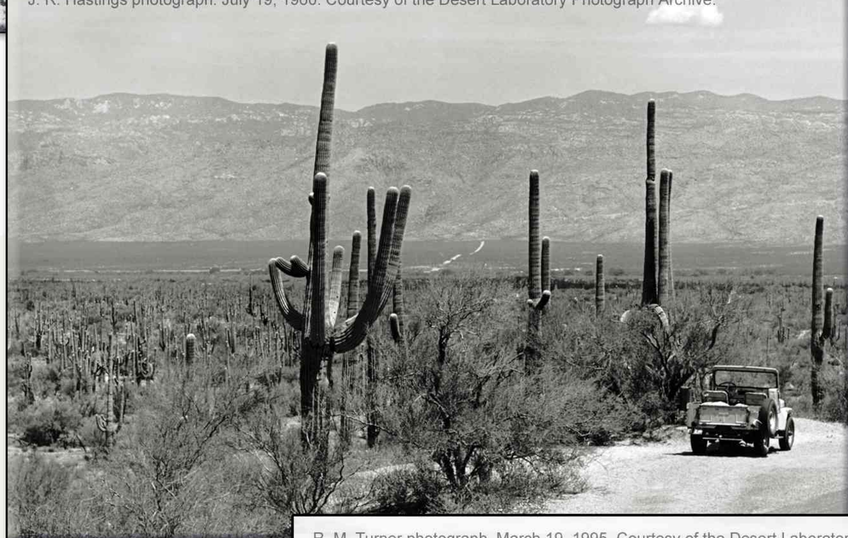
Pima County's Withdrawal from Its Past

Sonoran Desert Conservation Plan • Pima County, Arizona • 2003


Ca. 1935. Courtesy of the National Park Service


J. R. Hastings photograph. July 19, 1960. Courtesy of the Desert Laboratory Photograph Archive.


R. M. Turner photograph. March 19, 1995. Courtesy of the Desert Laboratory Photograph Archive.

Pima County, Arizona
Board of Supervisors

Ann Day, District 1
Dan Eckstrom, District 2
Sharon Bronson, Chair, District 3
Raymond J. Carroll, District 4
Richard Elías, District 5

County Administrator
Chuck Huckelberry

View to the north across the northwest corner of the Rincon Unit of Saguaro National Park.

Pima County's Withdrawal from Its Past

Raymond M. Turner

Reconstruction of Pima County's past vegetation from the time of the first European intrusion is an undertaking charged with obstacles. Few detailed descriptions were made of the vegetation encountered by those early intruders. These visitors often recorded the presence of conspicuous plants found throughout the entire region, but specifics were missing. Thus, we find written references to saguaros, greasewood (creosote bush), sagebrush (saltbush), and palo verdes by travellers passing through the region, but these generalized references do little to resolve the mystery of where rough boundaries between various plant communities might have been, nor do they offer a baseline for judging what changes might have occurred following those early days.

Interest in the history of Pima County's vegetation has increased in the wake of efforts to retain certain habitats as last-ditch refuges for waning populations of threatened organisms. In addition, the rapidly expanding need for space to accommodate the region's growing human population has made inroads into rural areas that were but slightly impacted by humans only a short time ago. Knowledge of a vegetation's history may aid in directing its destiny by providing a hint of the ways in which we might steer the forces of change. What is the effect of fire, livestock grazing, and climate on the vegetation of our region? One method that provides partial access to vegetation history is the art of photographic matching or repeat photography.

Repeat photography as a tool for documenting landscape change has been with us for over 100 years when it was first used to document changes in glaciers.[1] It was not used for studying shifts in vegetation until 1957, when Homer L. Shantz, former president of the University of Arizona, traveled across Africa, matching landscape photographs he had taken on a trip from South Africa to the Belgian Congo in 1920.[2]

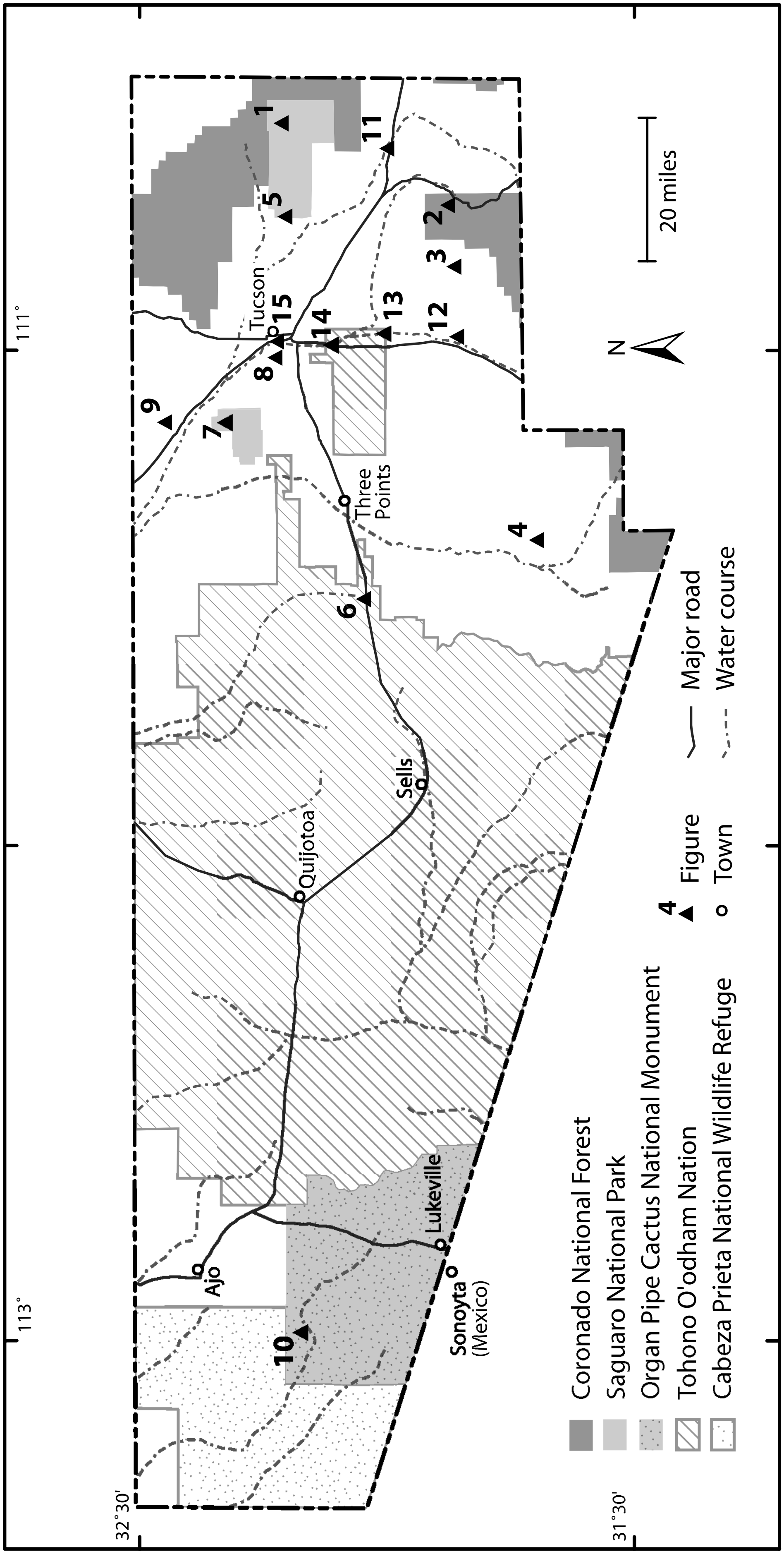
The vegetation of Pima County is as varied as its topography, from peaks ascending to more than 9,000 feet to desert valleys descending to roughly 1,000 feet. At the higher elevations, quaking aspen and corkbark fir mingle with other conifers and forest plants whose main distributional ranges extend far to the north; in the low valleys, desert species such as creosotebush and saguaros, with affinities to the south, dominate the landscape. Photographs of Arizona's varied landscape have been taken since 1867, although the first from Pima County were probably taken later. By selecting a few of the several hundred historic landscape views available from within Pima County and comparing those with exactly matched recent views, we can detect trends that may prove useful in making decisions about future management and use of Pima County land.

