the timber supply is coming from areas up to 1200 km away, with high transportation costs and consequently decreasing industries' profitability. The region presents relicts of secondary tropical forests which could participate in the regional wood production chain, but the forests are not being used due to lack of information about its resources and its economic viability.

These secondary forests are mainly composed of the so called Lesser Known Species - LKS – and their wood properties and qualities have not been identified. In the need to establish linkages between the secondary forest resources and timber supply for the regional industry, this research aimed to investigate physical and mechanical properties of four selected fast growing LKS. On defect free samples, basic density, compression and bending strength and quelling and shrinking were tested and statistically analyzed.

The evaluated fast growing LKS presented mean air-dry densities between 0,32 and 0,44 g/cm^3 and the strength properties showed high variation between the species. The results also showed high deformation in radial and tangential directions when drying, which will be relevant for definition of drying schedules and final applications. The LKS presented similar attributes compared with other already commercialized broadleaves species. The information of this study will contribute to target the LKS utilization to supply value added wood product industries in the region, which are expected to better compensate for the raw materials.

Keywords: Less Known Species, wood properties, timber secondary value, secondary tropical forest

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PP243

Physical and Technological Properties of hygro-thermally treated European hardwoods

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German Hardwoods, especially Beech (Fagus silvatica) and Ash (Fraxinus excelsior) are highly appreciated for interior use. but their

use under changing humidity/outside climate conditions is limited due to relatively high swelling/shrinking coefficients and limited natural resistance to fungal decay. Thermal treatment may improve these features,but also may have negative effects on physical and mechanical properties.

Extensive studies have been carried out on beech, ash and oak (Quercus petreae)samples both as small test specimen and real size boards. A hygrothermal pressure treatment method (WTT) was applied with 2 temperature levels (160°, 180°C) and moisture equilibrium, density, dimensional stability, static bending strength (MOR), Modulus of elasticity (MOE)and dynamic impact bending strength were tested. and compared with non-treated samples.

Results show statistically significant improvements in moisture equilibrium and dimensional stability in most cases already at the 160 °C level. whereas technological parameters, especially impact bending strength is affected already at the 160°C level and is substantially reduced at 180°C.

Keywords: Thermal treatment, European hardwoods, Oak, Ash, Beech

PP244

Improving Management Decisions In Portuguese Forests Through Fire Behaviour Modeling: Guidelines To Support A Sustainable Landscape

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The purpose of the research was to simulate fire spread in three forested landscapes to assist forest managers in identifying high-risk areas for actively integrating stand-level fuel treatments with explicit landscape-level management planning and develop fire prevention priorities. Specifically, several modeling applications to detect significant fire-landscape interactions between stand-level features and fire behavior were fitted through logistic regression and classification tree analysis to classify Portuguese forests to fire risk levels.

This research considered a data set encompassing 2504 inventories plots located in the three forested areas. This allowed us to make comparisons between different topographic and fuel structure patterns on different landscapes: Leiria National Forest, an even-aged maritime pine (Pinus pinaster Ait.) public forest in the Centre (≈10 881 ha), Vale de Sousa a mixed forest with multiple non-industrial private forest owners in the North (≈ 12 308 ha) and Globand area an industrial property where eucalypt (Eucaliptus globulus Labill) is predominant (≈ 11882 ha). The estimation of further non-spatial data was based on an exhaustive research of methodological issues, such as surface fuel models, fuel moisture (fine fuel moisture content) and stand characteristics (stand height, crown base height, crown bulk density) modeling in the Mediterranean.

Fire simulation was carried out with FlamMap 3.0.0 for three typical meteorological scenarios derived from historical weather records gathered from May to October over 1998–2008 to represent moderate, average and critical fire weather conditions. For each scenario, modeled fire behavior characteristics, landscape data and stand variables (tree density, basal area, quadratic mean diameter, dominant height) were overlaid in ArcGIS 9.3 and a database that stores landscape pixels that are homogeneous according to those attributes was established for each scenario to identify stand characteristics and spatial pattern metrics of fire prone areas. The database with the most critical combination values (4% fuel moisture content, 40 km/h wind speed) was selected as input for modeling analyses.

Logistic regression modeling was applied to develop models suited to end users ranging from typical forest practitioners to researchers, providing: (1) two compatible modeling fire behavior equations to predict crown fire activity (Pfcrown) depending on the available variables, i.e. Model I, based on simulator input data (slope, crown base height, fuel model and canopy cover), and Model II, using easily measurable stand characteristics suiting forest managers (dominant height, basal area and fuel model). Consequently, a guideline matrix to support the definition of appropriate management options in each forest area was developed according crown fire occurrence probability thresholds. Furthermore, a classification tree approach was employed to assess the type of fire (surface, passive or active crown fire) and the difficulty of fire suppression according to biometric patterns to support forest management.

The results demonstrate the potential of the strategies pursued to understand the influence of both biometric and environmental variables to support hazard-reduction silvicultural practices, through the development of management guidelines for fuel and stand structure modification in these fire-prone forest stands.

Keywords: Fire behaviour modeling; Fire-landscape interactions; Silvicultural practices; Sustainable forest management

PP245

Carbon Sequestration Of Stem Wood In Forest Regenerated Through Enrichment Planting And Strict Nature Reserve

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Carbon dioxide (CO2) is one of the most abundant greenhouse gases and a primary agent of global warming. Dramatic rise of CO2 concentration is attributed largely to human activities. The only practical way of removing large volumes of the major greenhouse gas from the atmosphere is through the absorption by plant into their biological system. The contribution of a natural forest regenerated through enrichment planting to carbon absorption was carried out in this present study. The amount of carbon in the tree biomass from this forest was also compared with the carbon value in the adjacent degraded forest. Tree growth data were collected from eight 25m X 25m plots located in each of the two forest types using the systematic line transect. Volume of the trees was estimated with analytical formula and biomass of every species was computed by multiplying the volume of the tree with its respective wood density. Tree biomass was converted to carbon stocks using 0.5 carbon fractions as default values. Our findings indicate that the potential of degraded rainforests to recover from degradation can therefore be enhanced through enrichment planting as the number of individual (446),

species (42), families (21), basal area (35.2m2), volume (345.76m3) and biomass (43.53kg) per hectare were comparatively higher in enrichment planting forest than the number of individual (60), species (18), families (11), basal area (0.95m2), volume (2.88m3) and biomass (3871.37kg) per hectare in degraded forest respectively. It was also reveal that the enrichment planting forest sequestered more carbon (1935.66kg/ha) than degraded forest (21.76kg/ha). The significantly higher carbon sequestered by the enrichment planting forest shows the effect of degradation and deforestation on carbon sequestration. It also shows the efficiency of enrichment planting for forest regeneration for environmental protection and carbon storage.

