PALMS

Journal of the International Palm Society Vol. 65(1) Mar. 2021

THE INTERNATIONAL PALM SOCIETY, INC.

The International Palm Society

Founder: Dent Smith

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Palms (formerly PRINCIPES)

Journal of The International Palm Society

An illustrated, peer-reviewed quarterly devoted to information about palms and published in March, June, September and December by The International Palm Society Inc., 1401 Lavaca St. #751, Austin, Texas 78701 USA.

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Claims for Missing Issues: Claims for issues not received in the USA should be made within three months of the mailing date; claims for issues outside the USA should be made within six months of the mailing date.

Periodical postage paid at Austin, TX, USA and additional mailing offices. Postmaster: Send address changes to The International Palm Society Inc., The International Palm Society Inc., 56 Autumn Oaks Drive, The Hills, Texas 78738 USA.

PALMS (ISSN 1523-4495)

Mailed at Lawrence, Kansas 15 March 2021

The full text of *PALMS* is available on EBSCO Publishing's database.

This publication is printed on acid-free paper.

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THE INTERNATIONAL PALM SOCIETY
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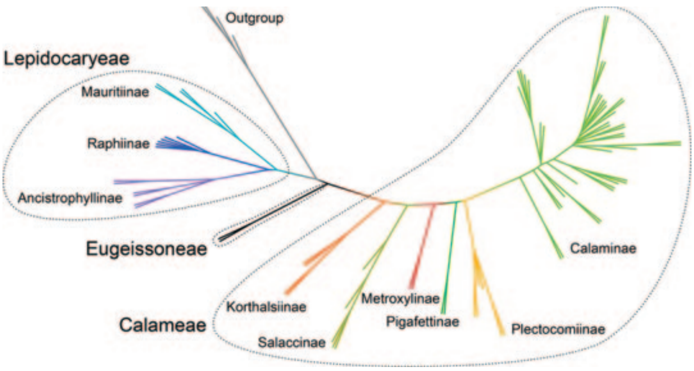
BACK COVER

Desert fan palms, *Washingtonia filifera*, at Seventeen Palms, Anza-Borrego Desert State Park, California. See article by Cornett, p. 43.

PALM NEWS

A new review of the current knowledge of the distribution, genetics and reproductive ecology of the Canary Island date palm (*Phoenix canariensis*) has been published by Sosa et al. (2020) in *Biodiversity and Conservation* (DOI: 10.1007/s10531-020-02096-1). Populations of this imposing palm are experiencing pressure from invasive pests and human activities, and this review summarizes current knowledge to inform conservation management strategies.

With ever more sophisticated analytical methods becoming available to assess relationships of organisms, Ben Kuhnhäuser and colleagues (2021) have just published **a robust phylogenomic framework for the calamoid palms** in *Molecular Phylogenetics and Evolution* (DOI: 10.1016/j.ympev.2020.107067). The work, based on part of Kuhnhäuser's PhD research takes advantage of the remarkable new monograph of *Calamus* by Andrew Henderson and the rich collections of calamoid palms at the Herbarium, Royal Botanic Gardens Kew, New York Botanical Gardens and elsewhere. The subfamily Calamoideae accounts for more than one fifth of all palms and supports a billion-dollar industry in rattan products. Almost one thousand nuclear genomic regions for 75 systematically selected Calamoideae were sequenced. The phylogenomic analyses resolved a maximally supported phylogenetic backbone for the Calamoideae, including several higher-level relationships not previously inferred. In-depth analysis revealed low gene tree conflict for the backbone but complex deep evolutionary histories within several subtribes. Overall, the phylogenomic framework sheds new light on the evolution of palms and provides a robust foundation for future comparative studies.



A detailed morphological and molecular study of a single species of rattan, *Calamus nambariensis* of northeastern India, revealed previously unrecognized taxonomic diversity. The study was published by K. Deka and colleagues (*Taiwania* 65: 529–540. 2020. DOI: 10.6165/tai.2020.65.529), who recognized a new subspecies and variety to accommodate the variation in this species found in across a wide area of Assam and Arunachal Pradesh.

Monumental Palms in Galicia (NW Spain)

J. Gaspar Bernárdez Villegas[1], Antonio Rigueiro Rodríguez[2], Ignacio Silva de la Iglesia[3] and Xesús I. Fernández Alonso[4]

The green corner of Spain, Galicia, is an autonomous community and historic nationality under Spanish law. Galicia (Fig. 1) is located in the northwest of the Iberian Peninsula, north of Portugal. Its 29,574 km^2 of surface are divided into four provinces: A Coruña, Lugo, Ourense and Pontevedra.

Galicia has been inhabited since prehistoric times. The contributions of different peoples and periods have left their mark on this land, which, along with their own language, Galician (which has affinity with Portuguese), helped to shape its cultural heritage and national identity. The megalithic period, Celtic culture and the Roman period, for example, left important remains in the form of monuments, such as tombs, castros (Celtic settlements) and fortresses. Monuments such as the Tower of Hercules in A Coruña, the oldest coastal lighthouse in the world still in operation, and the Roman Wall of Lugo were both declared World Heritage Sites by UNESCO. In the Middle Ages, Galicia was an independent kingdom. This and the Santiago pilgrimages, which contributed to cultural interchanges with the rest of Spain and other parts of Europe, contributed to forging the Galician cultural identity. Currently, three of the Santiago routes that run through Galicia (French Way, Northern Way and Primitive Way) to Santiago de Compostela have been declared World Heritage Sites.

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Galicia is not a land of palms. In continental Europe, only the Mediterranean palm (*Chamaerops humilis*) grows naturally; however, its area of distribution does not reach Galician lands. The nearly 1500 km of Galician coast has a humid and temperate climate, suitable for many palms. Thus, palms are often grown as ornamental trees in many parks, public and private gardens in northern and western Galicia.

In this article, we study the role of heritage palm trees in Galicia. Detailed information is provided on the five palms currently included in the Galician Catalog of Monumental Trees, and also other palms that we believe may be part of this catalog in the near future.

Many European countries have long been concerned with cataloging and studying their monumental trees. However, there is not yet a common definition for these trees (Cannizzaro, 2014). Regione Marche (1989) considered that monumental trees "… are part

1. Location of Galicia, in the NW of the Iberian Peninsula.

of the agricultural landscape, oak trees isolated or scattered groups in the country, tree-lined avenues or monumental oak, rows of poplars, elms, cypress and other species, hedges, forms of ancient cultivations in danger of extinction (such as tree-lined roads); isolated trees at crossroads, secular tall trees, of any species, the parks and gardens attached to houses, churches, castles and abbeys, even when of exotic species." According to Asan (2017), monumental trees have extraordinary physical dimensions related to their trunk circumference, diameter or height, great longevity or have interesting shapes caused by pathological formations on their trunk. Cannizzaro (2014) also included those trees which are part of local history and folklore, describing them as historical and cultural assets, natural monuments that form part of an inestimable heritage. Cannizzaro (2014) also considered that the presence of a veteran or monumental tree, is evidence of a long relationship between humans and landscapes of great environmental and scenic value, thus playing an important role due to historical aspects, local traditions and the maintenance of ecological balance.

Other literature, without establishing a definition of an outstanding tree, makes quite a few differentiations as to the classification of monumental trees. Helen Read (2000), defined a veteran tree as " a tree which is of interest biologically, culturally or aesthetically because of its age, size or condition." The Ancient Tree Guide (ATF 2008) considered an ancient tree "one which has passed beyond maturity and is old, or aged, in comparison with other trees of the same species." On the other hand, according to the practical handbook in use in the Ancient Tree Hunt (Owen & Alderman 2008, cited in Lonsdale 2013), an ancient tree is one which has all or most of the following characteristics: having a biological, aesthetic or cultural interest due to its old age, a growth stage that is described as ancient or veteran or have a chronological age which is old relative to other individuals of the same species. It also introduces the following definitions:

• Veteran. This term describes a tree which has survived various rigors of life and thereby shows signs of ancientness, irrespective of its age. To qualify as a veteran, the tree should present crown retrenchment and signs of decay in the trunk, branches or roots, such as exposed dead wood or fungal fruit bodies.

• Notable. Trees qualifying for this category are usually very large but might not qualify as ancient or veteran. Notable trees have been defined as mature and often magnificent, standing out locally because they are larger than other trees around them, a definition shared by ATF (2008).

• Champion. This term is reserved for a tree which is the tallest or has the largest trunk girth of its kind in the UK (or a given region).

• Heritage. Trees answering any of the above descriptions could qualify for this category, together with others of special cultural or historical interest.

What do we consider as a monumental tree?

The Xunta de Galicia's Decree 67/2007 of 22 of March, creates the Galician's Heritage Tree Catalogue. Article 2 of the decree includes the following definition: Will be considered Heritage trees and vegetal formations, those of any species, both native and non-native, located on public or privately owned land, which deserve specific protection measures due to the exceptional characteristics of their size, dendrometry, age, rarity, historical or cultural significance, aesthetic, educational, environmental or scientific interest, or any other circumstance which makes them deserving special protection.

Methodology

During the period 2006–2009, field and office work was carried out for the elaboration of the "Galician Heritage Tree Catalog," and during the period 2017–2019, we worked on the "Revision of the Galician Heritage Tree Catalog" in the context of different contracts for the Ministry of the Environment and Spatial Planning and the University of Santiago de Compostela. All the trees and tree formations included in the "Galician Heritage

2. Canary Island date palm (*Phoenix canariensis*) grove at Pazo de Baión (Vilanova de Arousa, Pontevedra).

Tree Catalog" (Decree 67/2007), as well as other specimens and tree formations, were assessed in the field with the aim of drawing up a list of possible candidates to join the catalog in the future.

During the aforementioned periods, we proceeded to draw up inventories throughout the Autonomous Community of Galicia. The work was carried out in three stages:

• Gathering of information. In this stage, interviews with forestry and environmental agents, environmental associations, municipalities and, in general, people interested in the conservation of this interesting plant heritage were carried out. In addition, a review was carried out of all the existing published data on heritage trees, natural spaces, botanical catalogs, and any other documents that would provide information on the location of outstanding trees in Galicia.

• Design of an inventory sheet and inventory database.

• Analysis of fieldwork data and selection of the most outstanding specimens.

Measured parameters

All specimens and tree formations were georeferenced using GPS (Datum ETRS89), also noting the main descriptors of the site in the database. In addition, the following dendrometric measurements were taken:

• Total height (measuring the height of the trunk, i.e., from the base of the trunk to the point of insertion of the youngest leaves), using a Nikon 550 Forestry Pro laser hypsometer and the sine measurement method, performing two or more measurements to get an average.

• Trunk circumference (measured at 1.30 meters above the ground and perpendicular to the trunk axis) and basal trunk circumference, using tape measure.

• Canopy spread in those specimens for which it was possible and considered a relevant measure (tape measure, two perpendicular measurements).

Information was collected on the health status of each specimen, noting the recommended cultural and health treatments.

3. Canary Island date palm (*Phoenix canariensis*) and Mexican fan palms (*Washingtonia robusta*) at Pazo de Fefiñáns (Cambados, Pontevedra).

Palms in Galicia

Even though there is no native species of the family Arecaceae in Galicia, thousands of palm specimens are cultivated in towns, villages and cities: at fairgrounds, in the vicinity of religious buildings or in public and private gardens, etc. Among those specimens, several examples of a monumental nature can be found. The unique climatic conditions of Galicia, between the Eurosiberian and Mediterranean floristic regions, are favorable for the establishment of plant species from almost all climatic regions of the world. The provinces of A Coruña and Pontevedra, more populated and with a milder climate than the eastern ones (zones 9 to 11 of the USDA plant hardiness classification), have the greater number of monumental palm trees within Galicia. Standing out, due the presence of monumental plants (palm trees among them) are the following publicly owned gardens: San Carlos and Santa Margarida in A Coruña, the Pazo de Mariñán in Bergondo, the Paseo da Ferradura or the Alameda do Campo da Estrela in Santiago de Compostela, the Historical Artistic Garden of Padrón, the Park and Oak grove of Caldas de Reis, Alameda de Pontevedra, Paseo das Palmeiras and Pazo de Lourizán in Pontevedra, the Castle of Soutomaior's park in Soutomaior, and the Park and Pazo of Castrelos in Vigo. Standing out among privately owned gardens are the pazo of Santa Cruz de Ribadulla in A Coruña, also the pazos of Oca, Torrecedeira, Torres Agrelo, Rubiáns and Baión (Fig. 2) in Pontevedra (Rodríguez Dacal & Izco Sevillano, 1994).

Among all these gardens, the Pazo de Castrelos (Vigo, Pontevedra) is worthy of attention. In this garden created probably by a Portuguese gardening firm around 1890 (Salinero Corral et al. 2018), the best collection of monumental palm trees in Galicia can be found. At Pazo de Castrelos there are several specimens which exceed 100 years-old, although none of them is listed as a monumental tree in the Galician Heritage Trees catalog. 100-year-old specimens, such as the jelly palm (*Butia odorata*, Fig. 4), the cabbage-tree palm (*Livistona australis*, Fig. 5), the Canary Island date palms (*Phoenix canariensis*) or the Senegal date palm (*Phoenix reclinata*), are planted along with other specimens that are around half a century old, like for example the Chusan palm (*Trachycarpus fortunei*). Most recent plantings include, date palm (*Phoenix dactylifera*), queen palm (*Syagrus romanzoffiana*), Alexandra or Australian royal palm (*Archontophoenix alexandrae*), kentia (*Howea fosteriana*), dwarf date palm (*Phoenix roebelenii*), Mexican fan palm (*Washingtonia robusta*) and its hybrid with the California fan palm (*W. filifera*), *Washingtonia* × *filibusta* (Fernández Alonso & Rigueiro Rodríguez 2001, Fernández Alonso 2015).