In this survey, we have obtained early photographs from various archives, with dates ranging from 1880 to 1942. We have attempted to provide examples from the main vegetation types that are represented in Pima County. This survey of matched photographs will begin at upper elevations and descend gradually to lower points across the landscape, except that riparian habitat comparisons will be set aside and addressed separately.[3]

[1] For a review of the use of repeat photography through the early 1980s, see Rogers *et al.* (1984).

[2] See Shantz and Turner (1958).

[3] One photograph (Figure 13) is presented without a photographic match because that site has not been visited to obtain a more recent photograph.



Map by Peter Griffiths.

Figure 1. Mica Mountain as seen from Man Head. Elevation: 8428 feet.

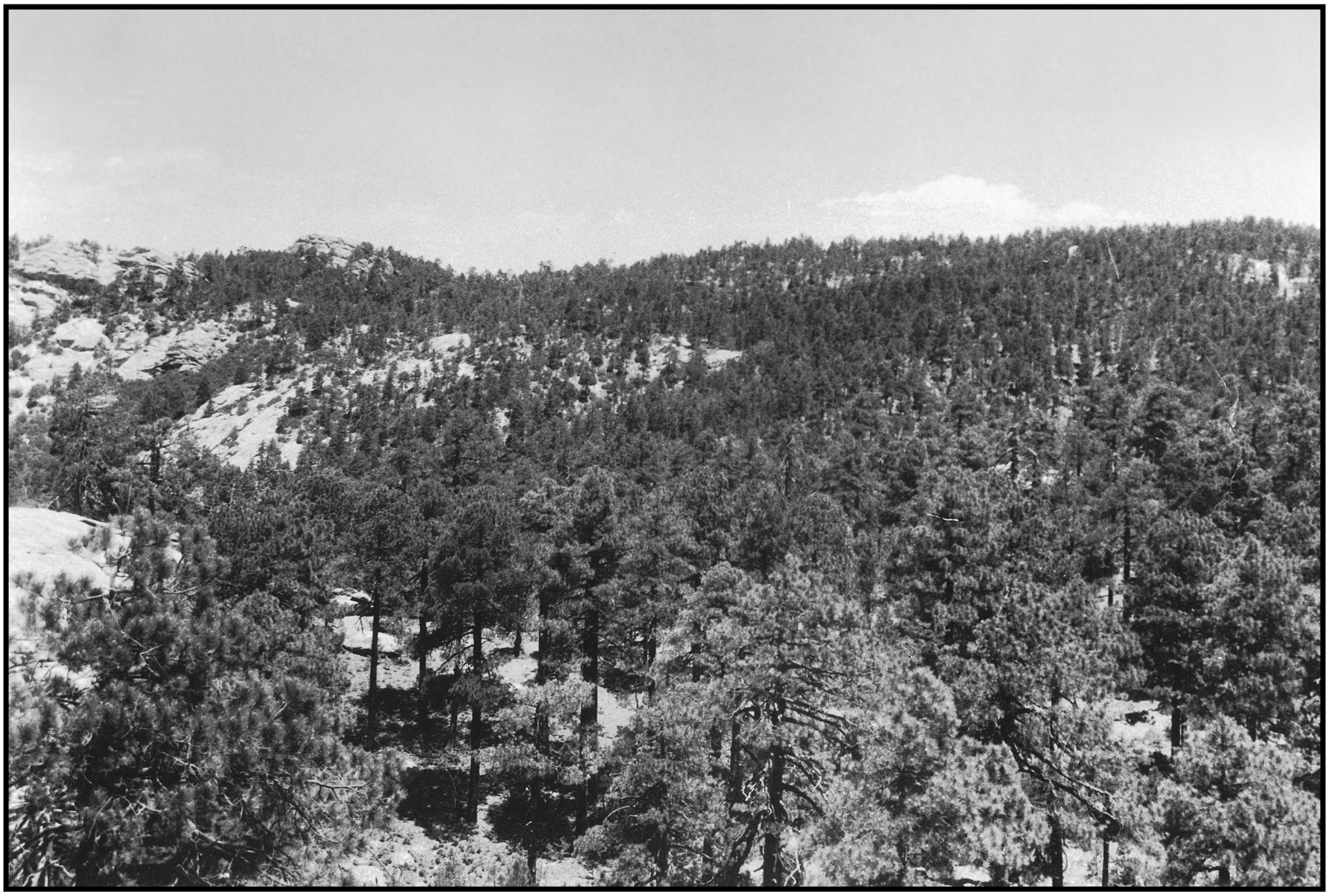


Figure 1a. Lawrence M. Huey photograph. June 1932. Courtesy of the Desert Laboratory Archive.

(1) Rincon Mountains

Mica Mountain, with an elevation of 8666 feet, is the highest point in the Rincon Mountains, on Tucson basin's eastern rim. The peak's southern slope supports a forest of ponderosa pine, the dominant tree in forests at this elevation. This tree is well adapted to survive low intensity ground fires once it becomes mature. One set of records maintained by Saguaro National Park shows that 411 lightning fires occurred in the Rincon unit of the park between 1937 and 1986. Mostly small in extent, over 350 of these fires occurred around Mica Mountain at elevations above 6500 feet. Centuries-long tree-ring records show that the frequency of large fires on Mica Mountain held at about one fire every six years until the 1890s, after which the return interval lengthened due to fire suppression.[4] The forest on Mica Mountain as seen in 1932 from the top of Man Head Rock (Figure 1a) has therefore experienced roughly three decades of low fire frequency. Figure 1b, taken in 1973, shows the fire lookout tower that stood on Mica Mountain for several decades but has now been removed. The slope below the tower experienced a stand

Figure 1b. Martin A. Turner and Roger C. Wolf. April 15, 1973. Courtesy of the Desert Laboratory Archive.

replacing fire in 1943 (the Manning Camp Fire) and a few new trees have become established during the 30 years since then. This 5,741 acre fire was the first large fire to occur following the beginning of fire suppression. Several trees growing just below the camera station have died during the interval between photographs, making patches of the forest floor more visible in the later view. Many small trees in a fire-sensitive size range have become established.

[4] See Baisin and Swetnam (1990).

Figure 2. Near the Helena Mine at the north end of the Santa Rita Mountains. View N40ºW. Elevation: 4600 feet.

Figure 2a. F. C. Schrader photograph. 1909. Courtesy of the U.S. Geological Survey Photographic Library, Denver.

(2) Helena Mine, Santa Rita Mountains

The Santa Rita Mountains have been an area of active mining since the late 1800s. In 1909, geologist Frank Schrader, working at the northern end of the mountain range, took photographs in the vicinity of the Helena Mine (Figure 2a). At an elevation of 4600 feet, this mountainous terrain is well above the Sonoran Desert and supported grassland, although incipient shrub invasion was evident by the time of Schrader's visit. Scattered mesquites and ocotillos, leafless in this winter photograph, have attained a size consistent with the age of a decade or more. The camera is aimed toward the northwest and captures a few evergreen oaks growing along minor north-facing canyons. The low, dark shrubs at midground are fairyduster, a palatable plant that is closely cropped by livestock.

When visited in November 2002, the mesquites had increased in density although the individual plants were relatively small considering the century-long life of some (Figure 2b). Their small size is undoubtedly partly the result of catastrophic freezes. The persistent dead branches on many of the mesquites is typical of plants frozen back by the severe freeze of December 1978.[5] The live oaks are no longer present along the

Figure 2b. R. M. Turner photograph. November 5, 2002. Courtesy of the Desert Laboratory Photograph Archive.

north-facing canyons. Since this site is within a few hundred feet of a former mine stamp mill which used many ricks of firewood during its mining heyday, we searched for signs that the oaks had been removed for stoking furnaces.[6] We found, lying on the ground where the oaks had stood, carcasses of large oaks that had fallen in place without signs of woodcutting activity. Death of these long-lived trees, which are resistant to freezing temperatures and fire, is probably the result of the 1950's drought.[7] The hills support many more ocotillos than earlier; the fairy duster has increased in number only slightly.

