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Sabal minor (Arecaceae): a New Northern Record of Palms in Eastern North America

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ABSTRACT

We report a new *Sabal minor* county record for North Carolina that represents the furthest known northern population of the largely tropical family Arecaceae in eastern North America. We give a brief introduction to *Sabal* and explain why this *S. minor* population may represent a northward range expansion in response to climate warming in northeast North Carolina. Finally, we discuss the usefulness of both historical herbarium specimens and modern day botanical collections to research on climate change and plant population responses.

INTRODUCTION

The genus *Sabal* Adans. (Arecaceae) comprises 16 species distributed along the coastal plains of the southeastern United States, eastern and western mainland Mexico, northwestern South America, and a number of Caribbean islands (Zona 1990). *Sabal minor* (Jacq.) Pers., known commonly as the dwarf or swamp palmetto, is native to the southeastern United States (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Oklahoma, and Texas). A disjunct population was discovered by Goldman (1999) in the Sierra Madre Oriental, west of Linares in Nuevo León, Mexico. It is the southernmost population of this species and likely represents a previously undiscovered or unrecognized population (Goldman 1999; D. Goldman, pers. comm.). Other extant *Sabal* species native to the continental United States include *S. etonia* Swingle ex Nash (Florida), *S. mexicana* Mart. (Texas and Louisiana), and *S. palmetto* (Walt.) Lodd. ex Schult. (Florida, South Carolina, North Carolina, and probably naturalized in Louisiana).

Sabal minor is more widespread than any other *Sabal* species in the United States and is currently in good conservation standing everywhere except perhaps Oklahoma (listed as S1, "critically imperiled", www.natureserve.org). *Sabal minor* is morphologically distinct from *S. palmetto*, the only other palm species in North Carolina, because it lacks an above ground stem and usually occupies a different habitat. Along the Atlantic and Gulf coastal plains, it is a facultative wetland species and grows near oxygen-limited "blackwater" swamps, in floodplains and alluvial forests, moist beaches, and into mesic and drier (e.g., in Texas and Alabama) mixed hardwood and prairie communities further from the coast (Zona 1997). It can be found on a number of substrates ranging from loamy limestone-derived soils to sandy soils. *Sabal* flowers are pollinated by bees, wasps, flies (Henderson 1986, Zona 1997), other insects, and probably wind to a lesser degree. The fruits, like other *Sabal* species (Zona 1997), are dispersed by birds and mammals (e.g., bear, deer, raccoon). *Sabal minor* has floating fruits and thus is also believed to disperse via water (Zona 1990). *Sabal minor* is of particular horticultural interest because it is one of the hardiest palms in existence (some to −20.6 Celsius or −5°F), inclusive of

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Figure 1. Map of North Carolina *Sabal minor* collections housed at DUKE, PH, UNC, and US; specimen location marked by collection date; 2004 is the new Martin County record; the previously believed (mistaken) northernmost population (Dare County) is circled; the actual, former northernmost population (Green County) is in a square; the closest known population (in km) to the Martin County population is in a polygon; two weather stations are labeled; four North Carolina collections not shown because localities are the same as other collections shown on map: *Burk 109-1* (Dare County, 1959), *An s.n.* (Carteret County, 1968), *Williamson 64* (New Hanover County, 1911), *Hunt s.n.* (Brunswick County, 1944).

all other *Sabal* species, and it is grown as far north as zone 6 (New Jersey, southeastern Pennsylvania, etc.).

We report a *Sabal minor* population found on 30 October 2004 while canoeing on Gardner Creek (Martin County), a tributary of the lower Roanoke River just southeast of the Bertie County border in North Carolina (Figure 1). At UTM 18 325035E 3965735N (USGS NAD 83) or 35°49′13″N and 76°56′12″W, the population is located on a partially inundated hummock in a bottomland bald cypress swamp, growing with *Nyssa aquatica* L., *Acer rubrum* L., *Taxodium distichum* (L.) L. Rich, and *Quercus lyrata* Walt. It is approximately 20 meters southwest of the main channel, 20 × 15 m in area, and contains an estimated 35 individuals. Plants are approximately 1.0 to 1.6 m in height (contact authors for photographs). A voucher is housed at DUKE (*Erin Tripp 119*). The entire population was sterile and we found no indication of a previous reproductive season (e.g., old peduncles, fruits). Nevertheless, we believe this to be a mature, reproductive population because the large number of individuals of varying sizes is

probably due to local reproduction. *Sabal minor* is not known to reproduce vegetatively, and 35 independent colonization events seem unlikely. Seeds and peduncles might have been washed away as this population's habitat is seasonally flooded.