Emigration to America, "to the Indies," was significant from the mid-nineteenth century to the mid-twentieth century. Many "Indianos" (returned emigrants) who fared well, settled when they returned, in large mansions of characteristic architecture among beautiful gardens, in some cases with prominent palm trees (Salinero Corral et al. 2018). This fact was also highlighted by López Lillo and Sánchez de Lorenzo-Cáceres (2006), when they stated that "It can be noticed that the greater presence of exotic plant species in private collections are found in those places where its inhabitants have deeply felt the emigration." When the "Indianos" returned from emigration, they usually planted in their homes broadleaf privet (*Ligustrum lucidum*), thuja (*Thuja* spp.), magnolias (*Magnolia grandiflora*) araucarias (*Araucaria heterophylla*) and mainly palms, especially the Canary Island

4. Pazo de Castrelos (Vigo, Pontevedra). At the center of the image the jelly palm (*Butia odorata*), at its left two specimens of Chusan palm (*Trachycarpus fortunei*) and at the right a Senegal date palm (*Phoenix reclinata*).

5. Cabbage-tree palm (*Livistona australis*) at Pazo de Castrelos (Vigo, Pontevedra).

Table 1. Location and dendrométric data of palms included in the Inventory of Outstanding Trees of Galicia (Xunta de Galicia, 1985).

Species	Location	Province	Height (m)	Circumference (m)
Phoenix canariensis	Mañón	A Coruña	11.50	2.73
Phoenix canariensis	Parque das Palmeiras (Fig.6)	Pontevedra	17.50	3.07
Phoenix reclinata	Xardín Histórico de Padrón	A Coruña	9.00	12.96

date palm (*Phoenix canariensis*). These palm trees were expensive and required lots of care, and thus, they became a symbol of status and power. Gradually this trend spread to the public sphere, as the "Indianos" took the responsibility for building schools, communal laundry places, public fountains, hospitals, cinemas and markets (not provided by the governments of the time) and decorated these public spaces with palm trees.

Palms in the Galician heritage tree catalogues

The first work dedicated exclusively to trees in Galicia was published in 1953, when the forestry engineer Rafael Areses published "Nuestros Parques y Jardines, Contribución al Conocimiento de las Plantas Exóticas Cultivadas en España. Galicia." This was the first volume of a collection, which aimed to catalog all the ornamental tree flora of Galicia. However, only the volume relating to the province of Pontevedra was published. Without being a specific document on monumental trees, the work cites some palm trees which are still in existence like for example, the California fan palms *(Washingtonia filifera*) of Pontevedra, the Canary Island date palms (*Phoenix canariensis*) and the Senegal date palm (*Phoenix reclinata*) of the Pazo de Castrelos, the butia (jelly palm) (*Butia odorata*, cited by Areses as "*Cocos erythrospatha*") at the Paseo das Palmeiras, in Pontevedra, or the cabbage-tree palm of Salcedo. Others, such as the kentia (*Howea belmoreana*) from Vigo, have disappeared.

However, the first data on monumental trees in Galicia, in the framework of a work dedicated exclusively to heritage and monumental trees, appeared in 1974 when the National Institute for Nature Conservation (ICONA) (under the Ministry of Agriculture) issued a circular (14/1974), promoted by the forestry engineer D. Antonio López Lillo. The circular was aimed at creating the Inventory of Outstanding Trees of Spain, in order to ensure their protection and conservation, "since some of these specimens were likely to disappear by felling, fires, pests and diseases, and mainly by ignorance of their value." However, the response of ICONA's regional delegations, in charge of gathering the information, was very heterogeneous, and the intended inventory did not materialize. The Territorial Delegation of Galicia sent data of 32 tree specimens, among which only one palm tree was found: the Senegalese date palm (*Phoenix reclinata*) in the Historical Garden of Padrón (A Coruña).

A decade later, in 1984, the General Directorate of Forestry and the Natural Environment (Xunta de Galicia's Ministry of Agriculture, Fisheries and Food) hired a consultant to carry out the Inventory of Outstanding Trees of Galicia, a document which comes to light in 1985 and which included 260 entries, including three palm trees (Tab. 1). The authors of this work mentioned the obstacles they encountered trying to obtain information and the skepticism, fear and caution of many tree owners (Rigueiro Rodríguez et al. 2008).

Carlos Rodríguez Dacal and Jesús Izco Sevillano published in the year 2003, the book "Árboles Monumentales en el Patrimonio Cultural de Galicia," in which they cited 345 specimens. Most of the monumental trees collected in this work are found in pazos (country houses), monasteries, castles, parks, and other places of historical and cultural interest. However, some of the specimens included are located in natural spaces. Several of the palm trees mentioned in this work have become part of the Galicia's official catalog, and others, despite their outstanding dendrometry, have not been included in it (Tab. 2).

The current Catalog is created by means of Decree 67/2007, published on March 22 in the

6. Canary Island date palm (*Phoenix canariensis*) at Xardins de Vicenti also known as Parque das Palmeiras (Pontevedra).

Diario Oficial de Galicia. An annex to the Decree publishes the Catálogo Galego de Árbores e Formacións Senlleiras (Galician's Catalogue of Heritage Trees and Tree Formations), which included 106 trees and 21 tree formations. It was an initial, provisional and open catalog. Among the species included are several palm trees (Tab. 3).

Table 2. Palms included in the book "Árboles Monumentales en el Patrimonio Cultural de Galicia" (Rodríguez Dacal & Izco Sevillano, 2003) which are not included in the Inventory of Outstanding Trees of Galicia (Decreto 67/2007).

Palm name	Species	Location	Province
Palmeira raíña do Pazo de Lourizán	*Syagrus romanzoffiana*	Pazo de Lourizán	Pontevedra
Palmeira azul mexicana do Pazo de Santa Cruz	*Brahea armata*	Pazo de Santa Cruz de Ribadulla	A Coruña
Butias brasileiras olorosas do Pazo de Castrelos	*Butia odorata*	Pazo de Castrelos	Pontevedra
Kentias dos Xardíns de Méndez Núñez (Fig. 7)	*Howea forsteriana*	Xardíns de Méndez Núñez	A Coruña
Palmeiras datileiras do Pazo de Mariñán	*Phoenix dactylifera*	Pazo de Mariñán	A Coruña
Palmeira canaria do Mosteiro de Samos	*Phoenix canariensis*	Mosteiro de Samos	Lugo
Livistonia austral do Pazo de Torres de Agrelo	*Livistona australis*	Pazo de Torres Agrelo	Pontevedra
Livistonia austral do Pazo de Castrelos	*Livistona australis*	Pazo de Castrelos	Pontevedra

In later years, the catalog was updated several times by the Galician public administration but failed to include any other specimens of Arecaceae.

The Spanish Society of Forest Sciences published a monograph in the year 2018 dedicated to monumental trees under the title "The Galician Catalogue of Monumental Trees: The Substitutes" (Bernárdez Villegas, Rigueiro Rodríguez & Mosquera-Losada, 2018). This monograph included those trees and tree formations which, according to the authors, gather all the necessary characteristics in order to be considered monumental. Among the proposals are a pair of Canary Island date palms (*Phoenix canariensis*) from the Casa Grande de Lourenzá (Fig. 8) (Tab. 4).

In the year 2020, J. Gaspar Bernárdez Villegas defended his doctoral thesis under the direction of Antonio Rigueiro Rodríguez and

Table 3. Palms included in the Catálogo Galego de Árbores e Formacións Senlleiras (Decreto 67/2007) and their distribution by provinces.

Palm name	Species	Location	Province
Cocoteiro de Chile do Pazo de Meirás	*Jubaea chilensis*	Pazo de Meirás	A Coruña
Palmeira Datileira do Mosterio de Herbón	*Phoenix dactylifera*	Mosteiro de Herbón	A Coruña
Washingtonias Robustas do Pazo de Santa Cruz	*Washingtonia robusta*	Xardín do Pazo de Santa Cruz de Ribadulla	A Coruña
Palmeiral Canario dos Xardíns de Méndez Núñez	*Phoenix canariensis*	Xardíns de Méndez Núnez	A Coruña
Palmeira do Senegal do Xardín Artístico de Padrón	*Phoenix reclinata*	Xardín Artístico de Padrón	A Coruña

7. Kentia (*Howea forsteriana*) at Xardíns de Méndez Núñez (A Coruña).

Rosa Mosquera Losada, with the title "As Árbores Senlleiras de Galicia. Diagnóstico da Situación Actual e Proposta de Liñas de Actuación." The thesis was the result of the review and study of 1108 specimens and tree formations distributed throughout Galicia, including 18 palm trees or groups of palm trees which were considered of interest and which were not included in the official catalog or any of the aforementioned works (Tab. 4).

Palms in the current Galician catalogue of monumental trees

The codes indicated are those of the Galician Catalog of Heritage Trees (Decree 67/2007).

• Chilean Wine Palm at Pazo de Meiras (Code 55A) (*Jubaea chilensis*) (Fig. 13)

The Chilean wine palm in Pazo de Meirás grows in a raised planter that is 40 cm high but insufficient for the proper development of this wonderful palm. The space between the stem of the palm and the edge of the planter is colonized by small palms growing spontaneously from the seeds that fall from this monumental specimen. Its stem, with a circumference at the base of 3.5 m, widens to a few meters below the crown, a common feature in adult palms of this species. It exceeds 18 m in height, thus, the largest Chilean wine

Table 4. Location and main dendrometric data of the new monumental palm trees included in Bernárdez Villegas (2020).

Species	Location	Province	Total height	Cicumference
Phoenix canariensis	Pazo de Maniños-Maniños	A Coruña	16.8m	2.73m
Phoenix canariensis	Praza de Amboaxe	A Coruña	17.9m	2.10m
Phoenix canariensis	Ribeiras do Sor	A Coruña	13.5m	1.98m
Phoenix canariensis (2 specimens)	Praza Finca de Dona Gloria	A Coruña	A:17.6m; B:16.1m	A:2.40m; B:2.40m
Phoenix canariensis (24 specimens)	Pazo de Baión	Pontevedra	17.9m (mean)	2.04m (mean)
Phoenix canariensis (15 specimens)	Alameda de Noia	A Coruña	16.2m (mean)	2.06m (mean)
Trachycarpus fortunei	Parque de Castelao-Fene	A Coruña	11.7m	0.56m
Trachycarpus fortunei	Xardín da Rectoral de Barallobre	A Coruña	10.6m	0.50m
Trachycarpus fortunei	Praza de Amboaxe	A Coruña	11.9m	0.52m
Trachycarpus fortunei (2 specimens)	Pazo de Castrelos	Pontevedra	A:13.1m; B:11.8m	A:0.56m; B:0.54m
Trachycarpus fortunei (2 specimens) (Fig. 9)	Pazo de Mariñán	A Coruña	A:12.9m; B:12.8m	A:0.58m; B:0.51m
Washingtonia robusta (Fig. 10)	Xardíns do Posío	Ourense	21.3m	1.48m
Phoenix canariensis	Vila de Mondariz	Pontevedra	13.7m	1.70m
Phoenix canariensis	Parque das Palmeiras	Pontevedra	21.1m	1.73m
Washingtonia filifera (2 specimes)	Parque das Palmeiras	Pontevedra	A:17.8m; B:18.5m	A:1.15m; B:1.00m
Washingtonia filifera (Fig. 11)	Alameda da Praza de Compostela, Vigo	Pontevedra	23.7m	2.88m
Washingtonia filifera	Vilagarcía de Arousa	Pontevedra	19.9m	2.50m
Washingtonia robusta (2 specimens)(Fig. 12)	Pazo de Fefiñáns	Pontevedra	A:24.5m; B:22.4m	A:1.70m; B:1.85m

palm in Galicia (Table 1) (Bernárdez Villegas, 2020).

• Date Palm at Herbón Monastery (Code. 66A) (*Phoenix dactylifera*) (Fig. 14)

Herbon Monastery's Date Palm has a straight stem that grows from an enlarged root mass at the base of the palm; however, in recent years its stem is leaning slightly to the southeast. It also hosts a small population of hare's-foot fern (*Davallia canariensis*), an epiphytic fern that climbs its stem. The crown is sparsely populated with leaves and has a rather disordered appearance, with the presence of numerous dead leaves that spoil the appearance of this noble specimen (Tab. 5) (Bernárdez Villegas, 2020).

• Mexican Fan Palms at Pazo de Santa Cruz (Code. 106A) (*Washingtonia robusta*) (Fig. 15)

This is a pair of palms of similar size. Their great height makes them stand out among other trees in the garden. Their trunks have wide bases and grow vertically. The crowns,

8. Image of one of the Canary Island palm trees (*Phoenix canariensis*) at Casa Grande de Lourenzá (Lourenzá, Lugo).

formed at a height just above 24 m, consist of the classic tuft of large fan leaves (Tab. 5) (Bernárdez Villegas, 2020).

• Canary Island Date Palm Grove at Xardíns de Méndez Núñez (Code. 13F) (*Phoenix canariensis*) (Fig. 16)

This palm grove consists of two different groups of palms, those located along the boulevard and those in the rose garden. There are 71 Canary Island date palm trees in total in the two groups. It is a fairly homogeneous group in terms of age, size and shape of the specimens. The stems arise from a wide basal root mass. They grow straight to a height which averages 25 m. The crowns are formed at this height and are composed of a large number of leaves. The palms show a lot of leafiness and good health (Tab. 5) (Bernárdez Villegas, 2020).

• Senegal Date Palm at Xardín Artístico de Padrón (Code. 14F) (*Phoenix reclinata*) (Fig. 17)

This beautiful example of a multi-stem palm tree is without a doubt one of the most impressive Senegal date palms within the Spanish territory. Several stems grow from its base, forming a large impenetrable mass of stems and leaves. It is difficult to know how many stems sprout from a common point, but more than 20 have been counted, which are almost free of leaves to their apex. Its leaves are collected by neighbors for Palm Sunday (Tab. 5) (Bernárdez Villegas, 2020).

Other palm species cultivated in Galicia

86 species of palm trees are currently mentioned in Galicia, among which the following deserve to be highlighted:

• The genus *Archontophoenix* is represented by the species *A. alexandrae* and *A. cunninghamiana*, with specimens up to 7 m in height.

