VEGETATION OF CALIFORNIA FAN PALM OASES ON THE SAN ANDREAS FAULT

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(Accepted for publication May 23, 1966)

Abstract. The vegetation of 24 oases located in the western Colorado Desert was composed 78 species from 34 families, with an average of 11 species per oasis. Species distributions thin an oasis were determined by available water and could be divided into three contoured lts. The hydric zone had 10% of the total species, primarily hydrophytes, and accounted one-fifth of the total plant cover. The oasis-proper zone contained phreatophytes and lophytes, comprising 17% of the total species and producing two-fifths of the cover. The naining cover was produced by 73% of the species, mainly xerophytes, present primarily the desert-oasis ecotone.

Oases were located on hillside seeps or in canyon washes. Although most dominant species re common to both types, they differed in vegetational composition. Hydric species were re common in wash oases. Species requiring stable sites with sub-surface water were more undant in seep oases. All oases showed individuality since *Washingtonia filifera* was the y ubiquitous species. *Haplopappus acradenius* and *Prosopis juliflora* occurred in 75% of oases; 10% of the species were restricted to two or three oases; and 33% were confined one oasis. Eleven rare species were encountered.

Absence of palm reproduction was due to inadequate water, lack of stimulating rains, or ali soils. Alkali soils appear detrimental to plant growth. Optimum conditions for new owth need occur only once a century to sustain oases. Maximum palm ages appear to be ut 200 years.

Floods alter wash geomorphology and vegetation, but have a rejuvenating effect on dense, gnating stands of hydrophytes. Fire determines oasis composition and affects the physiog-ny, productivity, reproduction, and maintenance of the fire-tolerant palms.

Introduction

s of the Colorado Desert of California rized by California fan palm (*Wash-era*). A study of palm groups along Ireas Earthquake Fault was designed ly and quantitatively define the vege-position and to determine factors in-e distribution of component species. studies of the vegetational composi-rnia oases are absent. California fan n noted as a characteristic species of o Desert (Coville and MacDougal ougal 1907, 1908, Parish 1930, Ben-row 1954), and palm oases have been r briefly described by MacDougal . Jepson (1910, 1922), Munz (1959), nd Wiggins (1964). Most literature popular nature (James 1907, Anony-Peattie 1953, Jaeger 1955, Gardner rson 1945, 1950, 1951, 1961, 1965).

debted to Paul Wilhelm of Thousand for information on the history of the obinson for jeep transportation, J. rial reconnaissance, and J. Schenck in field work. Randall Henderson, and I. L. Wiggins provided valuable and information.

Study area

The oases are located in and around the Indio Hills of Riverside County, from Whitewater to Indio, California (Fig. 1). Their elevations range from 200 to 2,100 ft. All oases, except Whitewater Oasis, are located on the San Andreas Earthquake Fault (Fig. 1 hatching), where ground waters percolate to the surface. This broad fault

Fig. 1. Location of California fan palm oases (numbered dots) along the San Andreas Earthquake Fault (hatching) in the western Colorado Desert. Oases were named after past or present owners or characteristics of the area.

consists of one main fracture that divides at Biskra Oasis into the Banning and Mission Creek branches.

Climate

At Indio, the closest weather station, the average daily maximum and minimum temperatures for July are 107°F and 78°F, respectively. The average daily January maximum and minimum are 70°F and 39°F. Temperature extremes recorded are 125°F and 13°F (U.S. Department of Agriculture 1941). Oasis temperatures are more moderate than those in Indio. Lower elevational oases have higher night and early morning temperatures during the winter months, and upper elevational oases are somewhat cooler than Indio throughout the year, but all are usually frost-free.

Winter rains usually occur from December to March and provide most of the total annual precipitation. Thunderstorms produce locally significant amounts of rainfall from July through September. The average annual precipitation ranges from about 3 inches at the lowest to 8 inches at the highest elevations (U.S. Army Corps of Engineers 1963). Precipitation is not uniformly distributed from year to year or place to place, and one storm of any type may drop more than the total average annual rainfall.

Strong northwest winds commonly funnel through San Gorgonio Pass to the desert and affect some oases.