Keyword: Wood Density, Carbon Storage, Enrichment Planting and Degraded Forest

PP246

Environmental and economical sustainability of round wood transportation systems

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The planning of the wood supply follows the demand of the market but generally without respect to spatial conditions. The distribution of single assortments to the customers has a strong spatial reference, so the transport distance and the fuel consumption are highly influenced. This has been identified as bottleneck for the environmental and economical sustainability of wood supply. Consequently, the aim should be a wood transport from the forest to the customers with minimal resource consumption.

This corresponds to a minimisation of the transport distance for a given wood volume. A procedure with two steps has therefore been developed. The first step is the optimal distribution of the assortments to the customers in a given period. The optimal distribution is equivalent to the so called 'Transportation Problem' (Hitchcock, 1941). For a given assortment the solution satisfies the needs of the customers with minimized transport distance. The second step comprises the minimization of the resulting empty runs using back freights.

The method was tested for a dataset of the Bavaria State Forest Enterprise. The data consists of 3 Mio. m^3 round wood of different assortments. At first this volume has been distributed with minimal transport distance by solving the cited 'Transportation Problem'. In a second step the potential of the minimisation of empty runs by back freights has been computed for the optimally distributed piles.

The incorporation of this procedure in the planning process resulted in a decrease of the transport distance by more than 20 %, which has direct impacts on the environmental and economical sustainability of the wood supply by reduced fuel consumption, a diminution of emissions and less traffic on the road network as well as lower transport costs and shorter delivery times.

Beside these results the computations are of analytical impact. The transport routes of optimal distributed timber assortments are separated by watersheds like a river system. The border of a customer's catchment area corresponds with the 'watersheds' of the transport routes. On the other hand optimal catchment areas of the customers can be described by 'Thiessen Polygons'. The more the catchment areas match these polygons, the lower are the transportation distances and the higher are thus environmental and economical sustainability of the wood supply.

Keywords: Round wood transportation, transportation problem, back freights, sustainable wood supply, catchment areas

PP247

Comparison of biomass production and total carbon balance of continuous-cover and clear-cut forestry in Sweden

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Continuous-cover forestry has been suggested as a management method resulting in higher quality products and greater carbon sink compared to clear-cut forestry. We conduct a system analysis to compare the services of continuous-cover forestry and clear-cut forestry in terms of biomass production and total carbon balance. The DT model is used to project forest biomass production under alternative forest management strategies for clear-cut forestry and continuous-cover forestry, with different production levels for Norway spruce (Picea abies) forest in northern and southern part of Sweden. We then compare the stand-level forest biomass production, its use, and total net carbon emissions into the atmosphere. The total carbon emission avoidance is estimated in terms of carbon stock increment in standing biomass, carbon stock stored in wood building materials, forest residues used for energy production and fossil fuel substitution, wood building products used in place of carbon intensive materials, and development of carbon stock in soil organic matter.

The results showed that continuous-cover forestry results in greater quantities of standing biomass but smaller amounts of forest biomass harvest residues, compared to clear-cut forestry. The greater standing biomass provides larger amount of organic matter litter fall to the forest floor and has greater soil organic carbon development compared to clear-cut forestry. The wood product stocks are comparable in the two forest management systems. The total avoided carbon emission is slightly greater in the clear-cut forestry than in continuous-cover forestry. This study concludes that clear-cut forestry has slight edge over the continuous-cover forestry in terms of biomass production and carbon benefits, but accounting for other environmental services may change the results.

Keywords: standing biomass, wood substitution, soil carbon, Norway spruce

PP248

Effect of air-leakage on energy efficiency of timber frame house

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Recently, energy has become one of the important issues because of high oil prices. In addition, the actions for reducing carbon emission resulted from use of fossil fuels. According to 'KEMCO(Korea Energy Management Corporation)' in 2008, construction field accounts for 20% of total energy consumption cost in Korea. Building energy became a major part of national energy consumption. In order to reduce building energy consumption, airtightness has been rising issue. Nowadays, the government has recognized the importance of Korean identity and national branding by evaluating the value of architectural culture freshly. Through the technical development of Korean-style house's moderation, the government set goal for improving the quality and value of buildings ultimately through development and spread of Korea traditional house, called a Han-ok. Therefore, 'Han-green house (based on Han-ok post-beam structure with wood stud infill wall)' was chosen because it was timber frame house with wood stud filled wall which had same way as structure and wall of Han-ok. The airtightness of Han-green house was measured using Blower door test. It showed higher infiltration more than any other normal houses. This result confirmed bad to energy performance. Further study is under way to detect influence factors on infiltration and to enhance energy performance by fixing those.

Thermal images of Han-green house in the winter time were taken by IR Flex cam to find out from where the heat loss occurred. More heat loss occurs at openings and gabs between frames and walls than other parts of this building. Air barriers were installed at each of those. And energy demand obtained from 'CE3 simulation(a commercial solution program for the evaluation of building energy performance based on international standards ISO 13790, and German evaluation standards DIN V 18599)' compared with infiltration data obtained from blower door test.