[5] For a description of the effect of the 1978 freeze on mesquite in the nearby San Pedro Valley, see Glinski and Brown (1982).

[6] By turning his camera to the right, Schrader took another photograph that shows the stamp mill and ricks of firewood. (F. C. Schrader #1533, USGS Photograph Library, Denver). Also see Plate 37 in Turner *et al.* (2003).

[7] See Swetnam and Betancourt (1998).

Figure 3. Gently sloping bajada of the Santa Rita Mountains as seen from Huerfano Butte. View northeast. Elevation: 3900 feet.

Figure 3a. Photograph by David Griffiths. 1902. Courtesy of the National Archives.

(3) Huerfano Butte

Huerfano Butte is a conspicuous isolated prominence east of Sahuarita on the Santa Rita Experimental Range. David Griffiths climbed to the top in 1902 and took a series of panning photographs. He wrote at the time that "close examination of the broad, gentle, grassy slopes between the arroyos. . . reveals a very scattering growth of mesquite (Prosopis velutina) which is in the form of twigs 2 to 3 feet high with an occasional larger shrub in some of the more favorable localities."[8] His suspicion that the shrub population was likely to grow was confirmed after seven more years of observation when he asserted that "the time is coming when these foothill grassy areas, which now have only an occasional small shrub, will be as shrubby as the deserts and lower foothills . . . if not more so."[9] Burroweed, a small shrub, had also "thickened and increased perceptibly during the last five years."[10]

Figure 3a , one of the Griffiths panning pho-

Figure 3b. R. M. Turner. 1986. Courtesy of the Desert Laboratory Photograph Archive.

tographs, faces toward the northeast. (The mining community of Helvetia lies at the base of the Santa Rita Mountains, to the left of center.) Griffiths' description of the vegetation is borne out by the scene above. The shrubs along the water-courses are probably mostly mesquite, although the large darker shrubs in the foreground are desert hackberry, identifiable because they persist to the present. The broad slopes between the runnels are grass covered, as noted by Griffiths.

Figure 3b shows the same area after 84 years. Griffiths' foresight about the increase of shrubs was remarkable. Shrubs, mainly velvet mesquite, now dominate the landscape. The grassy matrix has been largely filled by the small shrub, burroweed, as foreseen by Griffiths. Note the persisting desert hackberries, many of which have changed little in size since 1902.

[8] See Griffiths (1904).

[9] See Griffiths (1910).

[10] *Ibid*.

Figure 4. View west-northwest from the western edge of the Altar Valley toward Baboquivari Peak. Elevation: 3500 feet

Figure 4a. Grama grassland with a scattering of velvet mesquites some of which are probably a few decades old. Photograph by David Griffiths. Ca. 1912.*

(4) Baboquivari Peak and the Altar Valley

David Griffiths, botanist with the Bureau of Plant Industry in Tucson and early observer of Pima County vegetation, took a photograph in about1912 at the north end of the Sierrita Mountains on the edge of the Altar Valley, showing a dense growth of grama grass (Figure 4a). Baboquivari Peak can be seen in the background. A scattering of velvet mesquites is already visible across the rolling hills of this grassland which is part of a cattle ranch. Roughly 90 years later the terrain is no longer grassland and has been overtaken by woody vegetation, including velvet mesquite, ocotillo, catclaw, and gray-thorn (Figure 4b). Except for ocotillo, all are relatively resistant to fire after reaching large size. During earlier times when grass was abundant as fuel and frequent fires were not vigorously suppressed, these woody plants would have been kept at low levels across this landscape.

* Plate 71B in Griffiths, 1912.

Figure 4b. The gamma grasses present earlier have been replaced by three-awn grasses. Woody plants such as ocotillo and mesquite have markedly increased. R. M. Turner photograph. May 9, 2002. Courtesy of the Desert Laboratory Photgraph Archive.

Figure 5. View to the north across the northwest corner of the Rincon Unit of Saguaro National Park. The Santa Catalina Mountains are in the background; the course of Tanque Verde Creek is marked by the distant cottonwood trees. Elevation: 3040 feet.

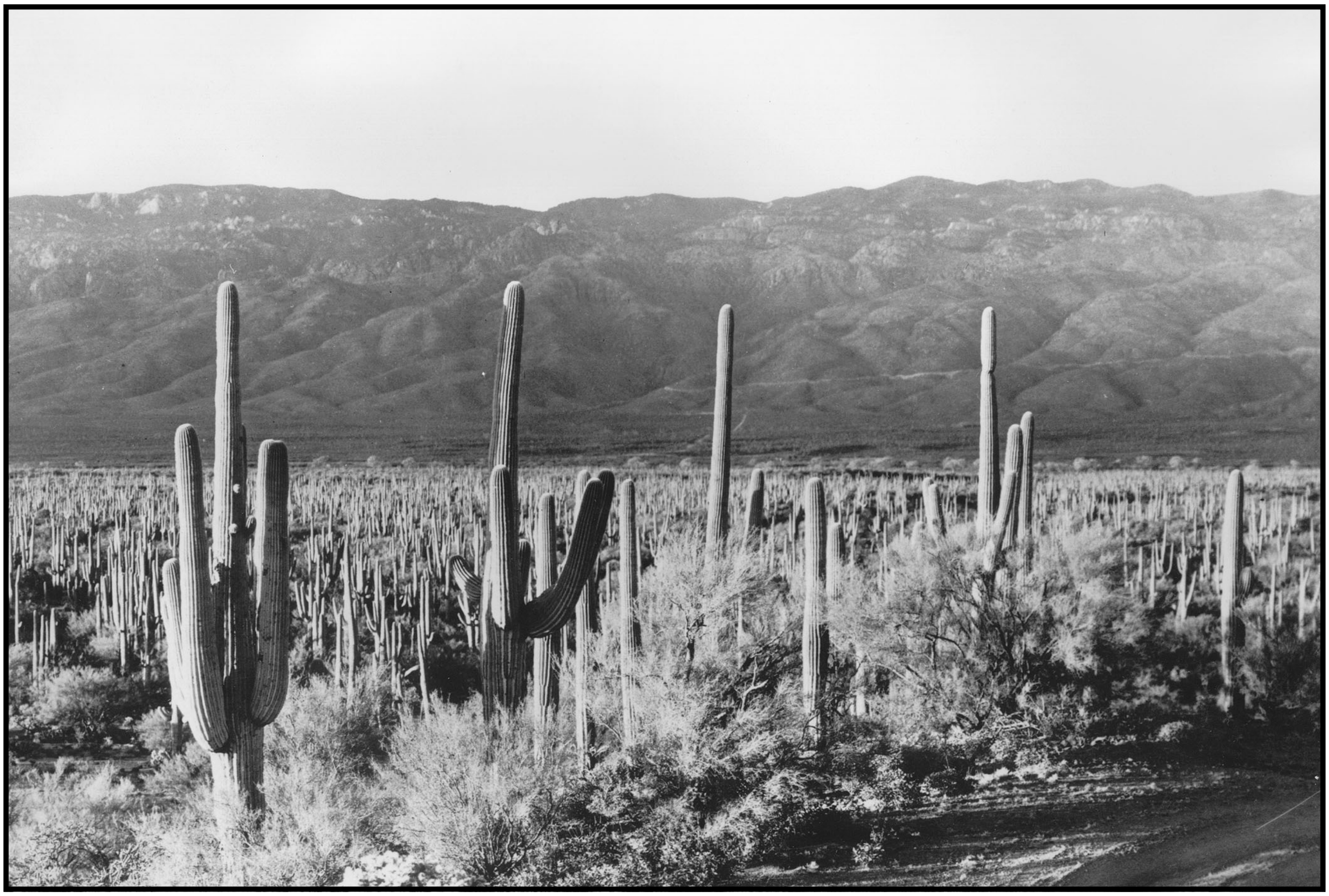


Figure 5a. The saguaro forest that prompted the establishment of Saguaro National Park appears across the scene. The recently constructed Mount Lemmon Highway ascends the mountain on the right. Ca. 1935. Courtesy of the National Park Service.