Effects of man

The palm oases in the present study have long been inhabited and utilized by Indian tribes (Barrows 1900). Some oases were grazed by cattle from 1911 to 1913 and by sheep in the late 1940's. Since 1900, Twelve Apostle Palms near Indio has been destroyed by agricultural development and Seven Palms Oasis in Seven Palms Valley, described as a "dying" oasis by James (1907), has been eliminated by the expiration of natural water sources. In the middle 1930's an attempt was made to build a hotel at Biskra Oasis, which resulted in some vegetational disturbance (P. Wilhelm, *personal communication*). These unique and limited plant communities are presently being disturbed or destroyed by urban development and a reduction of natural water supplies (R. Henderson and L. Tevis, *personal communication*).

Methods

The study was conducted from June 1962 to June 1964. Two oases were visited periodically since the early 1950's, permitting numerous observations of vegetational and environmental conditions and changes.

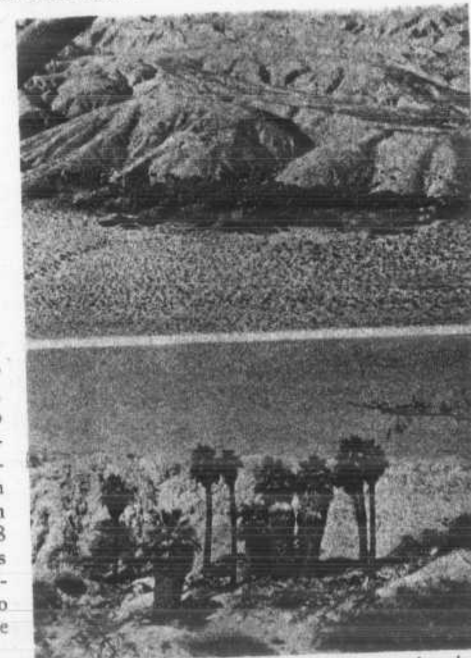

Fig. 2. Seep oases occur wherever water reaches slope surfaces and provides available moisture. An aerial view (upper) of a seep oasis located on the edge of the Indio Hills shows the contrast between oasis and desert vegetation. Horseshoe Palms (lower) occurs on a steep hillside of flocculent, alkaline soils.

The 24 oases sampled occurred in either of two physical locations. Seep oases were situated on steep hillsides or elevated sites where exposed strata or other geological structures produced available moisture (Fig. 2). Wash oases were confined to canyon or arroyo bottoms (Fig. 3). Biskra and Macomber Oases contained portions of both types, and each oasis type was sampled separately. The distribution of species within an oasis is not random, but is determined by available water which often varies over short distances (Parish 1930). As a result, the vegetation is not uniform and generally can be divided into three contoured belts or zones: the hydric portion, containing surface water; the oasis proper, characterized by the presence of palms; and the desert-oasis ecotone, a transition zone between open desert and oasis. Within each zone or association of the 24 oases studied, quantitative samples were taken objectively. Unnatural disturbances (road building, construction, bulldozing) were avoided.

One-hundred-foot line-intercepts were oriented

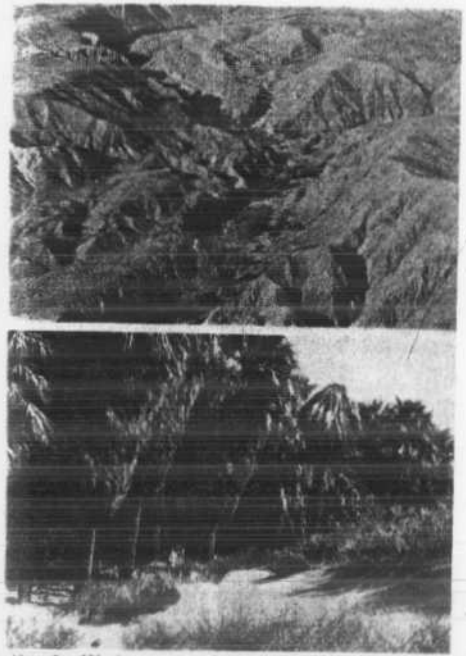

FIG. 3. Wash oases are located in canyons or arroyos. n aerial photo of Pushwalla Palms (upper) reveals that e oasis vegetation is confined to the moist canyon floor. ains and floods have deeply sculptured drainage patterns the clay hills. A dense growth of palms (lower) grow- g in a desert wash.

the long axis of each zone to obtain cover, and om this, relative dominance. The numbers of ch perennial species intercepting the line were sed to obtain relative frequency. Absolute and lative densities were obtained from one-fortieth- re rectangular quadrats (111 by 9.8 ft), which ere placed adjacent to the line-intercepts. The lative per cent dominance, relative per cent fre- ency, and relative per cent density were summed obtain the importance value (I.V.) for each ecies in a stand.