METHODS

We surveyed all North Carolina *Sabal minor* collections from the following herbaria: DUKE, NCU, US, and PH (28 specimens, see Appendix), and we sampled all fertile *S. minor* collections from the entire southeastern United States from DUKE and NCU (81 specimens). We chose these four herbaria because together they house a substantial number of southeastern United States collections from the 19th century to the present. We recorded the date, location (in UTM coordinates), and plant condition (flower buds, flowering, fruiting, sterile) for all specimens. Geographic coordinates were approximated if label locality descriptions were ambiguous. We also corresponded with curators at BH, NCSC, NY, and UNCC to verify their northernmost collections of *S. minor*.

To determine if *S. minor* has expanded its range northward through time, we regressed the UTM Northing coordinate of collection locations on the year of collection. We performed this on North Carolina specimens only because this is where northward shifts in distribution might be detected. In an effort to detect shifts in phenological timing of *S. minor* over time, we conducted three multiple regression analyses with fertile specimens from the entire southeastern United States, one for each phenological condition: flower buds (N = 15), flowering (N = 23), and fruiting (N = 43). We converted the collection date (dependent variable) into day number for the year (e.g., February 8th is day 39); the year of collection and UTM Northing coordinates were independent variables. This permitted the assessment of the effect of collection year on phenological timing, independent of a latitudinal effect.

We obtained minimum daily temperature data from the two weather stations closest to the newly discovered population (hereafter the Martin County population) to determine if this population might represent a range expansion due to climate warming. Data were publicly available from weather stations in Plymouth, Washington County, North Carolina (26 km east of collection) and in Williamston, Martin County, North Carolina (15.8 km west of collection), from 1945–2003 and 1953–2003 respectively. We excluded the winter of 1949–50 from the Plymouth station because 56 days were lacking data; the Williamston station lacked data from the winters of 1982–83 and 1984–85, so these were also excluded. We defined the length of winter as the number of days between the first freezing ($\leq$32°F) and the last. We then regressed the year on length of winter for that year.

RESULTS

Based on the survey of North Carolina *Sabal* collections from six herbaria, the new Martin County record represents the northernmost known native population for this species and the Arecaceae as a whole in eastern North America. It is also significantly inland from most other collections (Figure 1). We continued to search for additional populations along Gardner Creek, Devil's Gut (that connects Gardner to the Roanoke River), and Broad Creek to the northeast, but found none. The previously identified northernmost population was from Dare County, North Carolina (Zona 1997, Weakley 2005). It was collected from Buxton Woods on Cape Hatteras (Figure 1). However, based on our review of herbarium specimens, it seems the previous northernmost population was actually a collection from Greene County, North Carolina, 44.8 km south of our collection (measured due north to south), and also significantly inland compared to other collections (Figure 1). The closest collection in a straight line to the Martin County collection is from Bonnerton, Beaufort County, North Carolina, 51.7 km away (Figure 1). The Martin County population also marks the first *Sabal minor* collection from the Roanoke River basin and the entire Albemarle Sound drainage system.

The regression of UTM Northing coordinates on the year of collection was significant for North Carolina specimens ($p = 0.0005$, $R^2 = 0.382$), with more recent collections being found further north. The multiple regressions did not show any effect of UTM Northing or year of