• *Bismarckia nobilis*, from Madagascar, is starting to be grown in private collections and public places, such as the specimen in the municipality of Marín (Pontevedra).

• Some *Brahea armata* specimens are known to be up to 40 years old and up to 4 m in height, such as the one at the Forest Research Center of Lourizán (Pontevedra) (Fernández Alonso, 2015). Other species of the same genus, such as *B. brandegeei* and *B. edulis*, have been planted in recent years in several private collections.

• There are at least two dozen adult specimens of *Butia odorata* scattered over coastal gardens and boulevards. Several of these specimens are already 100 years old, such the one at the Alameda de A Guarda (Pontevedra), planted in 1885 and now 5.5 m tall (Fernández Alonso, 2015), or that at Parque de Castrelos (Vigo, Pontevedra), from the same period, which is nearly 8 m tall (Fernández Alonso, 2015). A specimen within the same genus, *B. yatay*, planted around 1980 in the grounds of a commercial nursery in Tomiño (Pontevedra), has already reached 4 m in height.

• Species of the genus *Chamaedorea*, are widely represented as indoor plants, with species such

9. Chusan palms (*Trachycarpus fortunei*) at Pazo de Mariñán (Bergondo, A Coruña).

as *C. elegans, C. metallica, C. microspadix* or *C. radicalis*. However, they are also occasionally planted outdoors, thriving in localities with mild climates.

• The European fan palm, *Chamaerops humilis*, a multi-stem palm which is common in cultivation in parks and gardens.

• *Dypsis lutescens* is common as an indoor plant, rarely grown outdoors, its planting limited to coastal areas.

• *Howea forsteriana* is common as an indoor plant. However, it is not difficult to find it planted outdoors in coastal areas, as for example, in the gardens of Méndez Núñez in A Coruña or at the Maristas School in Vigo (Pontevedra). *Howea belmoreana* is less common in cultivation, being grown outdoors at the Jesuit School, also in Vigo.

• There are several specimens of *Livistona chinensis* scattered along coastal gardens. The 100-year-old specimens at the Pazo de Torrecedeira, in Redondela (Pontevedra) reach 8 m in height.

• *Phoenix roebelenii* is occasionally planted outdoors, with specimens reaching 2 m tall. Other species, such as *P. sylvestris* and *P. theophrasti*, have been incorporated recently into private plant collections.

• *Rhapis excelsa* is not common in cultivation, either indoors or outdoors; however, it thrives outdoors when planted in coastal regions.

• Both *Rhopalostylis baueri* and *R. sapida* have been incorporated for a few years into several private collections, but the plants are small.

• Both *Sabal minor* and *S. palmetto* have been growing outdoors in a few private collections for the past few years; other species of the genus are cultivated only in a couple of private collections.

• The genus *Trachycarpus* is widely represented in Galicia, *T. fortunei* being the most common palm in Galicia after *Phoenix canariensis*. Other species such as *T. latisectus, T. martianus, T. nanus, T. oreophilus, T. princeps* and *T. ukhrulensis* have been added to a few private collections in recent years.

10 (left). Mexican fan palm (*Washingtonia robusta*) at Xardíns do Posío (Ourense). 11 (right). California fan palm (*Washingtonia filifera*) at Compostela Boulevard (Vigo, Pontevedra).

Acknowledgments

We thank all the owners of the lands in which monumental trees and tree formations grow, for granting us access and also for their care that has preserved these monumental trees. We also express our gratitude to all the people and institutions who provided us with photographs for this work, including Miguel Anxo Montero Vaz (Pazo de Meirás Chilean wine palm, Monastery of Herbón date palm, and Méndez Núñez Gardens Canary Island date palm grove), the Environmental Department of Ourense City Council (Posión Gardens Mexican Fan Palm) and Gonzalo Salgado Fraga (Pazo de Fefiñáns Canary Island date palms and Mexican fan palms).

Literature Cited

Anónimo. 1885. Los árboles gigantes de California. Revista Popular Conocimientos Útiles 240: 46–47.

Asan, Ü. 2017. Mystical and holistic aspect of the monumental trees, and their importance for ecotourism. International Symposium on New Horizons in Forestry. Turquía.

Ancient Tree Forum (ATF). 2008. Ancient Tree Guide. No. 4: What are ancient, veteran and other trees of special interest? The Woodland Trust, UK. 7 pp.

Bernárdez Villegas, J. G., A. Rigueiro Rodríguez and R. Mosquera-Losada. 2018. El Catálogo Gallego de Árboles Monumentales: los suplentes. Cuadernos de la Sociedad Española de Ciencias Forestales 44: 1–10.

Bernárdez Villegas, J. G. 2020. As Árbores Senlleiras de Galicia. Diagnóstico da Situación Actual e Proposta de Liñas de Actuación. Memoria de Tese de Doutorado. Universidade de Santiago de Compostela (estudio inédito).

Cannizzaro, S. 2014. The role of monumental trees in defining local identity and in tourism. A case study in the Marches Region. Geoprogress Journal 1: 29–48.

Castel, C. 1885. Los árboles gigantes. Revista Montes 194: 92–96

Diario Oficial de Galicia. 2007. Decreto 67/2007, do 22 de Marzo, polo que se regula o Catálogo Galego de Árbores e Formacións

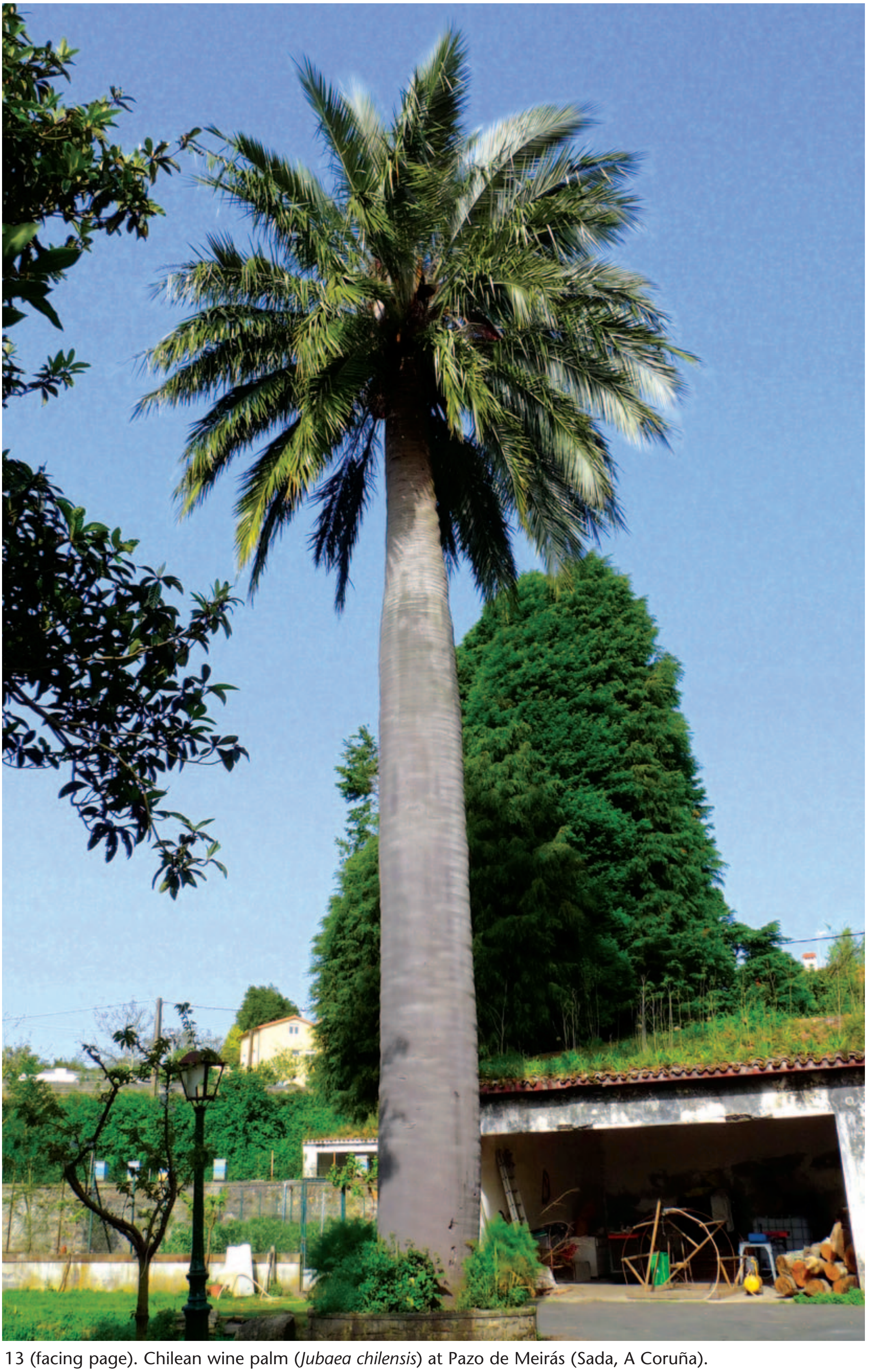
12. Mexican fan palm (*Washingtonia robusta*) at Pazo de Fefiñáns (Cambados, Pontevedra).

Senlleiras. nº 74: 6.136 6.141. Consellería de Medio Ambiente e Desenvolvemento Sostible. Xunta de Galicia.

FERNÁNDEZ ALONSO, J. AND A. RIGUEIRO RODRÍGUEZ. 2001. Catálogo das Árbores Singulares do Concello de Vigo. Ed. Concello de Vigo.

FERNÁNDEZ ALONSO, X.I. 2015. Catálogo da Flora Ornamental da Provincia de Pontevedra. Memoria de Tese de Doutorado. Universidade de Santiago de Compostela (estudio inédito).

LONSDALE, D. (ed.). 2013. Ancient and Other Veteran Trees; Further Guidance on



13 (facing page). Chilean wine palm (*Jubaea chilensis*) at Pazo de Meirás (Sada, A Coruña).

14. Date palm (*Phoenix dactylifera*) at Mosteiro de Herbón (Padrón, A Coruña).

15. Mexican fan palms (*Washingtonia robusta*) at Pazo de Santa Cruz de Ribadulla (Vedra, A Coruña).

Management. The Tree Council, London 212 pp.

López Lillo, A. and J.M. Sánchez de Lorenzo-Cáceres. 2006. Árboles en España. Manual de identificación. Ed. Mundi-Prensa. Madrid.

Read, H. 2000. Veteran Trees: A Guide to Good Management. Ancient Tree Forum. UK.

Regione Marche. 1989. PPAR-Piano Paesistico Ambientale Regionale 1989. http://www.ambiente.marche.it/Territorio/Paesaggio/PPARPianoPaesisticoAmbientaleRegionale.aspx. Accessed 20.10.2019.

Rodríguez Dacal, C. and J. Izco Sevillano. 1994. Pazos de Galicia. Jardines y Plantas. Consellería de Presidencia y Administración Pública. Xunta de Galicia. Santiago de Compostela.

Rodríguez Dacal, C. and J. Izco Sevillano. 2003. Árboles Monumentales en el Patrimonio Cultural de Galicia. 2 Tomos. Consellería de Cultura, Comunicación Social e Turismo. Xunta de Galicia.

Salinero Corral, C., A. Barros Martínez, G. Bernárdez Villegas, X. Fernández Alonso and A. Rigueiro Rodríguez. 2019. Xardíns históricos de Pontevedra. Un paseo por 20 xardíns singulares da provincia. Ed. Deputación de Pontevedra.

Xunta de Galicia. 1985. Inventario de Árboles Sobresalientes de Galicia (Inéd.). 3 Tomos. Dirección Xeral do Forestal e do Medio Ambiente Natural. Consellería de Agricultura, Pesca e Alimentación. Santiago de Compostela.

16. Canary Island date palms (*Phoenix canariensis*) at Xardíns de Méndez Núñez (A Coruña).

17. Senegal date palm (*Phoenix reclinata*) at Xardín Artístico de Padrón (Padrón, A Coruña).

Table 5. Dendrometric data for notable palms.

Species	**Location**	**Province**	**Coordinates UTM (X, Y; ETRS89 zone 29)**	**Total height (m)**	**Stem circumference (m)**
Phoenix canariensis	Casa de Oia (Casa Grande de Lourenzá)	Lugo	637708;4814438	22.70; 23.80	2.40; 3.40
Jubaea chilensis	Pazo de Meirás	A Coruña	556944;4800747	18.20	3.67
Phoenix dactylifera	Mosteiro de Herbón	A Coruña	530307;4731368	19.50	1.27
Washingtonia robusta	Pazo de Santa Cruz de Ribadulla	A Coruña	547123;4735670	26.7; 27.20	1.91; 1.96
Phoenix canariensis	Xardíns de Méndez Núñez	A Coruña	548465;4801858	25.80; 26.60	3.75; 3.42
Phoenix reclinata	Xardín Artístico de Padrón	A Coruña	528102;4732057	14.10	14.10

PALM LITERATURE

EXOTIC FRUITS AND NUTS FROM AROUND THE WORLD – TOMOHIRO KOBAYASHI, TOMOKI SANDO AND HIDEHARU YAMADA, Sogensha Co., Ltd., Osaka, Japan. 2020. Hardcover. ISBN: 978-4-422-43033-1. Price ¥3000 (ca. US$29). Pp. 176, color illustrations and map. Available from www.sogensha.co.jp

Like everyone fascinated by the diversity of palms, I have a bowl of dried fruits and seeds sitting on a table in my home. There are *Hyphaene*, *Calamus* and *Metroxylon* fruits and *Attalea*, *Wodyetia* and *Latania* endocarps, all long desiccated and dead. I keep them for their sculptural beauty, like natural netsukes, and because they remind me of both the people and places where I saw these palms. Over the years, my "carpological collection" grew to include a few "sea beans" (*Entada* and *Mucuna* seeds), some interesting pinecones and the winged fruits of some dipterocarps. If you have a similar collection of fruits and seeds in your home, this book is for you.