One line-intercept and quadrat were used to mple each zone in small oases. Larger oases ere sampled with a correspondingly larger num- r of lines and quadrats. A total of 52 line- tercepts and one-fortieth-acre quadrats were ed to sample the 14 seep oases, and 48 inter- pts and quadrats were used to sample the 12 sh oases.

Nomenclature of plant species follows Munz 959). Voucher specimens are in the herbarium California State College at Los Angeles.

Soil profiles were examined and the pH of the soil was determined in each oasis.

RESULTS AND DISCUSSION

Vegetational composition

The average number of species recorded per oasis was 11. Most dominant species were common to both seep and wash oases and therefore are discussed together for all oases. The 11 species with the highest importance values (I.V.) were called prevalents and are listed in Table I with their cover percentages. Three other widespread species were *Bebbia juncea*, *Prosopis pubescens*, and *Tamarix pentandra*. *Washingtonia filifera*, *Haplopappus acradenius*, and *Pluchea sericea* were the most important prevalents. Almost all of the prevalents were phreatophytes that depend upon ground water which lies within reach of their roots (Robinson 1958).

Species were classified by growing preference within the three zones associated with each oasis. Not all species were confined to one zone, but each species peaked in one of the zones. The hydric zone had the lowest number of species (10% of total species) and accounted for one-fifth of the total plant cover in the oases. *Scirpus olneyi* was the most common, reaching stem densities approaching one million per acre in the presence of surface water. Additional hydric species important in individual oases included *Typha domingensis*, *Heleocharis* sp., *Phragmites communis* var. *berlandieri*, and *Salix exigua*. This zone generally occupied the smallest area since it was restricted to the springs, seeps, pond edges, and stream banks.

The oasis-proper zone contained only 17% of the total species, but produced two-fifths of the total cover. Dominant species included *Washingtonia*, *Juncus acutus* var. *sphaerocarpus*, *Distichlis spicata* var. *divaricata*, and *Sporobolus airoides*. The wetter edges of this zone were often occupied by *Tamarix*, the only naturalized species which had attained a position of importance. Individuals and populations of this prolific seeder were established miles from points of origin by wind-disseminated seeds (Robinson 1958). This species was increasing wherever sufficient water was available and was displacing native vegetation by its rapid growth and vegetative habit.

Saturated soils, sometimes with high pH, often supported *Distichlis*, *Juncus acutus*, and occasionally *J. mexicanus*. *Washingtonia* and *Sporobolus* were usually confined to areas where the water table was just below the soil surface. These two species appeared to be able to tolerate highly

TABLE I. Prevalent and common species for wash and seep oases with their average cover percentage and importance values (I.V.). Importance values were obtained for each species in each oasis by summing the percentage frequency, density, and cover

Common species by zone	Seep oases		Wash oases		All oases	
	Average I.V.	Average I.V. all species	Average I.V.	Average I.V. all species	Average % cover	Average I.V.
Hydric zone		2.5		41.2	3.4	7.1
Scirpus olneyi	2.3		12.2			
Oasis proper zone		140.1		57.8		
**Washingtonia filifera*	52.6		36.9		21.0	44.8
**Pluchea sericea*	9.8		37.3		2.9	23.6
**Sporobolus airoides*	32.6		5.3		2.8	19.0
**Juncus acutus*	14.2		7.1		2.6	10.6
**Distichlis spicata*	7.3		1.9		4.6	4.6
Juncus mexicanus	5.0		—		0.7	2.5
Prosopis pubescens	1.0		5.3		0.9	3.2
Desert-oasis ecotone		92.4		125.7		
**Haplopappus acradenius*	22.3		20.6		3.8	21.4
**Suaeda torreyana*	10.3		16.6		1.7	13.4
**Prosopis juliflora*	16.3		6.0		4.1	11.2
**Atriplex hymenelytra*	14.6		—		1.1	7.3
**Atriplex polycarpa*	3.4		9.3		1.5	6.4
Bebbia juncea	0.9		8.9		1.0	4.6
Hymenoclea salsola	0.4		5.7		0.7	3.0
Dalea spinosa	—		4.3		0.5	2.2

*Prevalent species

alkaline soils, since these sites often supported heavy concentrations of surface alkali. In a few oases, these same sites supported *Prosopis pubescens*, *Populus fremontii*, or extremely dense stands of *Pluchea*.