Actual heat loss parts of openings and gabs were figured out using thermal images. More heat loss was observed at openings than gabs. Installing wind barriers results in decrease of heating energy demand. Sealing both openings and gabs showed the highest result. It is saving fossil fuel 1.03 liter per a square meter area. The Whole Han-green house showed significant performance which saved 185.4 liter of fossil fuel and about 250 U.S. dollar per year. Further study on reducing gabs between openings and walls at construction has to be conducted.

Keywords: airtightness, infiltration, airbarrier, building energy consumtion, fossil fuel

PP249

The Carbon Footprint of Office Paper: Influence of the Estimation Methodology

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While a full Life Cycle Assessment (LCA) may be difficult to develop and apply by industrial companies due to its complexity, carbon footprint studies are more feasible for industrial actors. The carbon footprint of a product is usually defined as a measure of the greenhouse gas (GHG) emissions from the life cycle of the product. Currently there are several methodologies available for estimating the carbon footprint of products.

The objective of this study is to perform a comparative analysis of the application of three different methodologies for estimating the carbon footprint: (1) the ISO 14040/14044 standards limited to the analysis of GHG emissions and the corresponding impact category global warming; (2) the PAS 2050; and (3) the Confederation of European Paper Industries (CEPI) framework. The product selected for this analysis is office paper produced in Portugal from virgin fibre chemical pulp.

The carbon footprint was calculated from cradle-to-customer, i.e., up to the arrival at the distribution platform. The three methodologies under analysis differ in several aspects, such as the allocation procedures and the cut-off rules that establish the processes that are included within the system boundaries. The inventory data for the production of eucalypt wood, eucalypt pulp and office paper were provided by the industry. Inventory data for the remaining processes were taken from LCA databases.

The carbon footprint was estimated to be 4.64, 4.74 and 4.29 g CO-2eq per A4 sheet according to, respectively, the ISO 14040/14044 standards, the PAS 2050 and the CEPI framework. The adoption of the ISO 14040/14044 standards required less effort in data collection and allowed the quantification of 98% of the total GHG emissions. General methodologies such as those analysed in this study are not enough for the comparison of products. More specific rules, such as Product Category Rules, that limit the degree of freedom in the choice of the functional unit, system boundary, allocation rules, data quality, between others, should be developed.

Keywords: Carbon footprint; methodology; office paper

PP250

Habitat Utilization and Conservation of Roan Antelope (Hippotragus equinus) in Kamuku National Park, Kaduna State, Nigeria

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Habitat utilization and conservation of roan antelope (Hippotragus equinus) in Kamuku National park, Nigeria was investigated. The purpose of the study was to assess the level of habitat utilization by roan antelope (Hippotragus equinus) in Kamuku National park, assess the conservation and conservation practices of roan antelope (Hippotragus equinus) in the park and establish whether there is a link between habitat utilization and conservation of roan antelope in the park. Observational and field survey method was used for the study in which field survey was embarked upon to observe physical aspects of the study.

A set of 60 questionnaires were administered randomly to the respondents mostly park officers in the Dagara and Doka ranges of the park and park researchers who have adequate knowledge and have monitored the roan antelope (Hippotragus equinus) over the years. Results obtained showed that majority (93%) of the park officials were aware that there is need for conservation of roan antelope in the park. Conservation practices included anti poaching (75%) with habitat management and improvement (25%). It was obtained that majority of the roan antelope (Hippotragus equinus) (36.67%), (33.34%) and (45%) utilize water holes, grazing areas and saltlicks respectively. The Chi square analysis showed that both habitat utilization and conservation are interrelated.

The conclusion drawn from the study is that habitat utilization and conservation of roan antelope (Hippotragus equinus) in Kamuku National park is interrelated. The need to ensure that the habitat is managed for the optimum utilization by the animal is essential. The roan antelope (Hippotragus equinus) should be protected anytime they are using features such as water holes and saltlicks where mostly they are sighted and killed.

Keywords: Habitat; conservation; saltlick; waterhole

PP251

Sustainability management of forest products and sustainability assessment of new forest industry and cross-industrial symbiosis products: barriers or new horizons?

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The purpose of this study was to assess the challenges of sustainability management of forest products and assess the sustainability of new forest industry symbiosis products. Sustainability assessment was focused on the recycling of residue materials from e.g. an integrated pulp and paper mill into secondary raw materials for new symbiosis products such as soil amelioration pellets. The overall assessment encompassed a review of EU and Finnish policy and legal framework, a life-cycle assessment (LCA) and a questionnaire survey directed at various forest sector companies. The LCA study aimed at comparing the environmental performance (in terms of Global Warming Potential (GWP)) of symbiosis products with the performance of similar commercial products based on virgin primary raw materials and the treatment of residues as waste (the current situation/management approach). Sustainability management challengeswere addressed through questionnaire survey and matrix-based assessment.

The results suggest that a comprehensive approach is needed to both sustainability management and to waste prevention and recycling encompassing the utilisation of wastes as a valuable resource to be recycled for further use and application of life cycle thinking for minimisation of environmental impacts. Key issues comprise addressing the implications of EU and national legal instruments for symbiosis products that are based on multiple cross-industrial residue flows (several recovered/recycled residues) as well as further development of EoW legislation and criteria encompassing focus on more product-based and innovative approaches as well as consideration of the practical implementation of the waste hierarchy. In general, new thinking is needed from both industry and regulatory authorities encompassing, for example, a stronger focus on local aspects. The results of the LCA indicate that manufacturing of secondary products causes very low environmental burden. Moreover, these new symbiosis products have great potential to improve the environmental performance of forest products industry through both product and process replacement and avoided landfilling and waste treatment. In brief, recycling of cross-industrial residues into secondary raw materials for new symbiosis products can especially reduce the environmental burden associated with the manufacturing of equivalent products based on virgin primary raw materials and with landfill construction and landfilling operations.

PP252

Water footprint methodology and concept analysis

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The application of environmental footprint calculation to products, inspired by Life Cycle Assessment Methodology, should have as major objective the reduction of the environmental impact to perform a certain function by:

- supplying sound and reliable information on the real impact of each option to the consumer for an informed choice;
- identifying opportunities for producers to reduce its specific impact along the production and supply chain of the product.