(5) Saguaro National Park

Saguaro National Monument east of Tucson was established in 1932 to protect the dense saguaro forest at the base of the Rincon Mountains. The Santa Catalina Mountains provide the backdrop for a view of that same saguaro forest (Figure 5a). The photograph was taken in about 1935, shortly after the Monument's establishment. Investigators at that time noted the near absence of young saguaros and predicted that this population of predominantly old plants was not sustainable. They predicted that the old plants, many of which were nearing their upper age limit (ca. 175 years), would inevitably die, leaving Saguaro National Monument without a saguaro forest.

By 1995 (Figure 5b), the saguaro forest had indeed disappeared, upholding the biological truth that populations cannot be sustained without reproduction. A permanent study plot, established in 1961 in the area seen in this view, recorded the saguaro's decline. In 1961, this nine-acre plot supported 209 saguaros; by 1983 the number had plummeted to 100. Undetected at that time, reproduction had begun and the many small plants then present were not counted. By 2001, however, when the plot was

Figure 5b. Change is widespread. Although Tanque Verde Creek still supports a line of cottonwood trees, most of the saguaros have succumbed to old age and the distant bajada at the base of the mountain supports many houses. R. M. Turner photograph. March 19, 1995. Courtesy of the Desert Laboratory Photograph Archive.

last examined, they were large enough to be counted and the population stood at 227. Although this is more than the number present in 1961, it is probably well below the value for the1930s, when the first photograph was taken. Because saguaros don't become sexually mature until they reach roughly 40-50 years of age, the reproductive potential of this forest of mainly immature saguaros will remain at an ebb for several more decades.

The cause for the saguaro's decline is possibly the result of two forces: livestock grazing, which was present until the late 1950s, and cutting of saguaro "nurse trees" (mesquites and palo verdes) to fuel a nearby charcoal kiln, which operated until after 1900. Removal of "nurse trees" reduced the protective cover essential for establishment, and cattle seeking shade under the remaining trees may have trampled many of the seedlings and small plants that managed to get started. Absent these negative forces, periods of abundant rainfall during recent decades have brought back the saguaro in large numbers.

Figure 6. Coyote Mountains as seen from the western edge of Avra Valley. Elevation: 2985 feet.

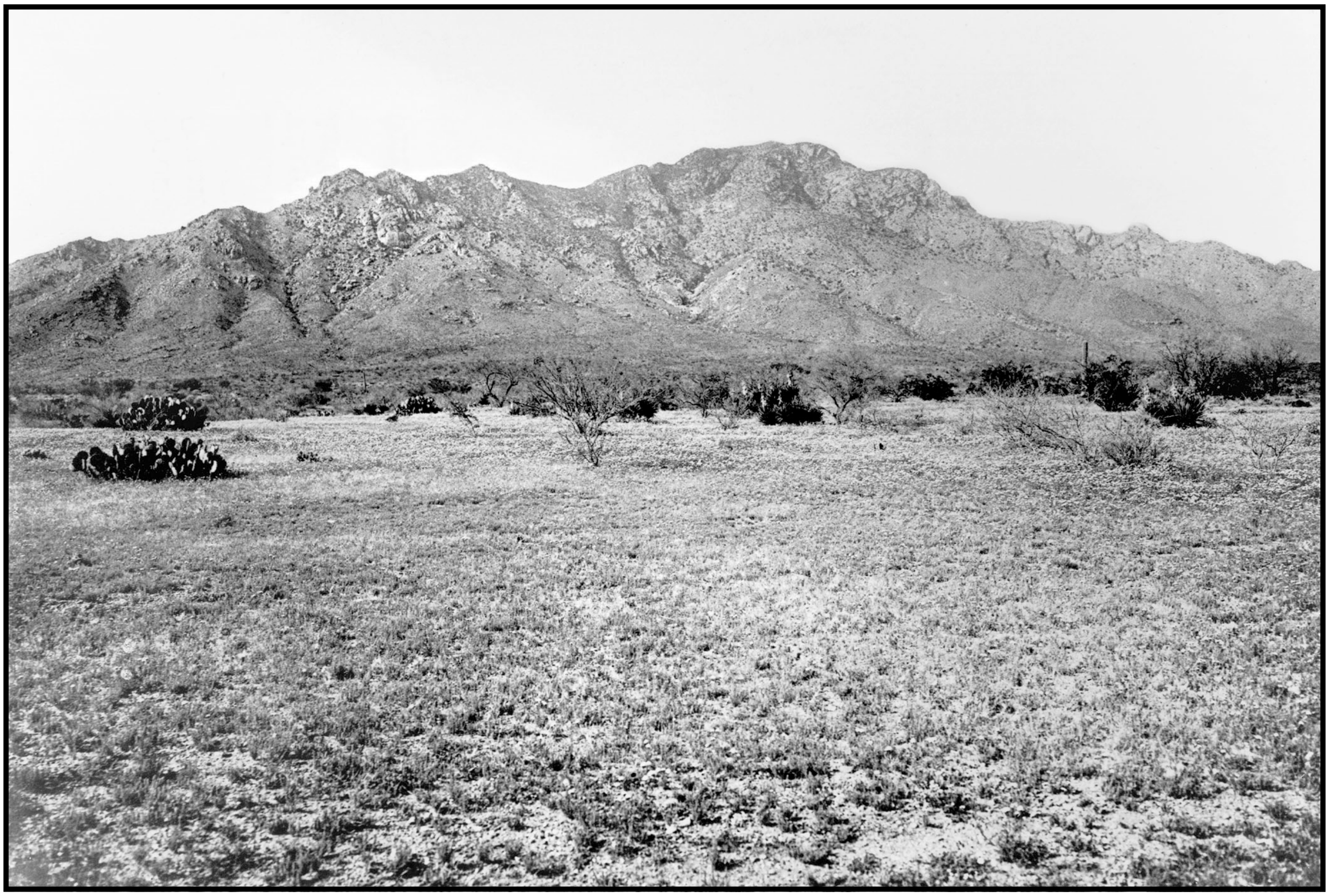


Figure 6a. Botanist David Griffiths photograph. 1903. Courtesy of the National Archives.

(6) Coyote Mountain

When botanist David Griffiths visited the Avra Valley west of Tucson in 1903, he found a dense sward of grass and forbs covering the valley floor at an elevation of just under 3,000 feet (Figure 6a). At this elevation, the Sonoran Desert meets the region's semidesert grassland. The distant saguaros reveal the desert's tenuous grip here, just as scattered yuccas reveal the station's grassland ties. As with much of the Avra-Altar Valley, this area had been grazed by cattle for only two or three decades at the time of Griffiths' visit. This area became part of the Papago Indian Reservation in 1916, and has continued under a livestock management regime since then.

Almost 100 years later (Figure 6b), the change is glaring. Both saguaros and yuccas persist, but the grass-forb turf is gone and many new cacti and shrubs have become established. Woody plants, such as creosote bush (extreme right), white-thorn (leafless at left foreground), velvet mesquite, and foothill palo verde, dominate, although succulents such as Arizona yucca, prickly pear cactus (three species) and cholla (two species) are also important constituents.

Figure 6b. R. M. Turner photograph. April 12, 2002. Courtesy of the Desert Laboratory Photograph Archive. Access to this camera station was granted by the Tohono O'Odham Nation, and is gratefully acknowledged.

Figure 7. View to the northwest toward Safford Peak (extreme right) and the Avra Valley from a low hill in the Tucson Mountains. Elevation: 2740 feet.

Figure 7a. Forrest Shreve photograph. March 20, 1916. Courtesy of the Desert Laboratory Photograph Archive.

(7) Safford Peak and the Avra Valley

The palo verde-saguaro desert, found on hills and bajadas in much of Pima County at elevations below 3,000 feet, is seen in a view toward the northwest from a low hill in the Tucson Mountains (Figure 7).