Authors Tomohiro Kobayashi and Tomoki Sando and photographer Hideharu Yamada present a visual feast of fruit and seed diversity across the plant kingdom. The first part of the book profiles families diverse in their seeds and fruits, such as acorns and beans, and includes a section devoted to palms. The illustrations of the double coconut and *Phytelephas aequatorialis* occupy two-page spreads. The second part illustrates how fruit form relates to function, i.e., dispersal. *Manicaria* and *Nypa* are illustrated as examples of drift seeds. The book focuses on dispersal by water or wind, so no attention is paid to fruits as food for animal dispersers. The third section focuses on shapes and forms. Six pages are devoted to various species of Calamoid palms, whose scaly fruits are eminently photogenic. The section ends with a world distribution map of notable fruits and seeds. The book closes with an index of scientific names.

The text throughout is in Japanese, but each illustration is captioned with the scientific name, the plant family and the length or width of the object (in cm). Yamada's photographs are spectacular: studio portraits with a neutral background so nothing detracts from the images of the fruits and seeds.

For those of us that cannot read Japanese, the format lends itself to casual browsing, enjoying the spectacular photographs and perhaps Googling some of the plant names. The book is similar in scope to *Seeds: Time Capsules of Life* and *Fruit: Edible, Inedible, Incredible*, both by W. Stuppy and R. Kesseler, but with more palms. *Exotic Fruits and Nuts…* is a lavish tribute to plant diversity, a book that anyone with a bowl of palm seeds at home will appreciate.

Scott Zona

Flower Color Variation in *Attalea phalerata* (Arecaceae) Revisited

Joanna M. Tucker Lima[1], Jessika Reyes[1,2], Natalie Salman[1,3]

Within the palm family, the genus *Attalea* attracts special attention from the passerby with its formidable inflorescences and infructescences that emerge among towering leaves that stretch up to 10 meters long in aborescent species. Acaulescent species also display a certain charm of their own with their elegantly tall leaves and often oversized fruits. Not only do *Attalea* species impress with their stature and beauty, they also evoke scientific interest by their fascinating reproductive biology.

Attalea palms are monoecious. Most species produce unisexual inflorescences, alternating between male and female inflorescences over time, while other species switch between entirely male and androgynous, or mixed inflorescences, which present male and female flowers together on the same stalk (Henderson 2002). This unusual pattern of sex expression sparked my initial interest in the reproductive ecology of *Attalea* palms. While studying the flowering phenology of *Attalea* palms in Acre, Brazil (southwestern Amazon), I also observed a surprising variation in *Attalea phalerata* flower color. During monthly visits to *A. phalerata* populations, I usually encountered creamy-yellow inflorescences, but over the two-year study, I also observed a handful of inflorescences that displayed variations of purple and magenta flowers. For me, this was entirely unexpected, since *Attalea* palms are known for their large inflorescences with creamy-yellow flowers.

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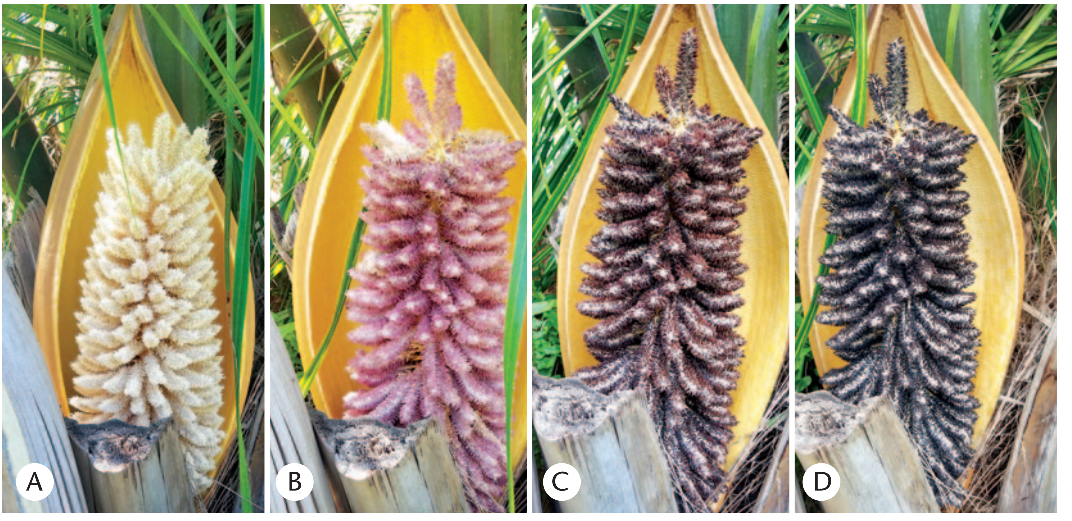
Initially, I hypothesized that the purple-colored inflorescences were a symptom of some transient environmental stress, such as cold temperatures, drought, or even fire (Tucker Lima 2009). However, I have since proven this assumption incorrect. The extensive palm collections at Montgomery Botanical Center (MBC) in Coral Gables, Florida, presented me with the unique opportunity to observe *A. phalerata* flowering continuously on a daily basis, rather than at monthly intervals, and revealed a consistent, predictable pattern of flower color change as inflorescences mature – all *A. phalerata* inflorescences change color (Fig. 1)! Rather than a response to environmental conditions, flower color in *A. phalerata* is a function of flower age that changes over time. Observations at MBC revealed that flower color changes quickly. Newly opened inflorescences display an abundance of creamy-yellow flowers color, but by the next day, new coloration spreads over the inflorescence and the flowers take on a magenta hue. Three days after opening, the flower petals appear darker magenta or purple in color and continue to gradually turn a

1. *Attalea phalerata* palm growing at Montgomery Botanical Center in Coral Gables, Florida (A), and staminate, or male (B, D, F) and pistillate, or female (C, E, G) inflorescences expressing a range of flower colors from creamy-yellow to magenta to purple.

darker purple to indigo over the next couple of days (Fig. 2). Not only do staminate (male) flowers follow this trajectory, but daily observations at MBC revealed that pistillate (female) flower petals change color in the same manner over time from creamy-yellow to indigo (Fig. 3). In pistillate flowers this change is sometimes relegated to the tip of each petal, but in other instances the color expands over the entire petal (Fig. 1E, G).

Upon digging into the published literature on *Attalea* palms, I came across only a few images or mention of purple-colored flowers in species considered part of the *Attalea phalerata* complex (Barbosa Rodrigues 1903 [as *A. kewensis*], Glassman 1999, Lorenzi et al. 2004, Fava et al. 2011). So, purple *Attalea* flowers are not a new discovery, per se; however, I know of no published investigation into the details of flower color change in this species, and as far as I know, only Fava et al. (2011) acknowledged the change in staminate flower color from creamy-yellow to purple over time. Other than a singular historical illustration under the name of *Attalea kewensis* (Barbosa Rodrigues 1903), ours is the first published record of purple coloration in pistillate flowers of *Attalea phalerata*.

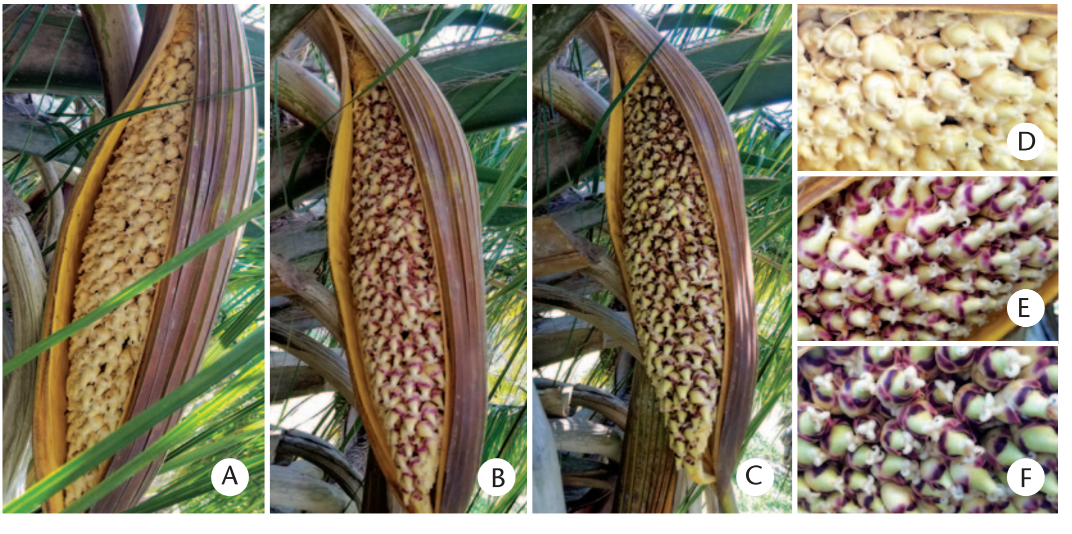


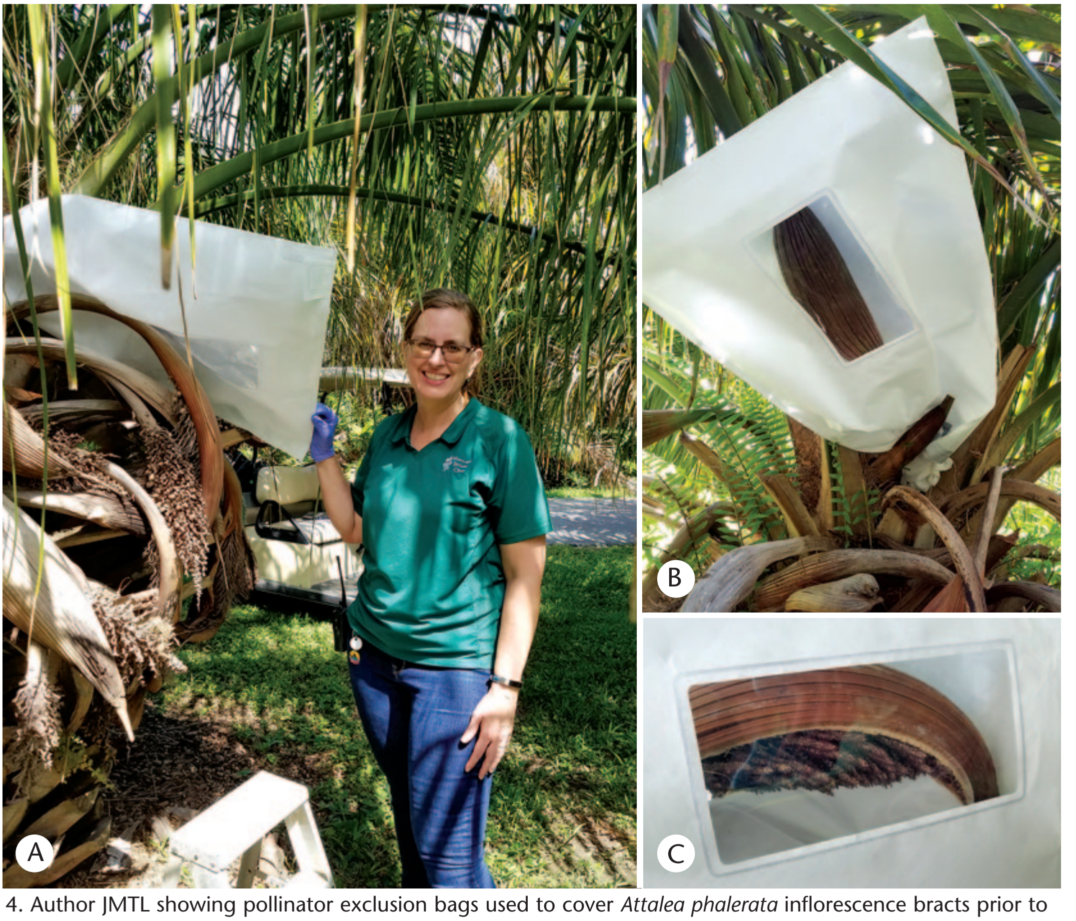
2. Flower color change sequence over time in an *Attalea phalerata* palm growing at Montgomery Botanical Center in Coral Gables, Florida. The staminate (male) inflorescence displays creamy-yellow colored flowers on first day of opening (A), but subsequently, over the next three to four days, flowers change to a magenta hue (B), then purple (C), and finally indigo (D).

Records of flowering in other *Attalea* species report only creamy-yellow flowers. Our findings related to patterns of flower color change in *A. phalerata* spawned a new set of questions about why only this particular species diverges from the typical creamy-yellow flowers presented by the other 30 species of *Attalea* (Henderson 2020). What role, if any, does floral color change play in the reproductive biology of this palm? Observations of other *Attalea* species at MBC, including *Attalea humilis*, *Attalea cohune*, *Attalea guayacule*, *Attalea brasiliensis*, *Attalea butyracea*, *A. speciosa*, *A. crassispatha* and *A. brejinhoensis* confirm that flowers in these species usually maintain yellowish, cream-colored flowers through anthesis and until flowers begin to drop a few days later. In a couple species (*A. butyracea* and *A. speciosa*), we did observe flower petals turning a brownish-tan color as inflorescences aged but never purple.

Flower color change is relatively common among plant species, occurring across as many as 78 different angiosperm families (Weiss 1995, Raguso & Weiss 2015, Yan et al. 2016).

3. Flower color change in a pistillate (female) *Attalea phalerata* inflorescence growing at Montgomery Botanical Center in Coral Gables, Florida. The new flowers display a creamy-yellow color on first day of opening (A, D), then change to magenta by the second day (B, E) and purple by the third day (C, F).