These concepts and objectives are easily addressed and achieved by carbon footprint calculation, where it is possible to establish commonly agreed methodologies of quantification and more important it is known and accepted the relation between the quantified indicator (CO2 equivalents) and the environmental impact (Global Warming Potential). Moreover, being a global problem, the decision for a lesser GWP intensive product will in fact contribute to a lesser environmental impact.

On other hand, the case of water footprint and specifically the methodology proposed by the Water Footprint Network fails to meet the above mentioned objectives and the application to pulp and paper industry leads to confusion and misunderstanding by general public and stakeholders.

The lack of relation between the water footprint global results obtained by this method and the real impacts in water resources is discussed in this article with special attention to the application to forestry and pulp and paper industry. Some of the crucial issues are:

- the multiple nature of water use impacts (environmental and social) makes very difficult to reduce its significance to an unique value of volumetric water use;
- the extent of water use impact is essentially local dependent and again extremely difficult to evaluate a single indicator;
- the concept and accounting of the so called green water and its application to forestry.

These limitations on meeting the objective of such and environmental management tool should and has been leading to the discussion and proposal of a revision of methodology and concepts by other authors.

Keywords: Water footprint, pulp and paper, forestry, water use and impact

PP253

The Oregon Wood Innovation Center: Lessons Learned in the first Six Years of Operation

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The Oregon Wood Innovation Center (OWIC) was established in 2006 as a joint initiative of Oregon State University's Extension Service and College of Forestry. Its primary mission is to help improve the competitiveness of Oregon's wood products industry by fostering innovation in products, processes, and business systems. This presentation discusses the first six years of operation – the primary activities, approaches that have worked well, as well as those that have not, and recommendations for others involved in outreach focused on forest sector competitiveness and innovation.

OWIC has had four primary areas of focus: 1) technical assistance; 2) applied research; 3) education; and 4) communication/networking. Technical assistance has varied from relatively simple activities like responding to an email about the physical properties of a wood species to more time-intensive activities such as a series of meetings with an entrepreneur discussing market opportunities and channels for a new product. Applied research has varied from exposing prototypes of new products to changing ambient conditions to student internships with companies to assist the firms enter a new export market. Educational efforts have included traditional approaches such as workshops and publications as well as electronic tools/resources and webinars. Lastly, efforts related to communication/networking have included web-based discussion forums and an industry directory that facilitates communication between buyers and sellers.

From the standpoint of industry impact, of the above mentioned activities, areas that have been most successful have been technical assistance and applied research. Not surprisingly, industry personnel are most interested in receiving timely and comprehensive responses to requests for information and/or in solving problems. Involving students in projects has helped to both complement the students' education and has stretched limited resources (financial and personnel).

Efforts focused on education have only been moderately successful in part due to the recession; low enrolment has led to cancellation of many long-standing courses. This has been the case even with a newly-developed distance education series. Web-based discussion forums were not at all successful. Despite being widely advertised to the target audience, only a very small group of people participated.

For others considering developing a similar entity, the areas of focus must, of course, match the metrics for success. Assuming tangible industry impact is the goal, experiences with OWIC suggest an emphasis on providing timely responses to industry requests for technical assistance and problem-solving research. Involving students in projects can greatly stretch limited resources. And while educational workshops and publications are undoubtedly valuable, it is suggested these activities should receive lesser emphasis.

Keywords: Innovation; technology transfer; industry extension/outreach

PP254

Wood Science and Technology Education in Europe after Bologna

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After the political reforms in 1989, the large research centers and high education institutions of Eastern Europe were reintegrated and reformed in order to be able to survive the economic and political changes. At the same time pressure from Western countries was high and resulted in a decline of the paper and wood processing industries. The harsh competition, massive immigration of high qualified personnel from East to West and the transfer of the production capacities from Western to Eastern part of Europe in order to avoid higher raw material costs, salaries but also high environmental requirements had a major impact on the quality and number of students in both regions. The effects of these developments during the past two decades have been dramatic for wood-based industries. Imports from multinational corporations, combined to low exports of own products and furniture at low margins impacted the industry. Many of the traditional production and national research centers had to close. The number of students reduces while the no. of faculties with wood science, technology or building program increased and governmental support declined. Political changes during the past decade, and the expansion of the European Community improved the situation, as foreign companies invested modern processing facilities and created new jobs in Eastern Europe. The impact of the Bologna process continued reformation of the state institutions, and the quick preparation for the job market requires highly motivated students and flexible and up-to-dated staff. A complete flexibility of studies between countries, regions and directions, the splitting of five years diploma studies in bachelor and master cycles and up ranking of universities of applied sciences are only some of the benefits of this Process. A short presentation of each main high educational center for wood science and technology in Europe and the data of the wood processing industries behind these will be given in this presentation.

Keywords: wood science and technology, European higher education, Bologna process

PP255

CNR-IVALSA experience in wood education at the Science Festival in Italy

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Wood is a material that has always accompanied man since his appearance on Earth and has been often essential for his survival. Forests live and grow continuously producing wood that, consequently, is one of the few truly renewable raw materials, the use and processing of which requires a low amount of energy. Throughout his history, man has always used timber to get warm, to manufacture equipment and tools, to build, to create works of art. Wood still has a lot to give, such as the numerous applications in the field of green building: roof beams, floors, wooden panel walls for earthquake-proof houses, bio-fuels as well as production of bio-oil and energy. Wood is all around us every day and it is important that ordinary people discover it.

Within the last decades the basic understanding of wood have been lost, what once was handed down from generation to generation, especially in rural areas, has left a void.

For this purpose we developed a series of experiences within an educational workshop, and we propose it since 2009 at the Science Festival held in Genoa, the most important event in Italy devoted to scientific dissemination.

The educational workshop deals with anatomy, wood chemistry, mechanical characteristic and other important topics related to wood.