As noted in Figure 9, the limestone hill called Picacho Calera has been removed as a source of raw material for a cement plant at nearby Rillito. By the time of the second photograph in 1995, the camera station had been part of the National Park Service's Saguaro National Monument (and then Park) for 34 years; before that, it had been part of Pima County's Tucson Mountain Park. Widely scattered dwellings in Avra Valley can be seen just beyond the Park boundary. During the 79 years between photographs, several prickly pear cacti have become established near the camera station. Biomass differences in other plants (such as saguaro, foothill palo verde, ironwood, ocotillo, brittlebush, and triangleleaf bursage), as captured by these two scenes, are probably negligible. Such views illustrate the relative stability of the Sonoran Desert in situations free of grazing impacts.

Figure 7b. Dominic Oldershaw photograph. January 18, 1995. Courtesy of the Desert Laboratory Photograph Archive.

Figure 8. Creosote bush dominated the area in the northwest corner of the Desert Laboratory grounds. View to the west with the Tucson Mountains in the background. Elevation: 2430 feet.

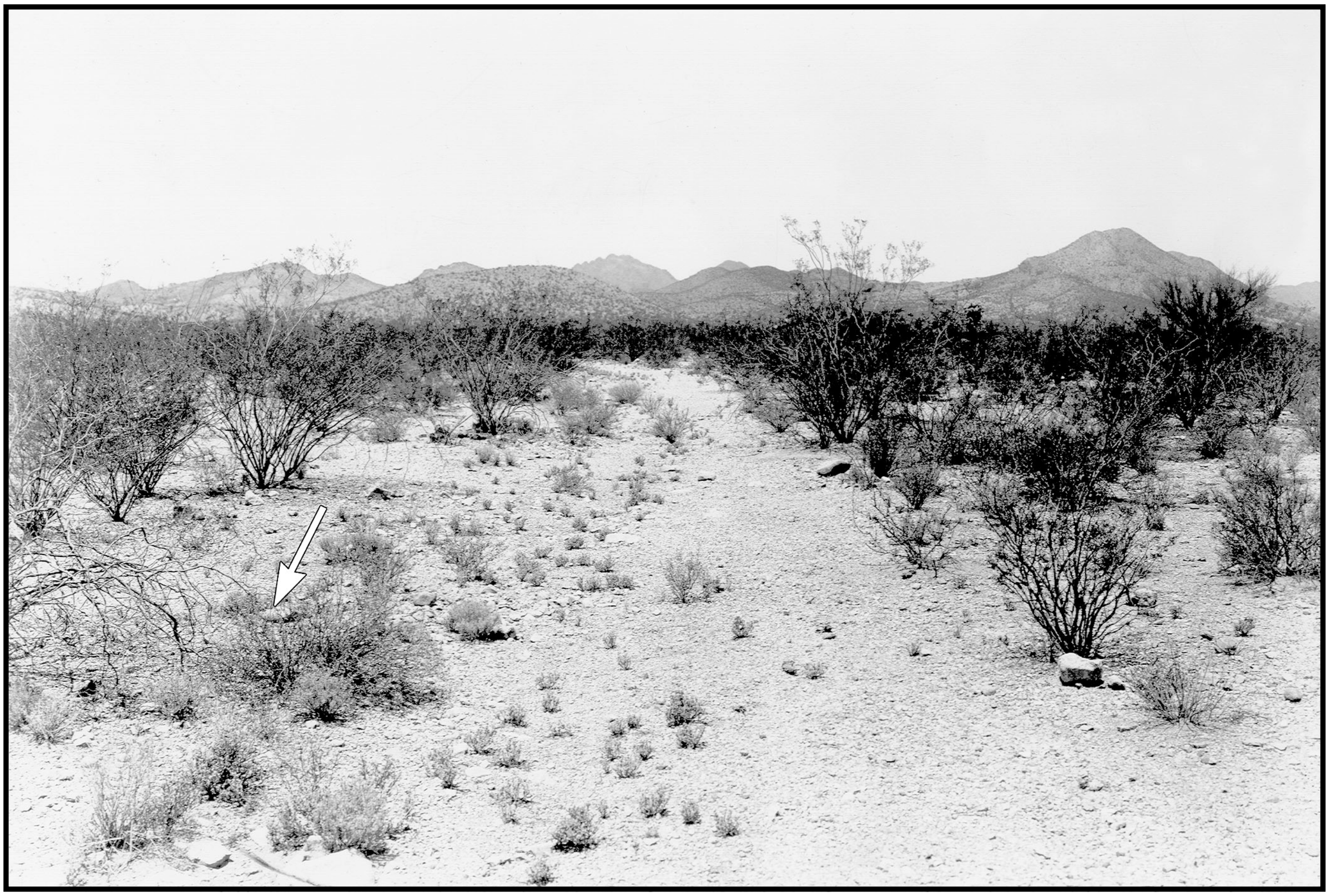


Figure 8a. Forrest Shreve photograph. July 1928. Courtesy of the Desert Laboratory Photograph Archive. The arrow marks a rock that is visible in both photographs.

(8) The Desert Laboratory

The Desert Botanical Laboratory of the Carnegie Institution of Washington was created in 1903. The 869-acre parcel on Tucson's west side was encircled by a fence in 1907, and a roadway crossing the northwest corner of the Desert Laboratory was abandoned as a result. Botanist Forrest Shreve photographed the road in 1928 to document its status at that time (Figure 8a). Prior to fencing, the area had probably been grazed by livestock for many years with dominance of the unpalatable creosote bush the result. After 21 years free from livestock grazing, the area was still dominated by old creosote bushes, leftovers from pre-fence days. The vegetation had probably changed little since fence construction, although small plants of triangle leaf bursage appear in the intervening spaces, marking a resurgence of this more palatable species. In 1998, following seventy more years without livestock, the old roadway has almost disappeared (Figure 8b). Gone also, are most of the creosote bushes. Only three of these long-lived

Figure 8b. R. M. Turner photograph. April 10, 1998. Courtesy of the Desert Laboratory Photograph Archive.

residents of North America's warm desert regions remain in view (circles). In its place are triangle leaf bursage, fairy-duster, and range ratany, all palatable to various classes of livestock. Also showing a notable increase are ocotillo, prickly pear, cane cholla, foothill palo verde, and saguaro. The Desert Laboratory property is now mostly surrounded by houses; some of the dwellings lining the western boundary of the Desert Laboratory are visible in this view. The arrows point to a rock that is visible in both photographs.

Figure 9. View to the southwest from "The Island," north of Tucson. The camera station is on a small hill near what is presently Tangerine Road. Elevation: 2228 feet.