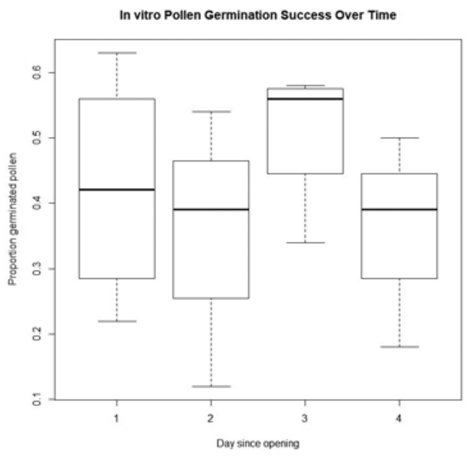


4. Author JMTL showing pollinator exclusion bags used to cover *Attalea phalerata* inflorescence bracts prior to opening (A). Each breathable bag has a front window enabling visualization of flower color during and after anthesis without opening the bag (B, C).

Among palm species, however, I know of no published record of flower color change, other than Fava et al. (2011). Scientific research links flower color change to pollinator attraction. In many cases, color change corresponds with availability of floral rewards, such as nectar or pollen (Casper & La Pine 1984, Niesenbaum et al. 1999, Oberrath & Bohning-Gaese 1999). Usually, color change indicates post-reproductive flowers, thereby increasing pollination efficiency by directing pollinators to fertile, rewarding flowers (Raguso & Weiss 2015, Delph & Lively 1989). In some species, researchers have identified a direct link between color change and pollen deposition on the stigma, loss of stigma receptivity, or developing pollen tubes (Lamont 1985, Nuttman & Wilmer 2003, Pereira et al. 2011). Sometimes plants also retain color-changed flowers to increase overall flower abundance and draw long-distance attention of key pollinators (Weiss 1991, Oberrath & Bohning-Gaese 1999, Nuttman et al. 2006).

To test whether flower color change in *A. phalerata* is related to pollinator visitation or pollen deposition in the case of pistillate flowers, we bagged 16 still closed inflorescence bracts at MBC and observed their flower color through the first week after opening. We used specialized breathable bags with a "window" for viewing (PBS International pollination bags, size 2D.4-1W; Fig. 4). In all cases, both staminate and pistillate flowers changed color from creamy-yellow to purple over the course of a few days. Thus, we can say with certainty that neither pollinator visitation, nor pollination itself triggers flower color change in *A. phalerata*.

Other related explanations for flower color change include the signaling of pollen viability or stigma receptivity. If color change signals post-reproductive flowers in *A. phalerata*, pollen viability and stigma receptivity should peak during the creamy-yellow phase and be significantly lower or even undetectable in



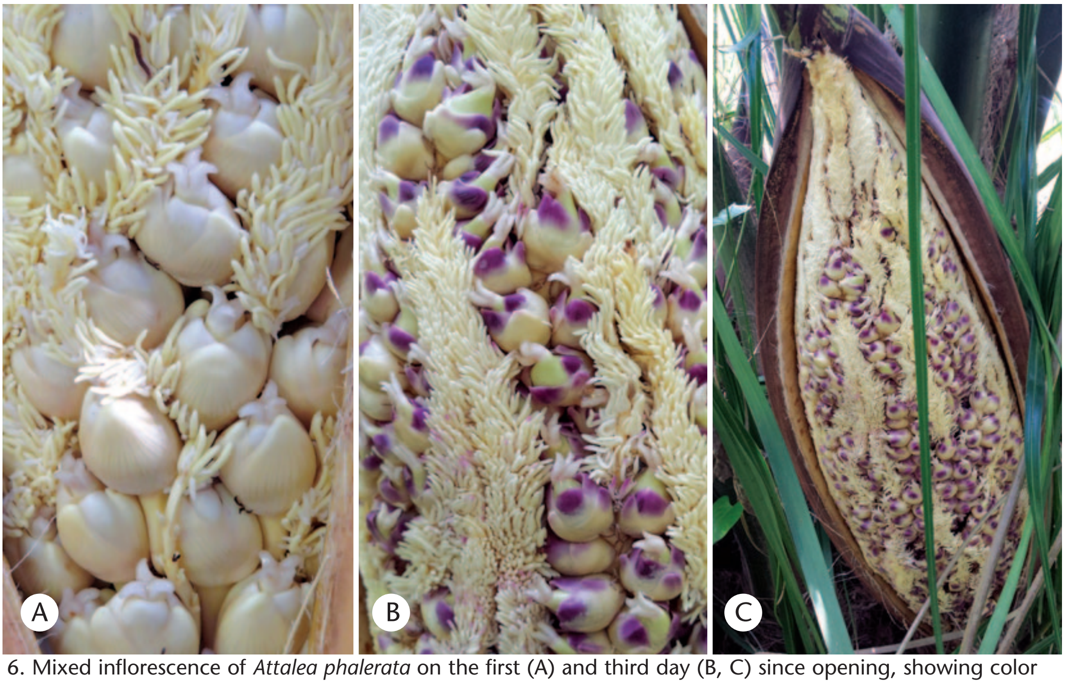
5. Proportion of *Attalea phalerata* pollen that successfully germinated *in vitro* on day 1, day 2, day 3, and day 4 after bract opening, based on pollen samples collected from six different inflorescences at Montgomery Botanical Center in Coral Gables, Florida.

purple-colored flowers. This would mean, however, that flowers are only fertile for up to 24 hours. To explore whether flower color change in *A. phalerata* is linked to pollen viability, we have begun to study germination rates in pollen collected at MBC from *A. phalerata* flowers during the first days after opening. To assess viability, we followed the *in vitro* pollen germination protocol described in Dafni et al. (2005), germinating pollen in Boric Acid medium mixed with a 20% sucrose concentration. Pollen samples were incubated at 26ºC for approximately 18 hours. We then used a hemocytometer to count germinated and ungerminated pollen grains using a compound microscope. Germination rate was calculated as the proportion of germinated pollen grains out of 300 grains systematically counted in each of four gridded quadrants on the hemocytometer. Preliminary results from six sampled inflorescences showed no clear pattern of loss in pollen viability over the first four days after bract opening, when flowers change from creamy-yellow to purple (Fig. 5). Although suggestive, further research is needed to better determine the relationship between pollen viability and flower color.

We also tested stigma receptivity of pistillate flowers over the first few days after inflorescence opening using two different methods: the application of hydrogen peroxide droplets and peroxidase test paper (Peroxtesmo KO, CTL Scientific Supply Corp) to the stigma, as described in Dafni et al. (2005). Both procedures are designed to test for the presence of peroxidase. This enzyme reflects receptivity; however, these tests can also give false positives if pollen is already present on the stigma (Kearns & Inouye 1993). We administered both tests on several different *A. phalerata* palms and found positive evidence of peroxidase on pistillate flowers both before and after color change. Further tests are needed to support these preliminary results.

One surprising finding was that the mere presence or absence of pollen seems to be linked with petal color in the staminate flowers. Shortly after the *A. phalerata* bract opens to expose its creamy-yellow flowers, anthers normally dehisce, and when jiggled, the inflorescence releases a large cloud of pollen. This continues to be true over the first 3 or 4 days after opening, regardless of flower color. On multiple occasions, however, we observed staminate inflorescences with no apparent burst of pollen when bumped. Flowers on these inflorescences also failed to change color, and upon closer examination, we found that the anthers contained no pollen. This also held true for mixed inflorescences, where only pistillate flowers exhibited color change but not the staminate flowers (Fig. 6). In *Attalea* species, mixed inflorescences are often functionally female with sterile male flowers (Anderson et al. 1988, Voeks 2002).

Flower color in *A. phalerata* does not seem to be a reliable indicator of pollen viability but may signal pollen availability. If color change to purple signals the presence of pollen, the question becomes, who is the palm signaling? And what about pistillate flowers? Could female flowers that do not change color also be sterile? The main pollinators of *A. phalerata* identified by Fava et al. (2011) are *Celetes* sp. *Colopterus* sp. *Mystrops* sp. and *Madarini* indet.*1*. These beetles are attracted to heat produced by thermogenesis. Temperatures peak just before the inflorescence opens, and accompanying scents released as volatiles also draw the beetles. Since both the heat and scent diminish quickly after the inflorescence is exposed (Fava et al. 2011), it is unlikely that color change plays a role in attracting the beetles. So, what purpose does the subsequent flush of purple serve? Does it somehow encourage the beetles to leave the inflorescence and visit another for cross-pollination? Or does the darkening color ensure a warmer environment for developing beetle eggs?



6. Mixed inflorescence of *Attalea phalerata* on the first (A) and third day (B, C) since opening, showing color change in pistillate but not in staminate flowers. Staminate flowers are void of pollen.

Could it possibly be attracting a secondary pollinator?

This paper revisits the question of flower color in *A. phalerata*, correcting an erroneous assumption that this palm displays two distinct types of inflorescences: one creamy-yellow and another purple (Tucker Lima 2009). Instead, daily observations revealed a predictable pattern of flower color change after the inflorescence opens. Whether this pattern has ecological significance or is simply a consequence of the passage of time remains to be proven, and our new discoveries have prompted many questions. The fact that *A. phalerata* is the only *Attalea* species to exhibit flower color change seems to hint at a deeper significance, but so far the usual explanations have come up short. Complementary *in situ* pollination studies to identify pollinators and their behavior are needed to explore possible associations between native pollinators and flower color. At MBC we shall continue our investigations into both the physiology and the ecology of flower color change and hope to shed light on the mechanisms, triggers, and possible reasons behind this mystery.

Acknowledgments

Jessika Reyes and Natalie Salman were supported under the Robert K. Zuck and Peter R. Jennings Internship Program offered through Montgomery Botanical Center (MBC). Many thanks go to Dr. Larry Noblick and Dr. Andrew Henderson for comments on earlier drafts of this manuscript. We are also deeply grateful to the curatorial staff at MBC for their field support and dedication to plant care, and to Dr. Michael Calonje for guidance with *in vitro* pollen germination protocols.

Literature Cited

Anderson, A.B., W.L. Overal and A. Henderson. 1988. Pollination ecology of a forest-dominant palm (*Orbignya phalerata* Mart.) in Northern Brazil. Biotropica 20: 192–205.

Barbosa Rodrigues, J. 1903. Sertum Palmarum Brasiliensium. Vol. 1. Imprimerie Typographique Veuve Monnom, Brussels.

Casper, B.B. and T.R. La Pine. 1984. Changes in corolla color and other floral characteristics in *Cryptantha humilis* (Boraginaceae): cues to discourage pollinators? Evolution 38: 128–41.

Dafni, A., E. Pacini, and M. Nepi. 2005. Pollen and stigma biology. In: Dafni, A., P.G. Kevan and B.C. Husband (eds.), Practical Pollination Biology, pp. 83–146. Enviroquest, Ltd., Cambridge, Ontario.

Delph, L.F. and C.M. Lively. 1989. The evolution of floral color change: pollinator attraction versus physiological constraints in *Fuchsia excorticata*. Evolution 43: 1252–1262.

Fava, W.S., W. da Silva Covre and M.R. Sigrist. 2011. *Attalea phalerata* and *Bactris glaucescens* (Arecaceae, Arecoideae): phenology and pollination ecology in the Pantanal, Brazil. Flora 206: 575–584.

Glassman, S.F. 1999. A taxonomic treatment of the palm subtribe *Attaleinae* (Tribe *Cocoeae*). Illinois Biological Monographs 59: 1–414.

Henderson, A. 2002. Evolution and Ecology of Palms. The New York Botanical Garden Press, Bronx, NY.

Henderson, A. 2020. A revision of *Attalea* (Arecaceae, Arecoideae, Cocoseae, Attaleinae). Phytotaxa 444: 1–76.

Kearns, C.A. and D.W. Inouye. 1993. Techniques for Pollination Biologists. The University Press of Colorado, Niwot, CO.

Lorenzi, H., H.M. de Souza, J.T. de Medeiros Costa, L.S.C. de Cerqueira and E. Ferreira. 2004. Palmeiras Brasileiras e Exóticas Cultivadas. Instituto Plantarum de Estudos da Flora, Ltd., São Paulo, Brasil.

Niesenbaum, R.A., M.G. Patselas and S.D. Weiner. 1999. Does flower color change in *Aster vimineus* cue pollinators? American Midland Naturalist. 141: 59–68.

Nuttman, C.V., F.M. Semida, S. Zalat and P.G. Willmer. 2006. Visual cues and foraging choices: bee visits to floral colour phases in *Alkanna orientalis* (Boraginaceae). Biological Journal of the Linnean Society 87: 427–435.

Oberrath, R. and K. Böhning-Gaese. 1999. Floral color change and the attraction of insect pollinators in lungwort (*Pulmonaria collina*). Oecologia 121: 383–391.

Pereira, A.C., J.B. da Silva, R. Goldenberg, G.A.R. Melo and I.G. Varassin. 2011. Flower color change accelerated by bee pollination in *Tibouchina* (Melastomataceae). Flora 206: 491–197.

Pintaud, J.-C. 2008. An overview of the taxonomy of *Attalea* (Arecaceae). Revista Peruana de Biología 15 (suppl.): 55–63.

Raguso, R.A. and M.R. Weiss. 2015. Concerted changes in floral colour and scent, and the importance of spatio-temporal variation in floral volatiles. Journal of the Indian Institute of Science 95: 69–92.

Tucker Lima, J.M. 2009. Flower color variation in *Attalea phalerata* (Arecaceae). Palms 53: 197–203.

Voeks, R.A. 2002. Reproductive ecology of the piassava palm (*Attalea funifera*) of Bahia, Brazil. Journal of Tropical Ecology 18: 121–136.

Weiss, M.R. 1991. Floral colour changes as cues for pollinators. Nature 354: 227–229.

Weiss, M.R. 1995. Floral color change: a widespread functional convergence. American Journal of Botany 82: 167–185.

Yan, J., G. Wang, Y. Sui, M. Wang and L. Zhang. 2016. Pollinator responses to floral colour change, nectar, and scent promote reproductive fitness in *Quisqualis indica* (Combretaceae). Scientific Reports 6: 24408.