Through the use of microscopes it is possible to reveal the anatomy of wood, and its particular structure. Looking at the structure of cells with the use of specific software, is possible to identify the most common wood species in the Mediterranean countries. Recognize wood is very important for cultural heritage and to protect species endangered. Some experiments deal with the physical characteristics of the wood. Wood is a material that shrink and swell when temperature and air humidity changes. This phenomenon is found for example in wood floors that "jump" due to an excess of humidity. Another part of the workshop is about wood chemistry. Why do some woods become black when wet for a long time and how were made the first inks? Wood chemistry with colours and smells that characterize the wood species are shown e.g. the pine, the pine Aleppo, cypress, chestnut, etc. Another part of the workshop is about insects that sometimes inhabit it (for us unwanted insects) and the forms of defence used to preserve important wood works of art. Schools and families with children participated to the workshop. We found a lot of intereste by children and people who had never had the opportunity to understand wood. It 'was so clearly important for people to come close to it!

Keywords: Wood education; workshop; teaching lab; experiment; wood material science

PP256

Society of Wood Science and Technology – A Bridge Linking Academia, Community, Industry and Government

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SWST is an internationally-recognized professional organization of wood scientists, engineers, marketing specialists and other professionals concerned with wood. Members are dedicated to the wise use of one of our most environmentally-sound resources. SWST is committed to protecting our forests through the development of new ideas, procedures, policies and products for the wood industry. This organization establishes a forum for the exchange of ideas, the communication of knowledge and the development of high standards, policies, and ethics for wood research and the wood industry. One mechanism we utilize to bridge education to ultimate practice is our quarterly journal, Wood and Fiber Science which is not only in printed format but available in an electronic format. Only by supporting the high principles of conservation-minded use of our wood resources, can we reduce the impact on our forests. Quality education in our field is a fundamental first step in taking wood science and industry into the 21st century. By fostering educational programs at all levels of the field--undergraduate, graduate and post-graduate--SWST aids universities and colleges in providing a quality educational foundation through accreditation of wood science and technology programs. In a continuing effort to expand awareness of problems and solutions concerning the overall wood resource use, SWST provides funding to assist qualified people to participate in national and international visits for increased awareness of progress within the wood industry field.

Keywords: Education, Accreditation, Wood Science, Professional, Ethics

PP257

Preparation of ultra-strength nanopapers using cellulose nanofibrils

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Cellulose nanofibrils were manufactured from cellulose powder (45 mm particle size) using a high pressure homogenizer with various pass numbers. In the present study, the cellulose nanofibrils were used to prepare nanopapers of extremely high tensile performance. Chemical modifications with the increased pass number through the homogenizer provided the dramatically increased tensile modulus and strength of the nanopapers. By using various pass number through a high pressure homogenizer, the cellulose nanofibrils (CNF) with diameter of 10–100 nm were prepared. The DP of the CNF was linearly decreased by the increase of the pass number. The increased pass number through the homogenizer provided the dramatically

increased tensile modulus and strength of the nanopapers, probably due to the increased surface area and hydrogen bonding sites by the homogenization, 3D network structure between the CNFs, and improved stress distribution during the tensile test. By the NaOH treatment, tensile strength of the nanopapers was significantly higher than the untreated counterparts. The extraordinary high tensile strength of the nanopapers with the TMOS treatment after NaOH treatment is highly related the increased surface area and density by the homogenization, 3-dimension network between the CNF and siloxane, and improved stress distribution during the tensile test. Without any chemical and enzymatic treatments, the tensile modulus of the simply homogenized nanopapers was 10.6 GPa.

With the NaOH (2%) and TMOS (2%) treatment after 16 pass through the homogenizer, the tensile strength of the nanopapers was 212 MPa. From this study, these ultrastrength nanopapers have potential for industrial applications, i.e., specialty papers for construction industry, reinforcing materials for composite industry, and separators in lithium ion battery for electronic industry.

Keywords: cellulose nanofibrils, nanopaper, alkali treatment, silanes, tensile properties

PP258

Impact of wood – rotting fungi on poplar and willow wood used in kraft pulp production

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The impact of microbiological changes, occurring during the storage of poplar and willow wood, on the yield and characteristics of kraft pulp produced in laboratory condi¬tions was researched.

For research purposes, round wood (pulp wood) with bark and without bark, in stack of one cubic meter, was exposed in the open for a year. The research includes wood of pop¬lar Populus deltoides cl.725, aged 9, and willow Salix alba cl.107/85/7 aged 13.The samples for the research of structural, physical and chemical characte¬ristics of wood, as well as for chipping for pulp production, were taken at the beginning of the experiment, 4 months and 12 months after the beginning of natu¬ral seasoning.

It was observed that, after aging for four months (winter period), there were no significant changes either in wood properties or in the obtained pulp. As after a 12-month interval of wood storage, along with saprophytic fungi and bacteria, white rot fungi (Trametes suaveolens (L/E) and Coriolus versicolor (L) Quel. were also isolated, some changes of wood were observed, i.e. wood degradation. This was manifested by the change of density which was reduced for 5 to 8%, depending on wood species and the method of storage – unbarked wood was subject to more severe damage due to a slower loss of moisture. The content of cellulose in wood apparently increased for about 8%, while the content of lignin decreased for about 1%.

The loss of wood substance had an adverse effect on the yield of pulp. Namely, by calculating to the initial state, the decrease of pulp yield is evident for both species of wood, and especially in case of unbarked wood. Kappa number of pulp decreases with the prolongation of wood storage, which is understandable considering the decrease of lignin content in wood.

Keywords: Populus sp., Willow sp. Trametes sua¬veolens (L/l), Coriolus versicolor (L) Quel.,kraft pulp.

PP259

Aplications of solid wastes from pulp and paper mill as fertilizers and soil amendment

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Demand for increased performance of the pulp and paper industry made solid wastes management an important issue, especially because higher productions means more solid waste generation and technologies adopted to minimise environmental impact generally lead to more solid waste production. Due to chemical composition and physical features, some solid wastes can be used as fertilizers and soil amendment, particularly primary and biological sludge, lime mud, ashes from biomass combustion and eucalyptus bark from wood yard. This paper joins up the main experimental results on the potential of these materials, as from lab and field trials carried out by RAIZ, which is Portucel Soporcel group's Forest and Paper Research Center.