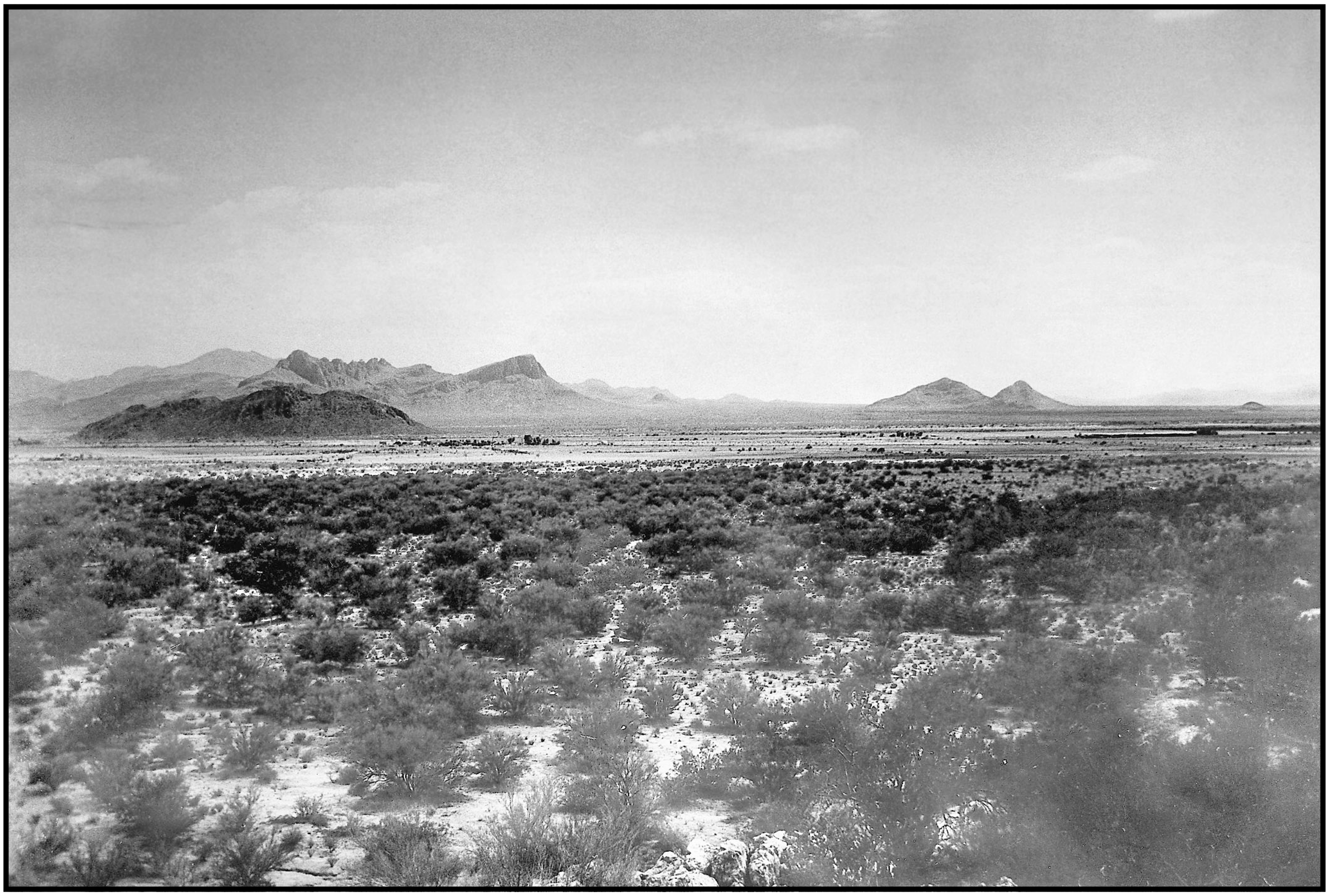


Figure 9a. The two isolated hills right of center are Picacho Gemelo (right) and Picacho Calera (left). Avra Valley lies beyond. The Santa Cruz River flows from left to right across the scene, passing close to the base of the dark mountain at left. The tiny settlement of Rillito is marked by the long clump of trees near the river. Forrest Shreve photograph. June 20, 1930. Courtesy of the Desert Laboratory Photograph Archive.

(9) "The Island"

In 1930, botanist Forrest Shreve climbed a small hill north of Tucson and took several photographs. The hill, known by Shreve and other workers at the Desert Laboratory as "The Island," served as a perfect vantage point for viewing Sonoran Desert vegetation. One of Shreve's photographs looks toward the southwest with northern outliers of the Tucson Mountains in the distance. In 1930, the level plain is dominated by foothill palo verde (Figure 9a). Note the absence of saguaros, a Sonoran Desert dominant that accompanies the palo verde on rocky hills but is often absent on level plains. The small shrubs near the camera position are brittlebush and triangleleaf bursage.

Sixty-five years later (Figure 9b), the plain is still almost free of saguaros but the palo verdes have increased in size, if not numbers. The spaces between the trees support more small shrubs than before. This recent increase in palo verdes has been noted in other photograph pairs from sites near Tucson, and is made all the more intriguing by the written observation of Forrest Shreve suggesting that these plants might have been newcomers a decade or so earlier. Shreve wrote in 1911 that "I have had a great many thousands . . . come under my observation . . . and have seen only two dead trees of full size."[11]

Figure 9b. Picacho Calera is gone, having been the source of limestone for the Arizona Portland Cement plant occupying the Rillito townsite since 1948. Dominic Oldershaw photograph. January 18, 1995. Courtesy of the Desert Laboratory Photograph Archive.

Fourteen years later, however, he noted that many palo verdes of all ages had died on Tumamoc Hill.[12] Subsequently this decline was reversed and then, in the late 1990s, another pulse of palo verde deaths was documented at Tumamoc Hill and elsewhere in the Tucson region.[13] Thus, over almost a century, observations of this desert tree show that its populations undergo episodic dieback and revival. What apparently is seen in the photographs from "The Island," are two points in one or more of these population pulses.

The reach of the Santa Cruz River crossing this scene is just downstream from Tucson's sewage treatment plants; streamflow is perennial here after many decades of only intermittent flow. The trees marking the distant Santa Cruz channel (near the base of the dark mountain) are mainly the riparian stalwarts Fremont cottonwood and Goodding willow, which make use of the abundant water at this site.

[11] See Shreve (1911).

[12] This reference to palo verde deaths at Tumamoc Hill is in Shreve (1924/25).

[13] See Bowers and Turner (2001) for a description of recent dieback of palo verde at Tumamoc Hill.

Figure 10. View north-northwest of the creosote bush desert along the Camino del Diablo, Organ Pipe Cactus National Monument. Tracks of the old Camino del Diablo can be seen crossing the foreground. The present-day camino is about 250 yards to the north. Growler Mountains in the background. Elevation: 1280 feet.

Figure 10a. Tad Nichols photograph. November 1935. Courtesy of the Desert Laboratory Photograph Archive.

(10) Organ Pipe Cactus National Monument

The creosotebush copes with variations in moisture availability by losing branches during times of little rain and then producing new ones when good times return. Over time, the stature and density of stands of this shrub experience slight pulses in biomass but maintain a size range set by the conditions of the habitat. The shrubs in a pair of photographs from west of Bates Well on the Organ Pipe Cactus National Monument in extreme western Pima County, illustrate this drought pruning and regrowth phenomenon (Figures 10a and 10b). Fifty-eight years have elapsed between the two photographs, and during this time the shrubs have increased slightly in size and number of branches. The increase in size probably reflects rainfall during immediately preceding years rather than any long-term trend. No new plants of this shrub became established during almost six decades. Much the same can be said for the other plant species seen here. Jumping cholla, ironwood (center midground), white ratany (small plants scattered among the creosote bushes), and ocotillo seem to have about the same representation in both views. Saguaro numbers are roughly the same although cacti at midground have died. In this arid environment with annual average rainfall of about 8 inches, creosote bush, along with white ratany, occupy

Figure 10b. R. M. Turner photograph. April 1991. Courtesy of the Desert Laboratory Photograph Archive.

the low ridges between the intervening drainageways. These runnels with their slightly improved moisture tend to support saguaros and desert trees such as foothill palo verde and ironwood, giving the landscape a distinctive lined appearance when viewed from above.

Changes on the region's rivers

The magnificent cottonwood-willow forests that grow along the rivers of southeastern Arizona are often described as endangered or declining. A frequently cited statistic states that today they cover only 10% of their former large expanse. The source of this statistic is unclear, but perhaps it arose from studies along the lower Colorado River where dam construction and channel revetments have so drastically altered natural conditions that, indeed, this once abundant riparian forest is nearly gone. The status of this forest along the streams of southeastern Arizona is far different than in earlier years. There has actually been a many fold increase in the extent of this forest since the beginning of Anglo settlement. Evidence of this expansion comes from both written accounts and old photographs. Evaluation of landscape change using long interval photography has proven especially useful in documenting these changes.

Figure 11. Cienega Creek, east of Tucson, as seen from a low ridge. View to the northwest. Elevation: 3612 feet.

Figure 11a. C. E. Watkins photograph. 1880. © Huntington Library.

(11) Cienega Creek

One revealing pair of photographs shows Cienega Creek east of Tucson in 1880 and again, more than a century later, in 1998 (Figure 11). Figure 11a shows the freshly laid tracks of the Southern Pacific Railroad running alongside Cienega Creek, represented here by a narrow, essentially treeless channel. The valley floor is covered by grasses and is free of mesquites and other woody plants, although shrubs are common on the adjacent uplands. (Note the brush fence running along the ridge at right midground.) The later photograph records remarkable changes (Figure 11b). The grass-covered valley floor is now occupied by a dense mesquite forest. The Cienega Creek channel is deeper and broader and supports a forest of cottonwoods and willows. The railroad tracks were moved across the river after the original bridge washed away and a new bridge was built upstream from this site in 1912.