Northward Expansion of Two Palms Native to the Southeastern USA

Keith Zimmerman[1]

Since 2010, I have documented the presence of *Roystonea regia* naturalizing within the Emerson Point Preserve in Manatee County, Florida, approximately 160 kilometers (100 miles) north of the nearest habitat in the Fakahatchee strand, and 55.5 kilometers (34.5 miles) north of the northernmost vouchered population in DeSoto County. Additionally, palm hobbyists in North Carolina and Florida have used satellite imagery to identify a population of *Sabal palmetto* in Kure Beach, New Hanover County, North Carolina, that is 10 kilometers (6.21 miles) north of the northernmost historical population on Bald Head Island, Brunswick County, North Carolina. This article will discuss potential causes behind this northward expansion and provide photographic documentation of both groupings.

Palms, as a family, consist of a large number of species which inhabit a diverse range of habitats. Due to their tropical appearance, palms are often planted in landscapes far outside their native range. In the US southeast, *Sabal palmetto* and *Roystonea regia* are two of the most commonly planted native palms in the landscape (Fitzpatrick 2005). *Sabal palmetto* is native to a diverse range of habitats in Florida, Georgia, South Carolina and North Carolina, and the current northernmost vouchered population occurs on Bald Head Island, in Brunswick County in North Carolina (Zona 1990). Due to the adaptability of the species, as well as its cold hardiness, landscape specimens are found much further north, and it is not uncommon to see fully mature specimens as far north as Virginia Beach (Virginia). *Roystonea regia* is somewhat more limited in its native habitat requirements, and within Florida it is currently vouchered for only Collier, Desoto, Dade, Martin, Monroe (mainland), and Martin Counties (Wunderlin et al. 2020). Moreover, it is classically listed as being distributed in the hammocks of the Everglades in Collier, Dade and Monroe counties (Zona 1996). Despite this, it is commonly found through landscaping in suitable zones in Florida, mainly within the southern third of the state (with some individuals surviving to maturity in private gardens as far north as Jacksonville). These range reports have been relatively stable (with one exception, discussed later in this article), despite the ready availability of both species for much of this time. Climate change appears to be altering the climate of the southeastern US, facilitating northward migration of both species in the environment.

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Somewhat counterintuitively, the ability to cultivate a palm in a particular area is not necessarily indicative of a palm's ability to grow wild in that area, as the environmental conditions of cultivation can facilitate growth of palms when they would otherwise perish under natural circumstances (Eiserhardt et al. 2011). Studies on modern palms have demonstrated that temperature range is the primary factor restricting palms from growing wild in areas where they may be found in cultivation, but other factors like availability of water and topography are important at the local scale (where temperature range is adequate).

Recent work has demonstrated the northern expansion of palms coinciding with increased average temperatures, including another member of the genus *Sabal*, *S. minor*, both at the northeastern most portion of its range in North Carolina (Tripp & Dexter 2006), as well as at the northwesternmost portion of its range in southeast Oklahoma (Butler et al. 2011, Butler & Tran 2017). Moreover, recent work predicts that northward expansion of several palm species native to the Southeastern US (*Sabal etonia*, *S. minor*, *S. palmetto*, *Rhapidophyllym hystrix* and *Serenoa repens*), with the northern shift of the centroid of the range of each species predicted to occur at a rate of 23.5 km/decade. This was most notable for *S. palmetto*, whose distribution was predicted to increase by a median of 21% by 2070. Other species were predicted to shift northward as the southern portion of their habitat became unsuitable, most notably for *S. etonia* and *S. minor*, which were predicted to become extirpated at the southernmost portion of their current habitat by 2070 due to warming climate (Butler & Larson 2020), although *S. minor* may be more tolerant of warm conditions than current range suggests, as evidenced by an isolated population of *S. minor* south of its main range in Nuevo León, Mexico (Goldman 1999).

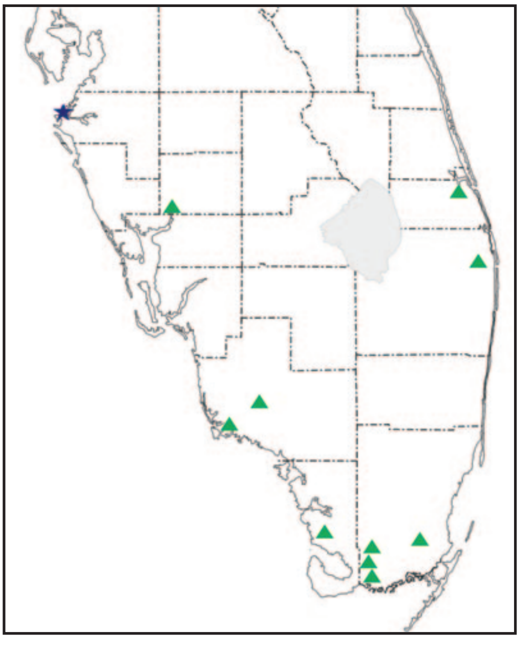
Surveys by the US Forestry Service have demonstrated a general northward migration of up to 70% of tree species in recent years. The current rate is not known, but fossil plant and pollen records have generally demonstrated a northward migration at the rate of 50 km per century during warming periods. Current migration of tree species is typically assessed by examining the average age of the tree within a known area. Predominance of seedlings and immature trees suggest a younger population, whereas predominance of more mature trees suggest an older population (United States Forest Service 2010). As will be described below, both populations listed in this current observation are represented largely by younger plants.

Northward expansion of *Roystonea regia* habitat

To underscore the significance of a northward moving *Roystonea regia* in Florida, a brief history of the species may be helpful. *Roystonea regia* was originally described in Florida by William Bartram in 1774 near Lake Dexter along the St. John's River. This originally described population is no longer present, and current hypotheses suggest that severe 1835 weather or exploitation of palm wood may have caused the demise of that population (Small 1928). Nonetheless, currently the northernmost vouchered native specimen of *R. regia* exists within the Deep Creek Preserve in DeSoto County, Florida (Wunderlin et al. 2020). Before publication of this article, *R. regia* has not been described naturalizing north of this population, despite having been cultivated in Manatee County for nearly as long as the nursery trade has existed in the state.

The first recorded collection of *Roystonea regia* from the Everglades for nursery trade and cultivation was made in April of 1885 by Pliny

1. Map of the southern portion of Florida with Emerson Point Preserve marked with a star. Currently vouchered populations of *Roystonea regia* marked with triangles.



2. *Roystonea regia* in Emerson Point Preserve.

3. *Roystonea regia* in Emerson Point Preserve.

4. Juvenile *Roystonea regia* in Emerson Point Preserve.

Reasoner of the Reasoner Brother's nursery in Oneco, Florida (Reasoner 1886–87, Simpson 1902). Since then, *R. regia* has been a staple in Manatee County landscaping, and century-old specimens still exist in some areas of Manatee County from the original collections by the Reasoner Brothers. Possibly most notable of these palms is a grouping at the historic Haley house in Palmetto, Florida, seen by many who have driven along the Bob Graham Sunshine Skyway Bridge. The presence of these individuals in the area stands testament to the long-term ability of this species to grow in Central Florida, despite the infrequent deep freezes. The question then arises as to why the species has not naturalized at this latitude during this span of time. Other work, which has studied the spread of *Trachycarpus fortunei* in the forests of southern Ticino and Northern Lago Maggiore, has shown that warming climate can allow a palm species which has been successfully cultivated in an area for many years to spread into nearby forests as the climate warms and becomes more suitable to naturalization (suggesting that climate appropriate for naturalization may be warmer than that required for cultivation) (Walther 2007, Fehr & Burga 2016).

Within the Emerson Point Preserve of Manatee County, Florida, is a pre-Columbian Portavant Temple Mound Complex, the largest Amerindian temple mound in the Tampa Bay region. Most of this mound is within or adjacent to the park's tropical hardwood hammock habitat (Tryon 2013). Per the Manatee County Parks and Natural Resources Department, canopy trees within this community consist of many West-Indian-origin trees and shrubs, and the dominant species seen are *Quercus virginiana*, *Capparis cynophallophora*, *Bursera simaruba*, *Sideroxylon foetidissimum*, *Eugenia axillaris*, *Zanthoxylum fagara*, *Ficus aurea*, *Coccoloba uvifera*, *Ardisia escallonioides* and *Lysiloma latisiliquum*. In this temple mound complex, soil mainly consists of calciferous shell substrate, with flatter areas predominated by Eau Gallie fine sand (Hunsicker 2013) Average yearly rainfall totals 142 cm (56 in), with the majority of this falling between the months of June and September. Climate of the area is considered humid subtropical, closely bordering a tropical savanna climate, with cold-snaps being significantly moderated by the near-by waterways, such as the Terra Ceia Bay, the Tampa Bay, the Manatee River, and the Gulf of Mexico (NOAA 2018). A map of the southern portion of Florida with the location of the preserve denoted by a star can be seen in Figure 1 (Wunderlin et al. 2020). Though not listed by the Manatee County Parks and

5. Map of the eastern portion of North Carolina with Kure Beach marked with a star. Currently vouchered populations of *Sabal palmetto* on Bald Head Island marked with a triangle.

Natural Resources Department within the species list in their management plan, multiple individuals of *Roystonea regia* are present within this area. During survey of the area, I noted 12 easily accessible individuals with ringed trunk up to 5 m (16.4 ft), 15 individuals with fully pinnate leaves but no ringed trunk, and five to ten seedlings (individuals without fully pinnate leaves) (Figs 2–4). In my ten years of observing the population at Emerson Point Preserve, I have noticed numerous palms that do not continue to develop past the seedling stage before perishing. However, individuals which developed fully pinnate leaves have generally survived once they reach this stage. The reason for this could be due to the lesser amount of rainfall during the dry season compared to the rainy season, as larger palms would have more extensive root systems and would be more resistant to drought, whereas smaller seedlings would more easily succumb. The size of the largest individuals, considering the quick growth of *R. regia* juvenile, suggest that the population of naturalized palms within the park is less than 20 years old. These palms are presumably the offspring of a number of large *R. regia* planted in the park when the property was purchased by Peter and Golden in 1910 (FCIT 2019). There are currently four surviving individuals from this original planting. Given the time of planting, and years of Reasoner's Nursery operation, these cultivated palms were most likely provided by the Reasoner's Nursery collection (Reasoner 1886–87). Some studies suggest that palms at the northern edge of their range may exhibit some additional cold hardiness, such as with the Oklahoma population of *S. minor* (Butler & Tran 2017), so it is possible that these

6. Kure Beach *Sabal palmetto*. Photo by Chris Eaton.

7. Kure Beach *Sabal palmetto* seedlings. Photo by Vincent Mario Falvo.

R. regia, likely sourced from the Florida population in the Everglades may have additional hardiness compared with individuals sourced from the Cuban population, introduced into the state by Thomas Edison (Dunn 1960).

As mentioned above, the main limiting factor behind distribution of a palm species is temperature range, with other factors like availability of water and topography becoming more important at the local scale. The presence of century-old palms within the region suggests that temperature range plays a small role for already established palms. However, as also mentioned previously, ecology in cultivation is distinct from that in the wild, and the establishment phase of the palm may be the limiting factor. Seedlings within the population appear to have a high mortality rate, as their smaller root systems are more susceptible to periods of cold and drought. However, water availability varies within the county, and areas exist which display waterlogged soils during droughts which should sustain *Roystonea regia*. These areas, however, tend to be located inland of the narrow band in which freezes are infrequent at this latitude within the state. As average temperatures in Florida have been increasing, and as freezes become less frequent, this could be the difference between survival and damping off of the royal palm seedlings. This changing climate could help explain the new increase in range.

Northward expansion of *Sabal palmetto* range

As mentioned above, currently the northernmost vouchered population of *Sabal palmetto* exists on Bald Head Island, in Brunswick County in North Carolina (Zona 1990) A combination of climate change, plus pressure from herbivory, may have led to the increase in relative local density of *S. palmetto* (Smith et al. 2015). Recently, members of an online palm forum have used satellite imagery to identify several palms located in Kure Beach, North Carolina, approximately 10 Kilometers (6.21 miles) north of the population on Bald Head Island (and, notably, in a more northern county). A map of the eastern portion of North Carolina with the location of Kure Beach denoted by a star can be seen in Fig. 5. After potential identification of these *S. palmetto* individuals via satellite imagery, Mr. Chris Eaton and Mr. Vincent Mario Falvo traveled to locate these *S. palmetto* specimens. It was observed that there were a number of *S. palmetto* growing within the maritime forest in the Kure Beach area. This included over 30 juvenile, non-trunking palms, 5–10 trunking palms (with petiole boots) up to 2 m (6.5 feet) in height, and at least one trunking palm with petiole boots fully shed at approx. 3 m (10 ft) in height. Unlike the population of *Roystonea regia* mentioned earlier in this article, the *S. palmetto* population discussed here consists of mostly juvenile individuals, with mature trees making up a small portion of the population. However, given that the oldest palms in the population are mature enough for seed production (Figs 6 & 7), it is still possible that this population could be self-sustaining. One should also remember that *S. palmetto* is slower to gain vertical height than *R. regia*, thus the younger population could be indicative of the slower growth rate. Of note, another juvenile *S. palmetto* was found growing in the woods of Emerald Isle Woods Park, 66 miles (106 km) north of the population on Bald Head Island. No other *S. palmetto* were found nearby, so this is not sufficient evidence to indicate that *S. palmetto* has become established in this location, but is an interesting curiosity given the findings in Kure Beach.

As with *Roystonea regia* in Florida, *Sabal palmetto* is historically common in coastal Carolinian landscaping, but this landscaping is primarily done through transplanting of mature palms from Florida. Previous research has demonstrated that nurseries and ornamental plantings may play a role in expanding the range of palm species (Svenning 2002), including in the northern expansion of native palms, such as *Washingtonia filifera* into the Death Valley via ornamental plantings nearby (Cornett 1987, Holmquest et al. 2011), so more investigation may be needed to determine if these northern naturalized *S. palmetto* palms originate from the Bald Head population or from more close-by landscaping specimens.

Conclusion

This current observation supports potential northward naturalization of two palm species in the southeastern United States, a phenomenon which may be due in part or whole to continuance of warming climates. Further research may be needed to determine the extent of northward movement of these two species, as well as the other 13 palm species native to the southeastern United States. Many of these native palms appear to be restricted by local ecology and slow growth, rather than absolute cold tolerance. However, these species are becoming more frequently used in public landscapes outside of their natural habitat, as the benefits of landscaping with native plants become more widely known, and thus habitat expansion may begin to occur.

