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

James W. Cornett[1]

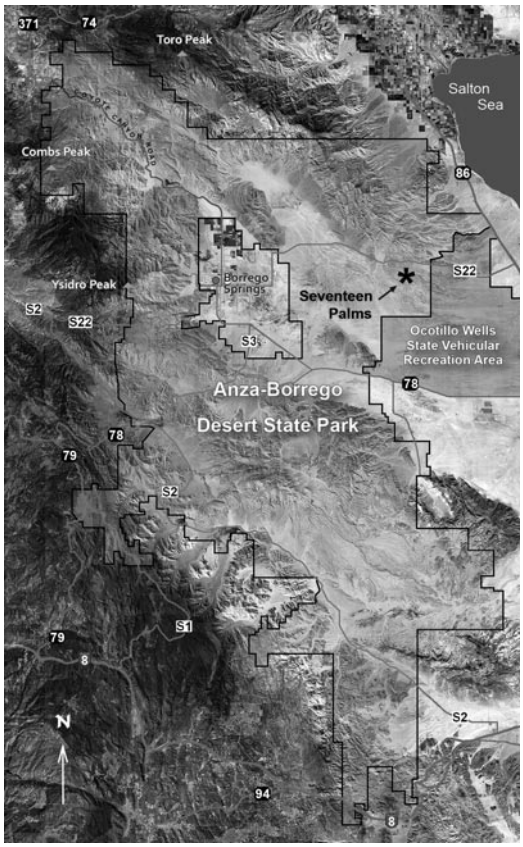
A population of *Washingtonia filifera* at Seventeen Palms in California's Anza-Borrego Desert State Park, was analyzed five times over a period of 104 years. A dramatic shift in structure from juvenile to adult dominance was recorded. With only two tentative recruits to the population since 1984, *W. 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

[1]*JWC Ecological Consultants,*
3745 Bogert Trail
Palm Springs, CA 92264
jwcornett@aol.com



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.

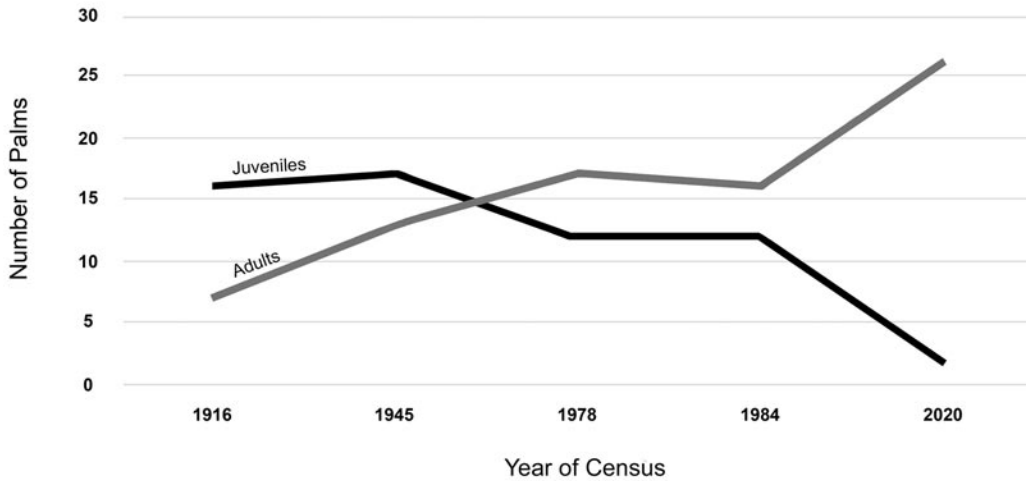


Table 2. Results of five *Washingtonia filifera* counts, spanning 104 years, at Seventeen Palms, Anza-Borrego Desert State Park, California. nc = no counts. *Count derived from Chase photograph.

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.