The remaining two-fifths of the cover was produced by 73% of the species that peaked in the desert-oasis ecotone. *Haplopappus* was found in all three zones, but typified the ecotone by occurring in pure stands on sheltered sandy locations. *Prosopis juliflora* var. *torreyana* occurred in large groves around most oasis edges. *Bebbia* was also a common species. Alkaline soils in this zone, occurring on the evaporating capillary fringes of soil water, commonly contained halophytes such as *Suaeda torreyana* var. *ramosissima*, *Atriplex hymenelytra*, and *A. polycarpa*. Most other ecotonal species were xerophytes that also occurred in the surrounding desert, but in lower densities.

Although dominant species were common to most oases, seep and wash oases differed in vegetational and minor floristic compositions. Hydric species were far more important in wash oases, indicating the greater availability of surface water. Species dependent upon flood water for dissemination and germination, such as *Dalea spinosa*, *D. schottii*, *Bebbia*, and *Hymenoclea salsola*, were most common in wash oases (Table I). *Dalea spinosa* seeds require the abrasive action of sand carried in desert floods to germinate (Went 1955). Water-dependent species like *Scirpus* and phreatophytes like *Pluchea* and *Prosopis pubescens* were more frequent in wash oases.

Oasis-proper species had higher average importance values in seep oases, perhaps because seep oases were more stable and provided larger areas of sub-surface water (Table I). *Juncus mexicanus* and *Atriplex hymenelytra* were confined almost entirely to seep oases. *Washingtonia*, *Distichlis*, *Prosopsis juliflora*, and *Juncus acutus* were more important in seep oases since they require growing sites protected from floods. Importance values for ecotonal species were slightly lower in seep oases. Seep oases had narrower and more abrupt ecotones than wash oases, particularly on upper slopes where they graded sharply into open desert.

Haplopappus was the only prevalent equally distributed between both oasis types.

Thirty-four families with 78 species were encountered. The most important families were Palmae, Compositae, Gramineae, Chenopodiaceae, and Leguminosae. All the oases showed species individuality, since the fan palm was the only plant occurring in all. Other widespread species were *Haplopappus* and *Prosopis juliflora* which appeared in 75% of the oases. Ten per cent of the species were restricted to two or three oases, and 33% were confined to one oasis. Whitewater Palms had the highest number (15) of species confined to one oasis because it occurs at the highest elevation and closest to coast, chaparral, coniferous forest, and Mojave Desert vegetation.

Although most oases species were also found in the nearby Salton Sea marshes or in the surrounding desert, there were 11 species extremely rare or unknown to these regions. They included *Apocynum cannabinum* var. *glaberrimum* and *Nicotiana attenuata* which are primarily coastal species, and *Anemopsis californica*. The most anomalous was *Epipactis gigantea,* normally found in mesic or wet sites in coastal regions. Perhaps the light wind-disseminated seeds of this species arrived on coastal winds. It was observed in some of the same palm oases by MacDougal (1908).

Species such as *Panicum urvilleanum, Opuntia ramosissima, Cucurbita digitata, Orobanche ludoviciana, Petalonyx thurberi, Atriplex lentiformis, Fagonia californica* var. *glutinosa, Peucephyllum schottii, Hilaria rigida, Acacia greggii,* and *Asclepias subulata* were common on the surrounding desert, but occurred only rarely within the oases.

Soils

Soils were generally poor, with organic matter confined to moist, densely vegetated oases. No soil horizons were observed. Most hillside oases were located on lacustrine sediments of mud and rock, while wash oases also contained sand (Figs. 2, 3). Hillside seep oases had fine, flocculent soils which were the consistency of loose snow (Fig. 2) and were often covered by a thin crust of deposited salts which tended to minimize wind erosion (Fig. 4). Alkali soils also appeared in stream beds, on banks, and around water sources in wash oases. High pH determinations (average pH 9.2) correlated with the general appearance of alkaline soils. Common soluble salts were carbonates, chlorides, and sulphates of sodium, calcium, and magnesium (Shreve and Wiggins 1964).