The most recent field trials evaluation, covering eight different soil and climate conditions in Portugal, suggests that the mixture of secondary sludge and ashes has a positive impact on eucalypt growth, overcoming traditional fertilization. Soil pH, organic matter and nutrient levels were increased with the application of this mixture. Developing stable composts from this kind of mixture has also been studied, due to high moisture level of solid wastes in original conditions impacting transportation costs and spreading operations. Different mixtures of wastes (primary and biological sludge, ashes, eucalyptus bark or wood preparation waste) were recently tested under different stack aeration and covering systems. Stabilization was achieved after 35 days of maturation and the final products presented lower moisture content.

Regarding lime mud, an incubation lab study, using nine different forest soils, demonstrated its efficiency for pH soil correction. This product was more efficient than commercial calcic fertilizer and did not induce negative balance on soil nutrients.

Keywords: solid wastes, fertilizers and soil amendment, plant growth, composting, soil correction.

PP260

Hemicellulose and Carboxymethyl cellulose /alum modified kaolin fillers: Preparation and their use as fillers in kraft bagasse pulp

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In this work the application of kaolin modified with hemicellulose and carboxymethyl cellulose (CMC) in presence of alum as fillers in kraft

bagasse pulp was investigated in detail. It was found that the kaolin modified with carboxymethyl cellulose/alum could improve the physical properties of hand sheets, while the modification of kaolin with hemicellulose and CMC/alum could enhance sharply the physical properties of hand sheets and the amount of the retained kaolin.

The breaking length of hand sheets filled with kaolin modified with CMC/alum increased by 15% compared with the control hand sheets without any additives added and increased by 22% in case of kaolin modified with hemicellulose and CMC/alum. Filler modification significantly improved filler retention and the brightness and opacity of the hand sheets filled with modified kaolin was significantly improved comparing with either the control hand sheets or that filled with unmodified kaolin.

SEM observations of the fillers confirmed the surface encapsulating effect of the modifiers on the filler. SEM images of the paper-sheets indicated that modified filler particles were more effectively adhered and bonded to the pulp fibers, in comparison to unmodified filler particles. The results indicated that the cooperation of hemicellulose and CMC could be used as a source for production of a good retention aid in papermaking.

Keywords: Kraft bagasse, Hemicellulose, Carboxymethyl cellulose (CMC), Alum, Kaolin, Hand sheet, Breaking length, Brightness, SEM

PP261

Direct effects of refining pilot-scale (Andritz Sprout-Bauer) on suspension and hand sheet properties of *Eucalyptus globulus*

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The preparation of pulp for the production of paper involves a key unit operation that is known as refining. In this process, the fibers are mechanically beaten in an aqueous medium to gain flexibility, collapsibility and ability to establish hydrogen bonds, which finally gives resistance to paper. This process consumes large amounts of electricity and is therefore an expensive operation, where the energy optimization is essential. One aspect of the subject of controversy, when this operation is applied to commercial Eucalyptus globulus kraft pulp, is to know how the refining variables, namely the specified edge load (SEL), the number of cycles, the flow rate, the residence time and the pulp consistency, n affect the development of the properties of the fibers, paper and energy consumptions.

The present work aimed at evaluating the influence of specified edge load (0.05, 0.1 and 0.2 J/m), flow rate (50, 100 and 200 L/min.), specific energy consumption (0, 40, 80 120 KW.h/ton), residence time and consistency (3 and 4%) on the development of fiber and paper properties of Eucalyptus globulus.

It was verified that when a relatively high specified edge load is used (0.2 J/m), the result is that mean fiber length (weighed in length) significantly decreases, indicating higher cut of the fibers during the refining. Regarding paper structure, papers with lower density (i.e., higher open structure, higher permeability and lower smoothness) were obtained by beating the pulp with a low specified edge load (0.05 J/m). Papers produced with a specified edge load of 0.2 J/m presented a higher resistance (, burst index and tensile index), but increasing refining energy from 80 to 120 kW.h/ton did not improve of the properties of the paper.

It was found that the papers obtained from refining conditions with the highest flow rate, 200 L/min,. are more resistant and have a lower opacity, while the papers produced with lower flow rates (100 and 150 L/min.) present lower density, i.e., a more open structure, and are more permeable and less smooth.

Keywords: Eucalyptus globulus; pilot refiner; specific edge load, flow rate, paper potential

PP262

Indices of the wood fiber of a clone of *Eucalyptus grandis* W. Hill ex Maiden x *Eucalyptus urophylla* S. T. Blake

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The Brazilian forest plantation though Eucalyptus genus are the supplying of the raw material demands of the major forest enterprise, in especial that pulp wood. The wood produced by these planting need to attend the rules of quality of trade market. To understanding of the material and your and adequation to the industry it's necessary to know the relationships among dimension of the fibers and properties of the pulp wood and paper. There index based in the wood anatomy are considered a good tool to something for characterization of wood for this purpose.

The present study was to determine the values of the indices commonly used to assess the quality of wood for paper production. The indices used were: Felting Index (FI), Flexibility Coefficient (FC), wall fraction (WF) and Runkel index (RI). Were used of fifty trees of Eucalyptus grandis x Eucalyptus urophylla clone with six years old belong provenance of planting located in the Martin Campos city, Minas Gerais state, Brazil. Of each tree were removed disks at the height of 1,3 m (DBH) were it used samples to make the macerate.

The average values of Felting Index (FI) was 68,32 , Flexibility Coefficient (FC) was 50,73%, wall fraction (WF) was 49,40% and Runkel index (RI) 0,98. These indicativos of the genetic material studied to show your adequacy to produce the tissue paper. This indication is due the high Runkel Index, near the one, and the Flexibility Coefficient near to fifty percent.

Keywords: wood, pulp production, short fiber anatomy.