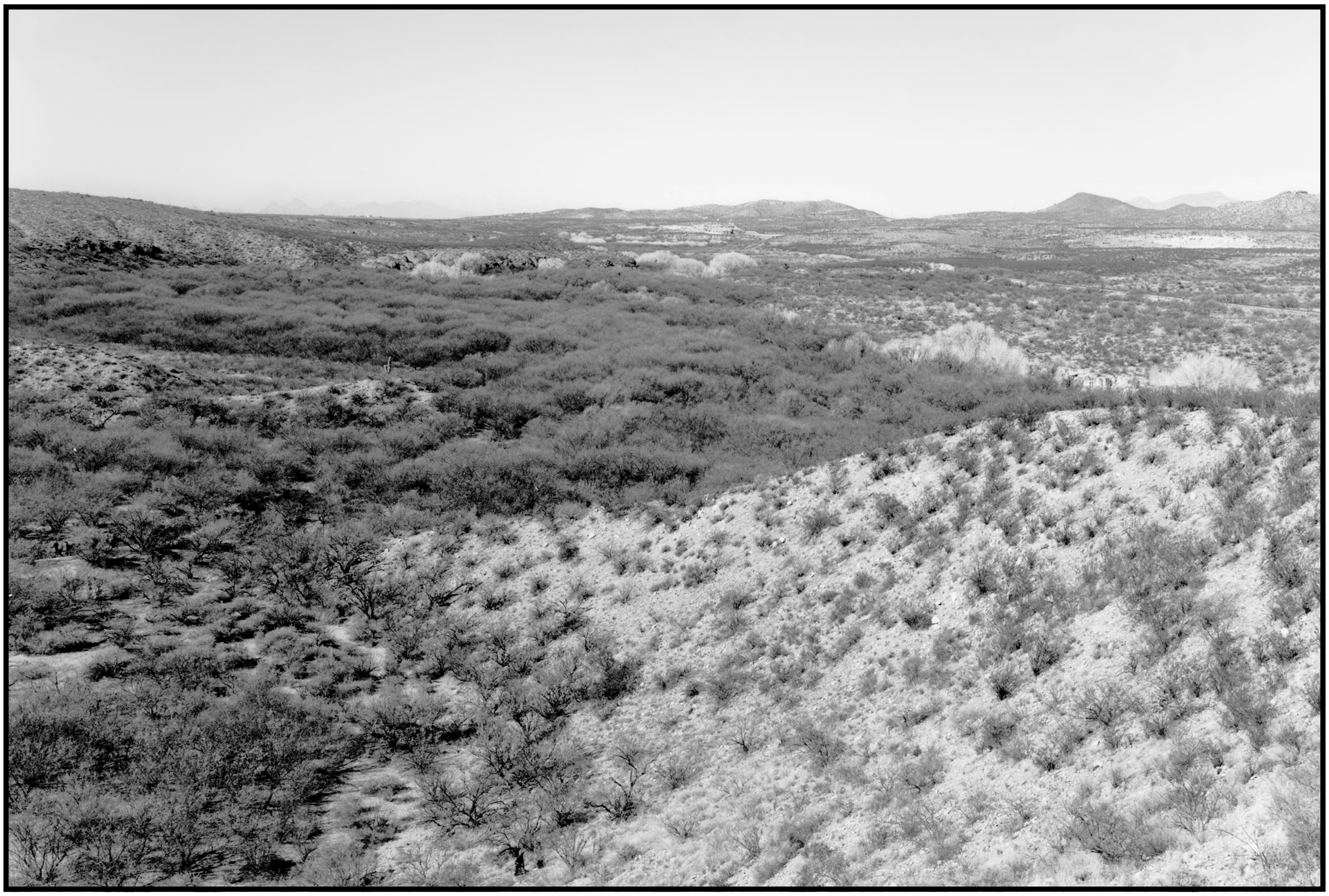


Figure 11b. R. M. Turner photograph. January 24, 1998. Courtesy of the Desert Laboratory Photograph Archive.

Figure 12. The eastern-most pier on the Continental Bridge at the Santa Cruz River as seen from the north side of the bridge. Elevation: 2818 feet.

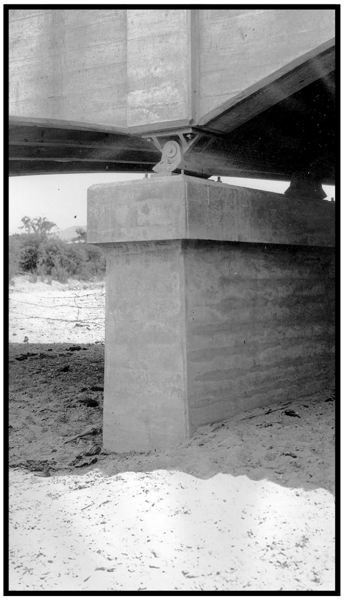


Figure 12a. Photographer unknown. June 1940. Courtesy of the U. S. Geological Survey, Tucson.

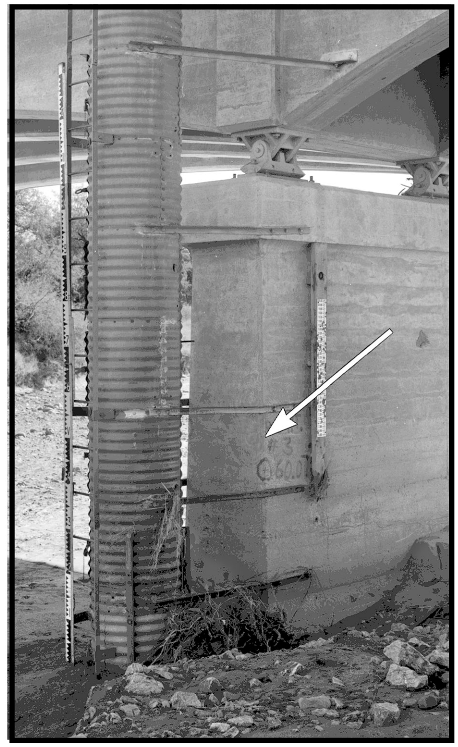


Figure 12b. The same pier with U.S. Geological Survey stage-gage housing attached to the bridge. The graduated pole is marked in feet. The arrow shows the approximate position of the 1940 streambed. R. M. Turner photograph. November 1978. Courtesy of the Desert Laboratory Photograph Archive.

(12) Santa Cruz River at Continental

The downcutting along the Santa Cruz River Channel is shown by a pair of photographs taken of one of the piers on the old Santa Cruz River Bridge at Continental. In June 1940, the river bed lies perhaps five feet below the top of the pier (Figure 12a). By November 1978, downcutting had removed an additional five feet of streambed material (Figure 12b). Matching these photographs today would not be possible; the bridge was replaced following the flood of 1983, which severely eroded approaches to the bridge.[14]

[14] The downcutting shown in this pair of photographs may merely record a brief decline of streambed elevation during an otherwise steady rise in this datum. In striking contrast to the decline shown by this pair of photographs, Parker (1995), using measurements from three widely separated years at the Continental Bridge, shows an increase in elevation of 10 feet from1929 through 1976 to1985.

Figure 13. Santa Cruz River Channel downstream from the Pima Mine Road Bridge. This canyon was formed when the old Tucson-Nogales wagon road was captured by the Santa Cruz River in about 1940. Note the vehicle for scale. Photograph by R. M. Turner. December 15, 1981. Courtesy of the Desert Laboratory Photograph Archive. Access to this camera station was granted by the Tohono O'Odham Nation, and is gratefully acknowledged. Elevation: 2650 feet.