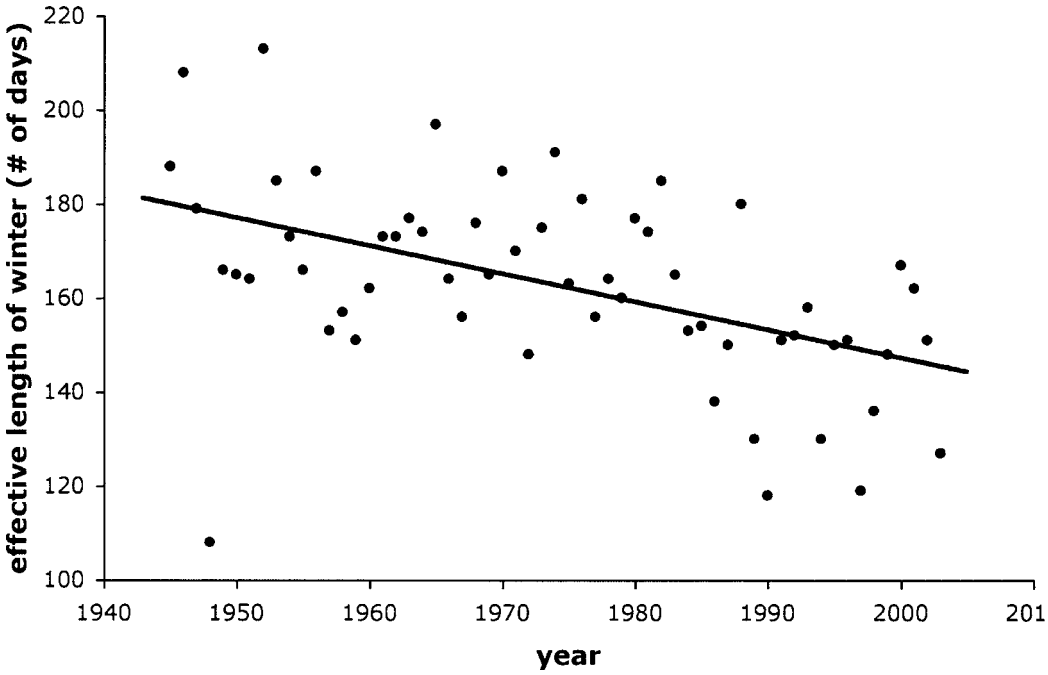

Figure 2. On Y-axis, the total length of winter (number of days between first and last freezing, i.e., below 32°F) declines over the last 58 years ($p < 0.0001$, $R^2 = 0.247$). If the outlying unusually short winter of 1948–49 is removed, the relationship is even stronger (regression not shown, $p < 0.0001$, $R^2 = 0.386$). Data from Plymouth Weater Station.

collection on timing of reproduction (flower buds, flowering, or fruiting) in *Sabal minor*. The Plymouth weather station data shows a dramatic reduction in the total length of winter from the 1940s to the present (Figure 2, $p < 0.0001$, $R^2 = 0.247$). If we substitute 1945 into the equation obtained from the linear regression analysis (length of winter = 1376.128 − 0.61458*year), we find a winter length of 181 days whereas if we substitute 2003 into the equation, we find a winter length of 145 days. The Williamston weather station shows a similar but weaker trend ($p = 0.0299$, $R^2 = 0.096$, length of winter = 1057.592 − 0.463361*year), with a drop in winter length from 156 days in 1945 to 130 days in 2003.

DISCUSSION

The recently discovered Martin County population is north of any previously documented *Sabal minor* or other native palm population (Figure 1) and also significantly inland from most other populations in North Carolina. We suggest that this population may represent a northward range expansion resulting from a less severe winter in recent years. The UTM Northing and year of collection regression analysis was significant, indicating a northward expansion through the century. However, the sample size (N = 28) is low due to the small number of available North Carolina herbarium specimens. Therefore, this trend is driven by several factors: the most recent collection date is the most northern, the oldest collections (1897, 1911, and 1911) are more southern, and the vast bulk of collections (from 1935–70) are from the central coast of the state. Based on all specimens from the four herbaria surveyed (DUKE, NCU, PH, US), either *Sabal minor* did not occur north of New Hanover County until 1935 or botanists failed to collect it north of there earlier. Future herbarium work surveying all North Carolina specimens could distinguish between these two possibilities.

An alternative explanation to the northward expansion hypothesis is that *Sabal minor*

may have always occurred this far north but botanists have failed to notice it. We discovered this population in late October via canoe, after significant leaf fall had occurred and the population was more visible. However, palms are conspicuous plants in temperate areas and populations are often easily observed. If *Sabal minor* has been present in the Albermarle Sound and Roanoke River basin for many years, it seems probable that an amateur or professional botanist would have noticed it but we cannot rule out the possibility this population has gone unnoticed.

If *Sabal minor* is indeed expanding northward, a probable explanation is the shortening in the total length of winter in northeastern North Carolina (Figure 2), interpreted as evidence of climate warming in this part of the state. However, other explanations should be considered. *Sabal minor* may still be engaged in a post-Pleistocene expansion from a southern refugium. *Sabal minor* has demonstrated an ability to grow in harsher climes than where it naturally occurs, and this species may be moving northward regardless of the recent changes in climate (e.g., during the last century). This explanation seems unlikely though because *S. minor* can be dispersed by birds and thus should not suffer from dispersal limitation, characteristic of a long lag in post-Pleistocene northward migration. Another explanation is that the Martin County population may represent an ephemeral, range-margin population that will go extinct in some years' time (Lennon et al. 1997). This also seems unlikely because the population has probably been successfully reproducing for several years, and reproduction usually does not begin until approximately 5 years after germination. A final alternative is that this population represents an escape from nearby cultivated individuals. We cannot rule this out, but the Martin County population is somewhat isolated and only reachable by boat. We did not notice any *Sabal minor* plants at the closest settlement, approximately 1.2 km upstream of the new population.