Acknowledgments

Dr. Keith Zimmerman greatly thanks Mr. Chris Eaton, Mr. Vincent Mario Falvo and Mr. Gray Tyrey for providing photos of *S. palmetto* specimens.

Literature Cited

Butler, C.J. and M. Larson. 2020. Climate change winners and losers: The effects of climate change on five palm species in the Southeastern United States. Ecology and Evolution 10: 10408–10425. https://doi.org/10.1002/ece3.6697.

Butler, C.J. and H.B. Tran. 2017. Dwarf palmetto (*Sabal minor*) population increase in southeastern Oklahoma. Castanea 82: 163–168.

Butler, C.J., J.L. Curtis, K. Mcbride, D. Arbour and B. Heck. 2011. Modeling the distribution of the dwarf palmetto (*Sabal minor*; Arecaceae) in McCurtain County, Oklahoma. Southwestern Naturalist 56: 66–70. https://doi.org/10.1894/JB-15.1.

Cornett, J.W. 1987. Naturalized populations of the desert fan palm, *Washingtonia filifera*, in Death Valley National Monument. In: Hall, C.A. Jr and V. Doyle-Jones (Eds). White Mountain Research Station Symposium: Plant Biology of Eastern California, Vol 2. Los Angeles: White Mountain Research Station (pp. 167–174).

Dunn, H. 1960. Edison launched Fort Myers “Avenue of Palms.”

Eiserhardt, W.L., J.-C. Svenning, W.D. Kissling and H. Balslev. 2011. Geographical ecology of the palms (Arecaceae): determinants of diversity and distributions across spatial scales. Annals of Botany 108: 1391–1416.

Fehr, V. and C.A. Burga. 2016. Aspects and causes of earlier and current spread of

Trachycarpus fortunei in the forests of southern Ticino and Northern Lago Maggiore (Switzerland, Italy). Palms 60: 125–136.

Fitzpatrick, G.E. 2005. Analysis of landscape palm species richness and diversity in southeastern Florida. Proceedings of Florida State Horticultural Society 118: 294–297.

Florida Center For Instructional Technology (FCIT). 2019. Gallery: Portevant Indian Mound at Emerson Point. Retrieved from https://fcit.usf.edu/florida/photos/native/portev/portev.htm (accessed on 13 Dec 2020).

Goldman, D.H. 1999. Distribution update: *Sabal minor* in Mexico. Palms 43: 40–44.

Holmquest, J.G., J. Schmidt-Gengenbach And M.R. Slaton. 2011. Influence of invasive palms on terrestrial arthropod assemblages in desert spring habitat. Biological Conservation 144: 518–525. https://doi.org/10.1016/j.biocon.2010.10.007.

Hunsicker, C. 2013. Emerson Point Preserve: State of Florida Division of State Lands Acquisition and Restoration Council Draft Management Plan. Bradenton, FL: Manatee County Board of County Commissioners Parks and Natural Resources Department.

National Oceanographic Atmospheric Association (NOAA) 2018. National Weather Service Forest Office: Tampa Bay, Florida. Retrieved from https://w2.weather.gov/climate/xmacis.php?wfo=tbw (accessed on 13 Dec 2020).

Reasoner, P.W. 1886–87. Royal Palm Nurseries Catalog.

Simpson, C.T. 1902. A visit to the Royal Palm Hammock of Florida. The Plant World 5: 4–7.

Small, J.K. 1928. The Royal Palm – *Roystonea regia*. Published by the Author.

Smith, C.K., E. Landreaux, H. Steinmann, R. Hayes, A. Keith-Lucas and C. Hayes. 2015. Climate, deer and hogs: Drivers of rapid change in the hickory-dominated maritime forest on St. Catherines Island. Natural Resources 6: 9–15.

Svenning, J. C. 2002. Non-native ornamental palms invade a secondary tropical forest in Panama. Palms 46: 81–86.

Tripp, E.A. and K.G. Dexter. 2006. *Sabal minor* (Arecaceae): A new northern record of palms in eastern North America. Castanea 71: 172–177. https://doi.org/a10.2179/05-12.1.

Tryon, T. 2013. Tryon: Preserving Emerson Point. Herald-Tribune, 14 Apr. 2013.

United States Forest Service (USFS). 2010. Study suggests tree ranges are already shifting due to climate change (Research Review No. 11). Newtown Square, PA: US Department of Agriculture, Forest Service Northern Research Station

Wunderlin, R.P., B.F. Hansen, A.R. Frank and F.B. Essig. 2020. Atlas of Florida Plants (http://florida.plantatlas.usf.edu/). [Landry, S.M. and K.N. Campbell, (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.

Zona, S. 1990. A monograph of *Sabal* (Arecaceae: Coryphoideae). Aliso 12: 583–666.

Zona, S. 1996. *Roystonea* (Arecaceae: Arecoideae). Flora Neotropica 71: 1–36.

Seventeen Palms: A Declining Desert Fan Palm (*Washingtonia filifera*) Oasis in Anza-Borrego Desert State Park

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A population of *Washingtonia filifera* at Seventeen Palms in California's Anza-Borrego Desert State Park, was analyzed five times over a period of 104 years. A dramatic shift in structure from juvenile to adult dominance was recorded. With only two tentative recruits to the population since 1984, *W. filifera* seems likely to be extirpated at Seventeen Palms if existing conditions persist. The near elimination of population recruits is most likely due to diminished spring flow. A decline in precipitation, increase in frequency and duration of drought and crustal displacement from earthquakes are possible factors in the reduction of moisture availability. Rising temperatures contribute to the moisture deficit.

The desert fan palm, *Washingtonia filifera*, is the only palm native to the western United States and the most massive palm in North America (Cornett 2010). I have recorded populations of this species at 168 discrete and geographically isolated sites in the southwestern U.S. and Baja California where streams, springs or seeps provide permanent moisture at, or near, the surface. Though dozens of perennial species are associated with oasis environments, when the desert fan palm is present, the site is usually referred to as a palm oasis (Henderson 1961, Kirk 1973).

While searching through institutional archives for historical landscape photographs, I came upon an image of Seventeen Palms, a desert fan palm oasis located in the Colorado Desert portion of Anza-Borrego Desert State Park (Fig. 1). The photograph was taken by author and naturalist J. Smeaton Chase in 1916, according to Renee Brown of the Palm Springs Historical Society (Fig. 2). The designated year of the photograph is supported by accounts in Chase's book, *California Desert Trails* (1919). The photograph's antiquity is bolstered by the presence of a horse-drawn buckboard, seen right of center. Though the origin of the name is unknown, Chase assumed there were 17 adult palms when the oasis was first encountered by prospectors in the 19th century (Chase 1919).

The utility of repeat photography in assessing changes in vegetation, including palms, has been well documented (Bullock & Heath 2006, Bullock et al. 2010). In the current example, Chase's large-format image, together with the clumped grouping of the palms, enabled a fairly accurate palm count. To the best of my knowledge, the photograph provides the oldest and most accurate baseline data on a

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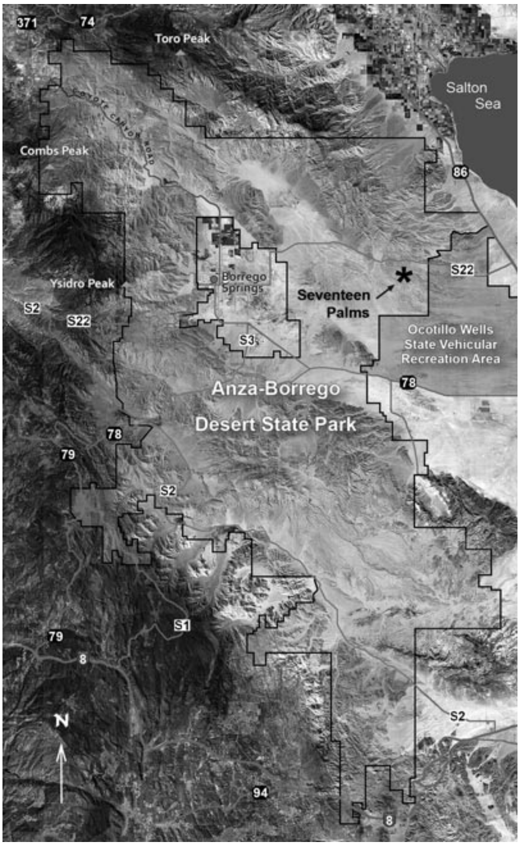

1. Map of Anza-Borrego Desert State Park showing location of Seventeen Palms. Satellite image courtesy of Google Maps/Google Earth.

population of *W. filifera* not modified by human activities. The existence of later field counts at the oasis enabled intermittent tracking of palm numbers over a period of 104 years. The population data were used to assess the possible impact of increasing temperature and increased frequency of drought on a desert fan palm oasis. These two parameters have been associated with climate change predictions in the American Southwest (Notaro et al. 2012).

Methods

For purposes of assessing changes in overall perennial plant composition and coverage, the palm oasis boundary was defined as a perimeter extending 10 m beyond the outermost palms in the oasis. The distance of 10 m was used as this is the maximum known root length of *W. filifera* (Cornett 2010). All living perennial plant species within the perimeter were recorded by my colleague, J. Stewart, in 1984 (field notes in author's files) and myself in 2020. Each species was ranked using a visual estimate of ground cover within the perimeter. Because plant species composition and plant coverage in an oasis can be affected by human-caused and naturally occurring fires (Vogl & McHargue 1966), an effort was made to determine if Seventeen Palms had ever burned, and if it had, how frequently.

Palm numbers were obtained from the Chase image as well as counts conducted by Randall Henderson (1945a, 1945b), Dick Bloomquist (1978), Jon Stewart (in 1984) and my own evaluation in December of 2020. In each of the five analyses, palms were grouped as either adults or juveniles. Additionally, in the years 1916, 1984 and 2020, I was able to assign each palm to one of four size categories based upon trunk height: < 1 m, 1–2 m, 2–4 m and > 4 m. Palms with trunk heights more than 4 m were classified as adults as this is the height at which the species typically begins producing inflorescences (Cornett 2010). A fifth category, seedlings, was defined as germinated palms that had not yet produced fan-shaped leaves. Photographs, descriptions in the literature and field notes were reviewed to determine the presence of seedlings in each of the five analysis years.

Annual weather summaries were evaluated to assess the degree and nature of climate change in the region of Seventeen Palms. Data for the years 1895 through 2020 was available for Imperial County, California (NOAA 2020). Though Seventeen Palms lies in San Diego County, the Imperial County line is just 2.6 km east of Seventeen Palms and, unlike most of San Diego County, Imperial County is entirely within the Colorado Desert subdivision of the Sonoran Desert. It was concluded that data from Imperial County would most closely approximate the climate experienced at Seventeen Palms. In addition to climate data, historical records and field notes were reviewed to determine observable changes in water availability, such as presence of waterholes or damp surface soil. Indirect evidence of changes in water availability, such as growth rates or inflorescence production, were also assessed. Inflorescence production is thought to be positively related to the quantity and reliability of the available water supply (Cornett 1986).

Results

Oasis flora consisted of nine perennial plant species with each being recorded in both 1984

2. Seventeen Palms oasis, in 1916, showing preponderance of juvenile desert fan palms, *Washingtonia filifera*. Note horse-drawn buckboard right of center. Photograph by J. Smeaton Chase, courtesy of the Palm Springs Historical Society.

Table 1. Perennial plant species present in Seventeen Palms oasis in 2020 and 1984. Species present in 2020 are listed in estimated order of decreasing ground coverage. *Prosopis glandulosa* was dominant in the area beyond palm oasis perimeter.

Species	Common Name	Rank in 2020	Rank in 1984
Washingtonia filifera	Desert Fan Palm	1	1
Isocoma acradenia	Alkali Goldenbush	2	8
Distichlis spicata	Salt Grass	3	2
Lycium brevipes	Baja Desert Thorn	4	3
Atriplex polycarpa	Cattle Spinach	5	4
Suaeda nigra	Bush Seepweed	6	5
Atriplex hymenelytra	Desert Holly	7	7
Juncus acutus	Wire Rush	8	6
Prosopis glandulosa	Honey Mesquite	9	9

3. Seventeen Palms oasis 104 years later, in 2020, showing dominance of adult palms and apparent absence of juveniles. Note the concentration of adult palms has shifted into the image foreground (75 m south). The location of the repeat photograph moved approximately 6 m west to show maximum number of palms.

and 2020 (Table 1). The relative coverage of each species also remained the same, with one exception. *Isocoma acradenia*, the alkali goldenbush, had increased and by 2020 was second only to *W. filifera* in ground coverage. It is worth noting that no non-native, perennial species had established at Seventeen Palms, in contrast to many other palm oases (Cornett 2008). Palms were the dominant plant in the oasis throughout the period of study, in part because the placement of the oasis perimeter was dictated by the locations of the palms. Images taken by Chase and Henderson, as well as Stewart's and my field surveys, indicated no other plant species had successfully encroached upon the palm's dominance in the 104 years covered by the study. The grove had burned at least once prior to Chase's 1916 visit. This conclusion was based upon the absence of ground-length leaf skirts and what appeared to be partially blackened trunks on all but the shortest (youngest) adult palm in Chase's photograph. This was Henderson's finding as well in 1945 (Henderson 1945a,1945b). In 2020, every young adult palm had leaf skirts to the ground indicating there had been no fire since before Chase's 1916 visit (Fig. 3). I concluded fire played no role in palm number changes or demography during the 104-year span of the analysis.