Large amounts of "self-rising alkali" appeared to be detrimental to plant growth (Fig. 4). Areas with slick, moist, black soils topped with heavy incrustations of white alkali were usually devoid of plants, except for an occasional palm, *Sporobolus, Juncus acutus,* or a thin growth of *Distichlis.* Further investigation might determine the relationship between pH, salinity, and species distribution.

Palm distribution

The California fan palm is a relic species dating back to Miocene and Pliocene. Climatic and geological changes eliminated widespread coastal and Mojave Desert locations of *Washingtonia* (Axelrod 1950), restricting the species to the more

favorable climate of the Sonoran Desert, particularly the shores of Lake Cahuilla, a lake formed in the Salton Sink by the diverted Colorado River (MacDougal 1906, Parish 1907, Jaeger 1955). Increasing aridity restricted the palms to sites with a permanent water supply such as the San Andreas Fault. Coyotes are primary agents in disseminating palm seeds from one water source to another (Henderson 1961, 1965). Coyote scats consist largely of palm seeds in the fall. Western bluebirds also eat palm fruits during fall and winter (R. C. Ross, *personal communication*).

The northernmost California fan palm oases are in the Turtle Mountains (Munz 1959), at and near Twenty-nine Palms (Parish 1930), and in the Cottonwood Mountains. Palm oases are found in desert-slope canyons of the San Jacinto and Santa Rosa Mountains (Henderson 1951) and in the Anza-Borrego Region of San Diego County (Jepson 1922). Henderson (1961) estimates that there are about 100 palm groves in California. Arizona has one oasis in the Kofa Mountains (Anonymous 1923, Benson and Darrow 1954). Fan palm oases, perhaps some of the largest, are found in Gulf of California canyons of the Sierra Juarez, San Pedro Martir, and Sierra Pinate Mountains of Baja California (Henderson 1950, Gardner 1961, Shreve and Wiggins 1964, E. C. Jaeger and I. L. Wiggins, *personal communications*).

There are an estimated 11,000 native California fan palms north of the Mexican border (Henderson 1961, 1965), with about one-third found in San Andreas oases. Numbers vary from 536 palms in Macomber Oasis to only two trees in Lone Palm Oasis (Table II).

Palm reproduction

Exaggerated statements have been made that some palms are over 2,000 years old. Since a palm's age cannot be determined by growth-ring counts, attempts were made to approximate ages of palms in oases of known fire history. This was done by measuring the length of dead frond thatch produced since the last fire and comparing it to the total length of the trunk (Fig. 3). This method serves only as a rough estimate, as growth rate varies throughout the life of the palm. The maxi-

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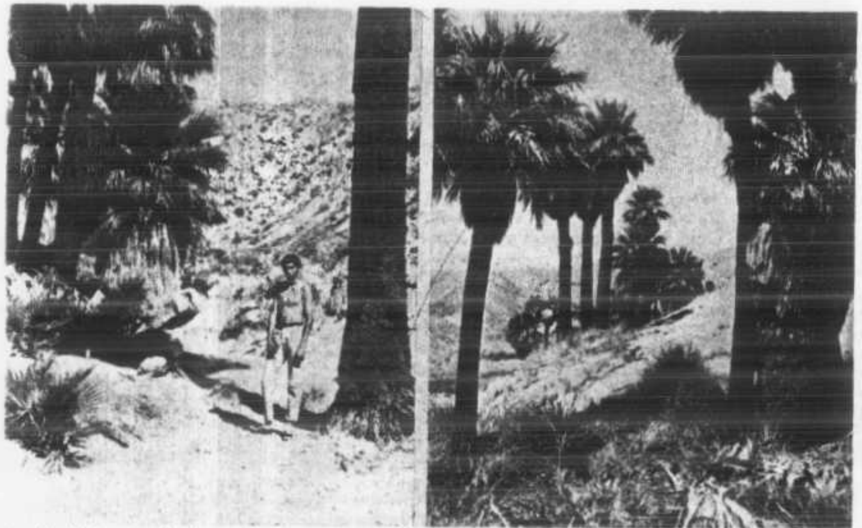
If vigorous stands should have at least as many or more young trees than mature trees to maintain themselves, only 5 of the 24 oases can be