The most probable explanation for *Sabal minor* in Martin County is that it is currently expanding northward in response to climate warming in northeast North Carolina, although we cannot definitively rule out any of the other possibilities. *Sabal minor* and other species found in the southern United States (both of temperate and largely tropical groups) might be expected to respond to climate warming in northern temperate zones with northward range expansions, and it would be interesting to search for such patterns among other taxa. In the western United States the only native palm, *Washingtonia filifera* (Linden) Wendland, is dramatically moving northward through time, perhaps due to climate change (Cornett 1987,1989). A population of *W. filifera* in Grapevine Springs (Inyo County), California now represents the most northern native palm population in the Western Hemisphere (UTM Northing 4097830) (J Cornett, pers. comm.). The possibility that palms may be moving northward on both coasts (and here, perhaps inland) is a compelling argument for the effects of global climate change. In general, coastal communities and species are more likely to demonstrate effects of global warming as coastal areas are more immediately affected by current climate change through alterations in sea level, flooding and rainfall patterns, tropical storm intensities (Williams et al. 2003), and tidewater and soil salinity (Perry and Williams 1996, Brinson et al. 1985). This is supported in our study, by the much stronger change in climate at the Plymouth weather station, the more coastal of the two weather stations studied.

Finally, we note the importance of herbarium collections to this study and to future studies of plant response to climate change. Biological collections form the basis of a large part of ecological and evolutionary research and serve as permanent, historical records, archiving the occurrence, appearance, date, locality, and habitat of a species as well as associated environmental information (e.g., atmospheric carbon dioxide levels). Primack et al. (2004), for example, showed that plants growing at the Arnold Arboretum in Massachusetts flower earlier today than they did in the late 19th century, as a function of increased spring temperatures. Even in temperate zones that are well known botanically, we will not be able to document the shifts in plant species' ranges without herbarium collections spread broadly through space and time.

APPENDIX

North Carolina collections examined, including sterile specimens, from herbaria at the following institutions: Duke (DUKE), The Academy of Natural Sciences (PH), The University of North Carolina (NCU), and The United States National Herbarium (US).

DUKE: *H. Rock 543*, 25 July 1954, Carteret Co.; *B. Wilbur 9618*, 2 November 1967, Carteret Co.; *H. Blomquist 11336*, 31 August 1940, Carteret Co.; *H. Grier s.n.*, 12 July 1965, Carteret Co.; *S. An s.n.*, 2 September 1968, Carteret Co.; *H. Oostrug 2083*, 3 April 1940, New Hanover Co.; *B. Wilbur 12743*, 19 August 1970, Onslow Co.; *B. Wilbur 71553*, 4 August 1998, Pender Co.; *E. Tripp 119*, 21 November 2004, Martin Co.

PH: *E. Walker 1431*, 1 March 1940, Columbus Co.; *Biltmore Herbarium 3410a*, 17 July 1897, New Hanover Co.; *E. Bartram 1010*, 14 April 1911, New Hanover Co.; *Williamson 64*, 15 April 1911, New Hanover Co.

UNC: *A. Radford 33555*, 17 May 1958, Beaufort Co.; *A. Radford 4085*, 20 May 1949, Bladen Co.; *H. Rankin s.n.*, mid-March 1944, Brunswick Co.; *W. Hunt s.n.*, 15 June 1944, Brunswick Co. (originally transplanted to Cumberland Co.); *J. Totten s.n.*, 27 December 1950, Carteret Co.; *C. Wood 395*, 28 July 1946, Carteret Co.; *A. Radford 37581*, 19 July 1958, Craven Co.; *A. Radford 8124*, 23 May 1954, Dare Co.; *C. Burk 109-1*, 3 June 1959, Dare Co.; *C. Galloway 3091*, 28 July 1958, Greene Co.; *A. Radford 7312*, 10 July 1953, Jones Co.; *C. Wood 6397*, 29 July 1946, Onslow Co.; *A. Radford 36038*, 5 July 1958, Pamlico Co.

US: *N. Hotchkiss 4794*, 12 October 1935, Pamlico Co.; *R. Godfrey 6517*, 1 September 1938, Pender Co.

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