PP263

Effect of Co-binders for Coating on the Performance of Fluorescent Optical Brightening Agents

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Proportions of BCTMP in pulp mix increase with the trend toward lighter paper grammage, leading to a decrease in brightness of coated paper which influence the quality of the paper as well. Adding fluorescent optical brightening agents (OBAs) to coating formula could raise apparent whiteness of the coated paper. If suitable co-binders could be found as carriers of the OBAs to exert a synergestic effect, then apparent whiteness of the paper can be further increased. The experimental design selected a typical coating formula for art paper and 3 kinds of typical co-binders (starch, carboxymethyl cellulose, CMC, and soy protein) were tested. Four different types of OBAs (di-, tetra-, hexa-sulpho, and a new DSBP chemicals) were applied at dosages of 0.25, 0.5, 1.0, 1.5, 2.0 and 4..0 parts (the whole color was 100 parts). The brightness, apparent whiteness, and CIE L*a*b* values of the coated paper were then evaluated. The experiments comprised of 78 sets of treatments. The results indicate that CMC co-binder and 4 parts hexa-sulpho-OBA produced coated paper brightness of 90.11% GE, and apparent whiteness of 92.20% GE was the highest combination. There was no significant effect on the coated paper brightness and apparent whiteness among the combinations of the 3 co-binders and 4 OBAs. When the slightly yellowish CMC was used, the resulting coated paper had slightly less apparent whiteness than those of starch or soy protein did. Calendering tended to lower the brightness and apparent whiteness of the coated paper. However, there was less effect on these parameters when CMC was the co-binder than in the cases when starch and or soy protein was the co-binder. We found that hexa-sulpho and DSBP OBAs were best suited for coating operation and the optimal dosages were 4 parts, while the di- and tetra-sulpho-OBAs reached their limit at 2 parts dosages. Using CMC as a co-binder showed better brightness and apparent whiteness gains while there was less influence of the calendaring on the coated paper.

Keywords: fluorescent brightening agent, brightness, apparent whiteness, co-binder, starch, carboxymethyl cellulose (CMC), soy protein.

PP264

Combustion and Weather Resistant Properties of Wood Composites Treated with Wood Ash Based Hydroxyapatite

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From a viewpoint of wooden waste reusing, they are widely combusted as woody biomass fuel in order to gain a heat and/or electrical power. But at the same time, enormous quantities of wood ash are also extracted and the reusing ways of wood ash were further explored. In this study, the wood ash was prepared from combusted bark of Japanese cedar (Cryptomeria japonica) and by treated with the phosphoric acid, Hydroxyapatite (HAp) gel solution was synthesized from the wood ash. The HAp solution was impregnated into the lumber of Japanese cedar, and a new composite wood material with the wood ash based Hydroxyapatite was developed.

In order to examine the combustion property of the wood-HAp composites, the analysis with a differential thermal and thermogravimetric analyzer (DTA-TG) were conducted on them. The results show that the exothermic peaks from untreated woods were weakened by the HAp treatment and the HAp composites show a similar burning characteristics to those treated with the other phosphoric fireproof agents.

Also to estimate the weather-resistant properties of the wood-HAp composites, the outdoor exposure test was conducted on the HAp treated stake specimens. The stakes were planted at the test area to their half length depth, and the degrees of their underground decay progress were periodically checked. At present, a lapse of two years exposure, the decay progress of HAp composites was comparable in those of controls, untreated wood stakes. In addition, the color measurements were also conducted on their overground area and the result indicates that the HAp-wood composites show a slow color fading compared with those of the untreated wood stakes. These results imply that the HAp treatment on woods have some weatherproof efficacy against a sunlight irradiation, although no retarding effects against a wood rotting progress were confirmed at two years exposure passed.

Keywords: Wood composites; Wood ash; Hydroxyapatite; Combustion; Weather resistance.

PP265

System for Prediction of Cork Growth

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A cork growth model for cork oak forests was developed using data from 77 cork samples. The McDill-Amateis difference model and difference forms of the Chapman-Richards, Lundqvist-Korf, Monomolecular and Schumacher growth models were derived to model cork growth in Sierra Morena (Andalusia, Spain). Both qualitative and quantitative criteria were used to compare alternative models.

The polymorphic difference equation derived from the Lundkvist-Korf function, Lundkvist-k, resulted in the best compromise between biological and statistical aspects, producing the best growth curves. This model can be used to predict cork thickness in complete rings at any year of cork rotation.

Keywords: Cork oak, Cork thickness, Growth models, Difference equations.

PP266

The threat of *Diplodia corticola* to cork oak – how does infection occur?

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Quercus suber, or cork oak, is a typical evergreen tree found in Mediterranean forests of increasing importance due to its renewable bark, cork. This natural product has numerous industrial applications, with emphasis to cork stoppers, of which Portugal is currently the production, processing and export leading country. Furthermore, the majority of worldwide transactions of transformed cork have its origin in Portugal and, consequently, this competitive sector entails enormous socio-economic advantages. Moreover, cork oaks have also ecological benefits, not only comprising a biodiversity hotspot in Mediterranean ecosystems, but also playing an important role in water balance regulation and soil conservation of cork oak forests.

However, cork oak forests have been suffering a serious decline in the Iberian Peninsula, promoted by the sum of severe droughts, summer flooding and alterations of agronomic practices that induces stress in lands around cork oak trees. The conjugation of these adverse environmental factors over the time weakens the oak tree's health, impairing its ability to resist to opportunistic pathogens, like insects and fungi, which exacerbate the illness. As a consequence, it has been notorious a progressive deterioration of cork oak forests that culminates in death of trees, a great threat to cork production and all industry associated.

Recently, it was identified a fungal phytopathogen directly related to this decline, Diplodia corticola, that causes symptoms like dieback, canker and vascular necrosis in oak trees. The infection mechanism of this fungus is still unknown.

The main question arising is: how can we control the infection caused by fungi? New technologies like proteomics can help answering this through the identification and characterization of fungal proteins involved.