Willow Hole	0	20	[illegible]	[illegible]
Two Bunch	6	41	47	10.0
Willis	114	370	484	4.0
Thousand	170	116	286	35.0
Powell	7	52	59	57.0
Simone	25	185	210	31.0
Indian	102	40	142	56.0
Indian East	14	17	31	38.0
Hidden	5	263	268	49.0
Horseshoe	56	113	169	48.0
Pushawalla	119	310	429	39.0
Nomad	1	2	3	46.0
Macomber	102	434	536	41.0
Biskra West	0	215	215	16.0
Biskra	45	382	427	49.0
Trickling Springs	45	62	107	42.0
Curtiss	20	199	219	38.0
Alkali Ledge	25	13	38	35.0
McHargue	54	22	76	62.0
Vanshing	1	5	6	60.0
Ross	0	7	7	44.0
Owl Hole	0	20	20	47.0
Lone	1	1	2	50.0
Total	920	2,905	3,825	
Average				39.6

[1]Seedlings or individuals with fronds not fully opened or trunks not fully developed were classified as young palms; individuals capable of reproduction and characterized by trunks that had attained final diameters were considered mature palms.

considered healthy and reproducing (Table II). However, it may not be necessary for palms to reproduce annually, or to be continually stocked with reproduction to maintain their numbers, since they have a long life span and low mortality rates. In fact, heavily stocked stands might create a critical water shortage. In January 1947 one 3-week rainy period at Thousand Palms produced hundreds of seedlings, many of which are now healthy young trees and more than enough to replace the existing mature palms. The stability and life span of palms indicates that such stimulating rains with accompanying optimum conditions for germination and survival need occur only once a century to maintain a palm oasis. Comparisons of early photos by Coville and MacDougal (1903) and Jepson (1910) with the same oases today reveal that they are still remarkably similar in appearance and are graphic illustrations of this stability.

Conditions were favorable for the establishment of palms during the winters of 1946-47 and 1963-64 (Fig. 5). Analysis of rainfall records indicates that rains of these magnitudes occur more frequently than once every 100 years. Yearly crops of seeds appear to remain dormant on moist alkaline soils until prolonged rains leach inhibiting



ɪɢ. 5. Palm reproduction varies; some oases (left) contain numerous young palms while others (right) devoid of reproduction. The oasis on the right contains cover of *Sporobolus airoides, Juncus acutus, Pro- pubescens,* and *Epipactis gigantea.* Note burned palms in each oasis.

from the soils or the seeds, or alter the of the ground water. Further research is ıry to determine the controlling factors.

Effects of water

ʏ rains affect oasis vegetation. Accumu- of surface alkali become pronounced in seep ollowing rain. Plants, however, may bene- a temporary removal of soil salts accumu- the root zone. The hard, cemented lacus- lays dissolve readily with water. Erosion mping caused by rain result in the under- and toppling of hillside palms. Two fallen that have begun to curve upward with new still survive in Biskra Oasis.

h oases are subject to the most violent treat- rom heavy rains. Since 1891 large Indio loods occurred in February 1914, January December 1921, April 1926, February 1927, 1938, September 1939, December 1940, ry 1963, and October 1963. The most floods were in 1927, 1938, and 1939. The orm produced 6.4 inches of rain in less than and was the worst thunderstorm recorded (U.S. Army Corps of Engineers 1963). h oasis vegetation is altered as flood waters stream beds and shift large quantities of d sand. Hydric zone species are excavated, buried, or battered by moving rock, sand, and mud. The 1927, 1938, and 1939 floods uprooted mature palm trees and strewed them across the alluvial fans several miles below Pushawalla and Thousand Palms. The 1963 floods littered plant debris over remaining plants and deposited plants and plant parts miles below oases. Although floods alter wash geomorphology and vegetation, the plants quickly recover. The 1963 flood effects were almost completely masked by new growth 1 year later. Floods actually appear to have a rejuvenating effect on dense stagnating stands of hydrophytes.

Earthquake movements along the San Andreas Fault have altered subterranean water supplies. A 1949 tremor increased the amount of water at Indian Palms after which many new palms became established. New shifts in the fault are expected to alter the flow of seeps and springs and thus affect future plant distributions.

Seep oases usually have water available in the form of moist soil or occasional springs. Wash oases generally have larger amounts of permanent water, enough to support flowing springs and surface or subterranean streams.

The amount of bare ground is an indication of available water and varies inversely with vegetation density and cover (Table II). Cover in each oasis decreases from the water source to the oasis edge. Some of the area designated as bare ground

was covered by fallen palm fronds which persist for many years and cover the ground so completely as to inhibit plant establishment.