The historical literature indicates surface water existed in the past. Small waterholes were present in 1916 (Chase 1919) and in 1945 (Henderson 1945a, 1945b). The waterholes had diminished to seeps when Bloomquist visited the oasis in 1978. Stewart found no signs of surface water in 1984 nor did I in five visits to the oasis in 2020. In addition to the absence of seedlings, it was concluded the water supply was inadequate for vigorous growth and reproduction in 2020 due to a lack of inflorescence production. Only one of the twenty-six adult palms had produced inflorescences, and the one palm that did, produced only two. A desert fan palm is known to grow up to fifteen inflorescences when moisture is both plentiful and reliable (Cornett 1986).

The total number of palms was roughly constant over the 104 years of the study period, ranging from 23 in 1916 to a high of 30 in 1945 (Table 2). The ratio of juvenile to adult palms, however, had reversed when Bloomquist conducted his count in 1978 (Fig. 4). In the 1916 and 1945 counts, juvenile palm numbers dominated the oasis. By 2020, however, juveniles were nearly absent. Conversely, adult palms were in the minority in 1916 but overwhelmingly dominant in 2020. Indeed, only two young palms were present in 2020 and their growth and survival seemed in doubt as they struggled to emerge from beneath ground-level leaf skirts of adult palms. In contrast, Chase's 1916 image reveals many juvenile palms that were not confined to the center of the palm grove but had established more than 25 m from adults.

Though seedling palms may have been present, they could not be discerned in Chase's or Henderson's photographs and were not mentioned in any historical accounts of the oasis. Site visits in 1984 and 2020 failed to reveal seedlings. By way of contrast, seedling palms in the moist, lower eastern drainages of Southern California's Peninsular Ranges, such as in Borrego Palm Canyon, can be extremely common (personal observations in 1987, 2004 and 2020). The absence of seedlings at Seventeen Palms in 1984 and 2020, indicates suitable conditions for germination – i.e., a permanent or near-permanent saturated surface soil layer – were likely not present from at least 1984 onward.

To determine if there was a long-term decline in precipitation and presumed decline in natural recharging of the aquifer, I used the calculated mean precipitation for the years 1946 through 2020 (NOAA, 2020). This was the time span in which adult palms became dominant. I compared this with the mean precipitation from 1895 through 1945, the interval when juveniles were dominant. The climate summaries indicate that there was less precipitation, greater incidence of annual drought, and a greater incidence of extended drought lasting three years or more during the most recent interval from 1946 through 2020 (Table 3).

The last metric examined was temperature. Transpiration increases with temperature (Raven et al. 2005). A rise in temperature increases water loss through stomata resulting in palms needing to take up more soil moisture if they are to maintain water balance. The mean temperature from 1895 through 1945 was 22°C (Table 3). The mean temperature from 1946 through 2020 was warmer with a mean of 22.9°C. An increase in the rate of transpiration during a period of diminishing precipitation and extended droughts would be expected to stress palms, particularly juveniles with their less extensive root systems.

4. Population changes among juvenile and adult desert fan palms, *Washingtonia filifera*. Juveniles dominated the population through at least 1945. Adults dominated the population from 1978 through 2020. By 2020 only two juveniles were present and adult palms had reached their greatest number in 104 years.

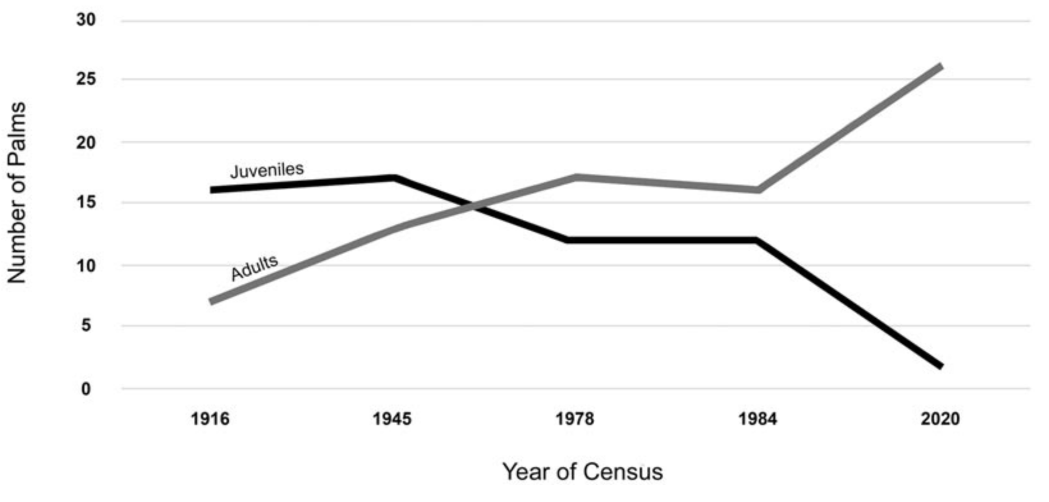

Table 2. Results of five *Washingtonia filifera* counts, spanning 104 years, at Seventeen Palms, Anza-Borrego Desert State Park, California. nc = no counts. *Count derived from Chase photograph.

Year of Census	Number in Each Size Class					Total Palms
	<1 m	1–2 m	2–4 m	Total Juveniles	Adults >4 m	
1916*	15	1	0	16	7	23
1945	nc	nc	nc	17	13	30
1978	nc	nc	nc	12	17	29
1984	2	8	2	12	16	28
2020	2	0	0	2	26	28

Increasing temperature also accelerates the evaporation rate of water at, or near, the surface. Palm seeds are dependent upon moisture lingering at the surface for germination. The reduction in inflorescence production in the fall of 2020 (and ultimately seed production) is one indication of water-stressed palms.

Discussion

Recorded data indicate the *W. filifera* population at Seventeen Palms oasis has transitioned from one dominated by juvenile recruits to one dominated almost entirely by adults. The trend was first documented in 1978 with the slope becoming particularly steep from 1984 to 2020 (Fig. 4). Typically, this characteristic indicates a population in decline (Harper 1977, Barbour et al. 1987). Without recruits, and if recent trends continue, it may be predicted there will be insufficient juvenile palms to compensate for the eventual death of aging adults.

An insufficient supply of water is the likely reason for the sharp decline in recruit numbers. Decreasing moisture could be the result of one or more of the following factors: (1) decrease in upward flow of groundwater due to crustal displacement from an earthquake; (2) lowering of the aquifer due to long-term precipitation decline or pumping of groundwater for commercial and domestic use; (3) an increase in temperature requiring a concomitant increase in transpiration and water demand by the palms and other plant species in the oasis.

Earthquakes and Groundwater

Most desert fan palm oases, such as Seventeen Palms, are associated with crustal faults or bedrock fractures that connect with aquifers (Norris & Webb 1990, Sharp 1994, Sylvester 2016). Many large aquifers contain "fossil water" that accumulated thousands, sometimes millions of year ago during a period when precipitation and runoff were much greater than in at any time during the past century (Kreamer & Springer 2008). Under such circumstances, changes in climate over the period described in this study may have little if any impact on the amount of water reaching the surface. Crustal shifts occurring during earthquakes, however, may have dramatic effects on fossil water flow including an increase in fossil water reaching the surface, a decrease, a complete cessation, or a new emergence site (Vogl & McHargue 1966, Sneed et al. 2003). Water flow to the surface clearly decreased after Henderson visited the oasis in 1945. The waterholes referred to by Henderson were gone by Bloomquist's 1978 visit. There also appears to have been a shift in the location where water rises to the surface. Based upon the density of adult palms in 2020, the concentration of upwelling water moved approximately 75 m to the south.

Groundwater Extraction

Pumping out groundwater for domestic and commercial use can result in lowering the aquifer, potentially reducing flows, or even eliminating naturally occurring desert springs (Unmack & Minckley 2008). The only largescale groundwater extraction in the region is from the Borrego Valley Groundwater Basin located approximately 22 km west of Seventeen Palms (Faunt et al. 2015). The northeastern extent of the aquifer, however, ends abruptly at the Coyote Creek Fault. Seventeen Palms is located on the opposite side of the fault, 9 km to the northeast. It is not, therefore, part of the Borrego Valley Groundwater Basin.

Table 3. Climate parameters for Seventeen Palms oasis region (NOAA, 2020).

Climate Category	Interval		Change
	1895–1945	1946–2020	
mean Annual Precipitation, mm	92	77	-16.3%
SD of Precipitation Intervals	1.58	1.51	-0.07
Drought Frequency for Interval	47%	61%	14%
Drought Frequency of 3 Years or Longer	8%	16%	8%
mean Annual Temperature, °C	22.0	22.9	0.9

Climate Change

Precipitation decreased and drought frequency, duration and temperature increased after 1945 (Table 3). These phenomena have all been associated with climate change predictions and are well documented (Cole et al. 2011, Notaro et al. 2012). Considered alone, the phenomena might explain the near absence of juvenile recruits from 1984 through 2020. Such a conclusion is strengthened when one considers that temperature increase is an independent variable that increases evaporation from soil surfaces and potential transpiration rates regardless of the amount of upwelling moisture along the fault. Unfortunately, it is not possible to separate impacts of earthquakes and crustal shifting from impacts of climate change, at least at Seventeen Palms.

The degree to which Seventeen Palms and any of the other 168 known palm oases is independent of the frequency and duration of drought – the extent to which they are completely reliant upon fossil water – is unknown. I have recently observed die-offs of many dozens of once-vigorous palm trees in Palm Canyon in Riverside County, the largest desert fan palm oasis in existence (Cornett et al. 1986). As a keystone species in Colorado Desert oasis environments, the desert fan palm is relied upon by many birds, mammals and other organisms as food, shelter, and nesting resources. Potential impacts to populations of *W. filifera* under a changing climate should be of concern and more research into their current and future status seems warranted.

Acknowledgments

The Garden Club of the Desert and Joshua Tree National Park Association provided funds for the research described in this paper. Jon Stewart participated in palm oasis data collection in 1984. Danny McCamish and Shannon McNeil provided valuable assistance in acquiring and implementing the research in Anza-Borrego Desert State Park (Permit #CDD-2020-016-ABDSP). Jim Dice and Elaine Tulving of the Steele/Bernand Anza-Borrego Desert Research Center facilitated the days spent in the Borrego Springs region. My deep appreciation is extended to each of these organizations and individuals.

LITERATURE CITED

BARBOUR, M.G., J.H. BURK AND W.D. PITTS. 1987. Terrestrial Plant Ecology (second edition). Benjamin-Cummings Publishing Company, Menlo Park.

BLOOMQUIST, D. 1978. Seventeen Palms oasis. Desert Magazine 41(7): 16–17.

BULLOCK, S.H. AND D. HEATH. 2006. Growth rates and age of native palms in the Baja California desert, Journal of Arid Environments 67: 391–402.

BULLOCK, S.H. AND R.M. TURNER. 2010. Plant population fluxes in the Sonoran Desert shown by repeat photography. In: WEBB, R.H., D.E. BOYER AND R.M. TURNER (eds). Repeat Photography Methods and Applications in the Natural Sciences. Island Press, Washington D.C.

CHASE, J.S. 1919. California Desert Trails. Houghton Mifflin Company, Boston.

COLE, K.L., K. IRONSIDE, J. EISCHEID, G. GARFIN, P.B. DUFFY AND C. TONEY. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications, 21: 137–149.

CORNETT, J.W. 1986. Palm burning and increased spadix production. Southwestern Naturalist 31: 552–553.

CORNETT, J.W. 1993. Factors determining the occurrence of the desert fan palm, *Washingtonia filifera*. San Bernardino County

Museum Association Special Publication 93: 37–38.

Cornett, J.W. 2008. The desert fan palm oasis. In: L.E. Stevens and V.J. Meretsky, (eds). Aridland Springs in North America. University of Arizona Press, Tucson

Cornett, J.W. 2010. Desert Palm Oasis (second edition). Nature Trails Press, Palm Springs.

Cornett, J.W., T. Glenn and J. Stewart. 1986. The largest desert fan palm oases. Principes 30: 82–84.

Faunt, C., C. Stamos, L. Flint, M. Wright, M. Burgess, M. Sneed, J. Brandt, P. Martin, and A. Coes. 2015. Hydrogeology, hydrologic effects of development, and simulation of groundwater flow in the Borrego Valley, San Diego Co., CA. U.S. Geological Survey Scientific Investigations Report 2015–5150.

Harper, J.W. 1977. Population Biology of Plants. Academic Press, New York.

Henderson, R. 1945a. Up Arroyo Salado to 17 Palms oasis. Desert Magazine 8(6): 7–9.

Henderson, R. 1945b. R. Henderson field notes and photographs. Provided by American Heritage Center, University of Wyoming, Laramie.

Henderson, R. 1961. On Desert Trails. Westernlore Press, Los Angeles.

Kirk, R., 1973. Desert: The American Southwest. Houghton-Mifflin Company, Boston.

Kreamer, D.K. and A.E. Springer. 2008. The hydrology of desert springs in North America. In: L.E. Stevens and V.J. Meretsky, (eds). Aridland Springs in North America. University of Arizona Press, Tucson.

National Oceanic and Atmospheric Administration (NOAA). 2020. National Centers for Environmental Information, Climate at a glance: county time series (Imperial County). https://www.ncdc.noaa.gov/cag/.

Norris, R.M. and R.W. Webb. 1990. Geology of California. John Wiley and Sons, New York.

Notaro, M., A. Mauss and J.W. Williams. 2012. Projected vegetation changes for the American Southwest: combined dynamic modeling and bioclimatic-envelope approach. Ecological Applications 22: 1365–1388.

Raven, P.H., R.F. Evert and S.E. Eichhorn. 2005. Biology of Plants. W.H. Freeman and Company, New York.

Sharp, R.P. 1994. A Field Guide to Southern California. Kendall/Hunt Publishing, Dubuque.

Sylvester, A.G. 2016. Roadside Geology of Southern California. Mountain Press Publishing, Missoula.

Unmack, P.J. and W.L. Minckley. 2008. The demise of desert springs. In: L.E. Stevens and V.J. Meretsky (eds). Aridland Springs in North America. University of Arizona Press, Tucson.

Vogl, R.J. and L.T. McHargue. 1966. Vegetation of California fan palm oases on the San Andreas Fault. Ecology 47: 532–540.

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