In this communication we will present data concerning the proteins that are expressed by D. corticola addressing their functions within the cell. The identification and study of the complete pool of secreted proteins may lead to new control measures for fungal diseases, impacting the plant yields and agricultural profits.

Keywords: Cork oak decline; Diplodia corticola; Proteomics

PP267

Mediterranean woody shrubs properties and biomass potential as source of energy

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The woody shrub species Cytisus multiflorus, Erica arborea, Pterospartum tridentatum and Ulex europaeus native from central Portugal and NW Spain were studied, in order to assess their potential as a source of biomass.

Physical, thermal and chemical properties, including density, moisture content, calorific value, proximate and ultimate analysis were determined, and the fuel energy density (Ear) was calculated. Also, ash characterization, slagging and fouling risk and potential heavy metal contamination risk and emissions risk, was evaluated.

Fuel moisture content ranged from 37.1 to 59.2 % and shrub particle density ranged from 798.7 to 896.6 Kg m-3, with the highest values found for Erica australis. The Higher Heating Value (HHV) ranged from 24.44 MJ kg-1 for Erica australis, 22.46 MJ kg-1 for Cytisus Multiflorus, 21.94 MJ kg-1 for Pterospartum tridentatum and 21.16 MJ kg-1 for Ulex europaeus.

Carbon content ranged from 46.20 to 49.84 % for shrub aboveground biomass and from 45.49% to 46.50 % for shrub belowground, with the highest Carbon content found for Erica australis shrub aerial biomass. Nitrogen content ranged from 0.63 to 2.05 %, with the highest values found for the leguminous Cytisus multiflorus at both areas of study. All shrub biomass samples had shown a Sulphur content below 0.1 %.

Ashes composition ranged from 16.6 % to 33.6 % in silica, and an alkali metals content of 23.7 to 30.1 %, this representing a probable slagging risk. Ash heavy metal content (As, Cd, Pb, Co, Cu, Cr, Mn, Ni, Cr, and Zn) was below national and European legislation maximum levels suggesting the possibility of utilizing shrub ashes as a fertilizer for nutrients replenishment after biomass harvest.

Keywords: Shrub biomass; Fuelwood; Combustion properties; Heating Value; Biomass ash

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PP268

Bark fibre biometry of *Brachystegia bohemii* Taub., *Burkea africana* Hook and *Pterocarpus angolensis* DC. from Niassa National Reserve (Miombo)

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Niassa National Reserve in northern Mozambique is the largest conservation area of miombo woodlands on Earth and one of the most pristine areas of Mozambique. It is recognized that Miombo woodlands provide a wide range of forest products, namely as source of timber and wood fuel but also non- timber forest products such as the tree bark.

Bark is an important source of fibre and it is recognized that has great potential in sustainable forest management and livelihood of

the local communities. The knowledge of bark fibre length, width and cell wall thickness is essential for adequate uses, although in the Miombo woodlands people widely used it for making i.e. fastening strings, ropes, mats, baskets, bags and fishing nets. This preliminary study was made on trees of Burkea africana Hook, Brachystegia boehmii Taub. and Pterocarpus angolensis DC., species with relevance to the local communities. In literature no records of bark biometric features of these three species are available, so the aim of this study is adding new information to promote and improve different uses of this resource material.

For each species 10 trees, with different diametric classes, were sampled at breast height (bh). Bark individual specimens were taken sequentially from the cambium towards the periphery and prepared for maceration. Length, width and wall thickness of 40 fibres per tree were determined using a semi-automatic image analyzer.

Fibre length, width and wall thickness were respectively 1.35mm, 22 µm and 7µm for B. africana; 1.87 mm, 14 µm and 4µm for B. bohemii and 1.46 mm, 24µm, 8 µm for P. angolensis. For all species an analysis of variance showed significant differences ($P<0.05$) between tree diametric classes and fibre biometric characteristics.

Keywords: bark; fibres biometry; Brachystegia bohemii; Burkea africana; Pterocarpus angolensis

PP269

Economics Of The Conversion Of A Traditional Paper Mill For Valued-Added Dissolving Pulp Production

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ABSTRACT

The increasing world demand for rayon has prompted an interest in the conversion of traditional paper mills to the production of dissolving pulp, with a goal of increased profitability. An analysis was done of a model mill manufacturing printing and writing papers, to investigate the economic feasibility of converting it for the manufacture of dissolving pulp suitable for viscose rayon production. The process changes were modeled using a computer simulation. Capital equipment requirements and costs were estimated, and an overall economic and sensitivity analysis were performed.

PP270

Assessment of Total Biomass Production of Two Potential *Acacia* Species Planted in A Mixed Exotic Tree Species Plantation

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Acacia mangium Willd and Acacia crassicarpa A. Cunn Ex. Benth are two potential exotic species, commonly planted in plantation in Asia. Both species are native to northern Queensland, Australia, Papua New Guinea and Eastern Indonesia. In Malaysia, these species were introduced mostly for multi-purpose not only for timber production but also to assess the possible effects on environmental and social needs. Despite the uncertainty in using fast growing exotic species for timber production in Malaysia, these species may be useful in overcoming the imbalance in carbon exchanges.

The aim of this study was to quantify the total biomass production of planted A. mangium and A. crassicarpa at aged 12 years old by developing allometric equations through destructive sampling. Eight representative sample trees per species were destructed. The best fit of allometric equations were developed from the combination of quadratic of D and H which is recommended for estimating tree component biomass and stem volume.

The results showed that A. crassicarpa has higher stem volume (323.44 m3 ha-1) compared to A. mangium (304.13 m3 ha-1). The aboveground biomass and total biomass of A. crassicarpa were also found higher than the ones found for A. mangium. The aboveground biomass and total biomass of A. crassicarpa and A. mangium were 223.42 t ha-1 and 268.41 t ha-1, and 191.91 t ha-1 and 233.63 t ha-1 respectively.

Keywords: Acacia mangium; Acacia crassicarpa; biomass production; allometric equation; exotic forest

AUTHOR INDEX

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