Palms, as well as other phreatophytes, are dependent upon stable water supplies. A lowering of water tables or the inundation of root systems was observed to kill palms.

Effects of fire

Both man-caused and naturally occurring fires are considered important factors affecting the vegetational composition of oases. Burning of palms by Indians during religious ceremonies removed the highly flammable, persistent dead palm thatches believed to harbor evil spirits (Henderson 1961) and increased fruit production (James 1907). Burning entire oases made them more accessible and facilitated hunting.

Many of the oases have been burned in recent decades by vandals, movie companies, carelessness, and braceros on fiesta. Parts of Thousand Palms were burned in 1921, 1924, and 1930. Willis Palms was burned in 1943 and 1956. In 1945 there were 261 palm trees in Pushawalla Canyon Oasis (Henderson 1945). Since then at least 30 palms have died, most as a result of a hot night fire in 1959. A wind-blown, advancing, crown fire does not inflict as much damage or kill as many palms as a fire burning in still air like this night fire. Effects of fire were observed in all oases. Early photographs by MacDougal (1908) and Jepson (1910, 1922) show views of burned palms.

Lightning also starts fires in oases (Gardner 1961, Henderson 1961, E. C. Jaeger, *personal communication*). Desert thunderstorms are typically accompanied by lightning, but evidence of it is often difficult to find since palms do not generally show easily observed disfigurement (Sharples 1933, Komarek 1965). Decapitated palms that had presumably been killed by crown rot, possibly by *Penicillium vermoeseni* (Muirhead 1961), were observed in almost every oasis (Fig. 3). Perhaps crown rot is not the primary cause of death, but only secondarily attacks lightning-damaged buds as Sharples (1933) found in coconut palm plantations.

Gardner (1961) found freshly burned oases in remote and inaccessible canyons in Baja California which local residents claimed had not been visited by man. He suggests that static electricity generated by dead fronds rubbing against one another during hot, windy periods might have produced sparks and kindled the fires. Undetected lightning may have caused these fires. Sparks generated from rock slides or falling stones might start fires in the tinder-dry fuels which often occur in substantial amounts in these highly flammable oases. Besides man and lightning, the most probable cause of fire is spontaneous combustion in the hydric portions of oases which produce dense, subtropical growth with heavy accumulations of litter. Spontaneous combustion has been shown to be a natural occurrence in Louisana marshes (Viosca 1931), and parts of oases are similar in composition and environment.

Oasis fire records and observations of burning of native vegetation encroaching on nearby irrigated farm lands indicate that fires can occur at any time of the year, including periods immediately following a rain or a rainy winter. Oasis fuels are usually so prodigious and desiccated that lightning accompanied by heavy rain could readily produce a persistent fire. California fan palms are not usually killed by the burning of the thatch or by repeated burning, and appear to be adapted to fire as are other members of the family Palmae. Each successive fire kills some of the outer vascular bundles and burns off some of the trunk, causing a reduction in trunk diameter and crown size. Fire-charred and fire-dwarfed trees were observed in almost all oases (Figs. 2, 5), but only rarely was a dead tree suspected of being killed directly by fire.

The presence or absence of recent or recurring fires on different growing sites may be responsible for some of the confusion surrounding the classification of the genus *Washingtonia,* since trunk, thatch, crown, and frond characteristics have been used in its taxonomy (Parish 1907, 1909, Bailey 1936, Wolf 1941, Benson 1943, Benson and Darrow 1954).

A series of photographs taken by the Wilhelm family of Thousand Palms Oasis showed little growth under the palms for 10 to 15 years after the 1930 fire. *Distichlis* became established first and was displaced by a dense growth of *Prosopis juliflora, P. pubescens, Haplopappus,* and young palms. These shrubs are readily killed by fire or resprout weakly. After 35 years of fire protection, parts of Thousand Palms Oasis are jungle-like, with a dense, tall undergrowth and a humid microclimate. This environment is optimum for plant growth, and year-around productivity has resulted in massive litter accumulations. This oasis is now in a highly flammable condition with a high fuel content, and the next fire will probably eliminate some palms as well as fire-intolerant understory species.

After Willis Palms burned in 1956, the first understory species to become re-established was *Distichlis. Pluchea, Sporobolus,* and *Juncus acutus* are now invading, but *Distichlis* is still most