(13) Santa Cruz River at Pima Mine Road

A story of downcutting along the Santa Cruz River with a slightly different twist is illustrated by viewing the Santa Cruz channel just downstream from the bridge at Pima Mine Road. This station is approximately 25 miles downstream from the Continental Bridge and seven miles upstream from our next station in this series at Martinez Hill. First, a visit to this site will reveal that the river's course here is not at the lowest point in the valley, which lies perhaps another mile to the east. This seeming defiance of natural design arose when the old Tucson-Nogales wagon road, which paralleled the Santa Cruz to the west, was gradually eroded by rainwater intercepted from minor arroyos running out of the Sierrita Mountains. (The road's presence here is verified as shown on the original land survey maps for this region.) By 1940, the old wagon road had eroded into a deep channel which later migrated upstream to capture the main flow of the Santa Cruz, thus rerouting the river to its present course in the valley.[15] Figure 13 (the only photograph in our series not offering a second look) shows the channel as it appeared in 1981. The channel through this reach is basically an artifact of man's activities. The absence of riparian vegetation is probably the result of the resistance of the soil to lateral erosion. Seedlings that become established along the floor of the miniature canyon are swept away by relatively minor floods. Thus, in this reach of the Santa Cruz, man's activities shifted a river channel having the potential to support a riparian forest to a new location where geologic constraints precluded the growth of such a forest.

[15] Betancourt, Julio L., and Raymond M. Turner. Unpublished ms. Tucson's Santa Cruz River and the Arroyo Legacy. On file at U. S. G. S Desert Laboratory office.

Figure 14. View from the top of Martinez Hill to the south toward the Santa Rita Mountains. Elevation: 2598 feet.

Figure 14a. 1942. Courtesy of the Arizona Game and Fish Department.

(14) Martinez Hill

The Santa Cruz River passes along the base of Martinez Hill east of the San Xavier Mission. This is a new route for the river. Its earlier course had been farther west, closer to the mission, until a cut-off dike was built in 1915, diverting the river eastward. Thus, like much of the river's course today, this reach to a large extent is man made. In a photograph taken in 1942 (Figure 14a), the channel had been deeply cut by erosion and supported a narrow forest of cottonwoods. Tall cottonwoods grow along the channel and a low mesquite woodland appears above the vertical bank within the river's meander. According to the photographer, the dense mesquite forest on the old flood plain by this date had been greatly altered, and, as he note: "This mesquite forest . . . is one of the oldest stands for nesting and roosting of the Whitewing [dove] in the U.S. Cutting of the

Figure 14b. R. M. Turner photograph. 1989. Courtesy of the Desert Laboratory Photograph Archive. Access to this camera station was granted by the Tohono O'Odham Nation, and is gratefully acknowledged.

mesquite has greatly depleted the Whitewing population from its once fabulous abundance." By 1989 (Figure 14b), the channel had been widened, eliminating the riparian forest.[16] The mesquite forest has continued to decline, perhaps by cutting, but also because of heavy groundwater pumping which commenced about 1940. The dead or dying trees are harvested for firewood by the local inhabitants.

[16] See Parker (1995), for a detailed description of channel changes along the San Xavier reach of the Santa Cruz River at Martinez Hill

Figure 15. Santa Cruz River as seen looking upstream from the Congress Street Bridge. Elevation: 2330 feet.

Figure 15a. November 22, 1930. Photograph courtesy of the U. S. Geological Survey, Tucson, Arizona.

(15) Congress Street Bridge

The Santa Cruz River bisects Tucson along its historical midriff. In the city's early days, the river's perennial flow and its cottonwood- willow forest provided Tucson's citizens with a welcome change from the surrounding desert. By 1930, perennial flow at the Congress Street Bridge had ceased but remnants of the riparian forest still existed (Figure 15a). Sixty-five years later the view from the bridge emphasizes man's works and his attempts to control the river's force (Figure 15b). Both banks are stabilized, a trail runs along one side of the channel, and the river is still ephemeral here, although for short periods, as on January 5, 1995, water flows beneath the bridge.

Figure 15b. Dominic Oldershaw photograph. 1995. Courtesy of the Desert Laboratory Photograph Archive.

Summary

Many photographic sets picturing the upper San Pedro and upper Santa Cruz Rivers reveal a surprisingly uniform sequence of changes. Before the turn of the century, these valleys were largely free of trees and shrubs, covered instead by grasses, such as sacaton and tobosa. Prior to the floods of August 1890, the Santa Cruz River above present-day Green Valley supported much grass and some forests.[17] Several early photographs of these valley bottom grasslands show them to be free of stumps or other woody plant remnants that would be present had the absence of forests been the result of recent wood cutting. As shown by several photographic sets, by mid-twentieth century, these channels were densely covered by forests of mesquites, willows, and cottonwoods and in general, remain densely covered today. Yet, journalists and even some scientists have incorrectly reported the opposite trend.

The perception that the decline of this forest extends upstream from the Colorado River mainstem to its tributaries in southeastern Arizona is boosted by wildly inaccurate reports. For example, one can read in an account about the San Pedro River, that "steamboats once navigated all the way to Charleston to supply Tombstone and Bisbee with goods."[18] In another, one reads (concerning steamboat navigation): "When Anglo Americans first came to the Southwest, much of the Gila River was navigable."[19] These exaggerated claims overstate the volume of historic flow in these rivers. Undeniably, dam construction, water diversion, groundwater pumping, and other forces have altered the hydrologic regimes of many of the region's rivers, resulting in dramatic losses of fish species and other aquatic animals. However, along rivers that are still unobstructed by dams, these dramatic declines have not occurred. In fact, a dramatic forest expansion has taken place over the past century.

The sequence of changes along our major valleys appears to have started when sluggish flow across flat, seasonally flooded swards of sacaton became forcefully erosive during the last decades of the 19th century. Rivers cut narrow defiles through the grassy bottomlands. Downcutting produced a drop in the water table and an end to seasonal flooding of the grassy flats. The earlier alternately dry and waterlogged conditions on these low-lying heavy soils promoted the growth of grasses and the exclusion of woody plants. With the drop in the water table, conditions for woody plants improved, and mesquite and other shrubs were able to occupy the new habitat. In addition, the floor of the newly deepened channel provided stretches of open mineral soil ideal for the establishment of cottonwood and willow. With subsequent widening, the bands of riparian trees broadened and became multi-aged, gallery forests. Thus, today we have cottonwood-willow forests flanked by mesquite bosques where a century ago the valleys supported grassy expanses of sacaton and tobosa grass.

Accompanying the changes from grassland to forest have been dramatic changes in birdlife. The lost grasslands were prime habitat for many sparrows including Baird's and Botteri's, both of which are now "species of concern." As noted in the book, Birds of Arizona, "Until about 1878 [Baird's sparrow was] an abundant transient and doubtless winter resident in the grasslands of southeastern Arizona . . . ; until 1920 decidedly uncommon but still a winter resident about the bases of the Chiricahua and Huachuca Mountains. Now apparently much rarer . . . ." In Birds of Arizona, one can also find that Botteri's sparrow is a "rather uncommon summer resident, . . . Usually in giant sacaton grass . . . Formerly much more common, especially before 1895 . . . . "

The changes in birdlife brought about by growth of the new forests of cottonwood and willow are probably even more dramatic. According to recent estimates for the San Pedro River, the new riparian forest is home to a new biota that includes half the birds known throughout the United States and more mammals than occur "in any comparable area on the planet, save for tropical cloud forest in Costa Rica." Among the birds in this new gallery forest is the rare southwestern willow flycatcher, a "listed" species and the yellow-billed cuckoo, whose numbers are said to be dwindling (See The Arizona Daily Star, August 2, 2000, "2nd Suit Filed over Cuckoo").

The causes for the dramatic shift in the valley's biodiversity is probably the result of both climate and land use. The downcutting on the Santa Cruz, in August 1890, followed heavy month-long rains falling across a region that had been severely denuded by livestock grazing. Although we may never completely separate the impacts of livestock grazing from those of climate, it is clear that the change from grassland to forest came at a time when livestock grazing was heavy. These animals eat seedlings of the riparian trees, yet sufficient seedlings were left behind to establish the grand forests that are now the object of much well deserved interest. Furthermore, if livestock grazing on the uplands was indeed a dominant factor in causing downcutting along the region's valleys, we have the livestock to thank for the cottonwood-willow forest we are protecting today.

The mesquite forests flanking the narrow cottonwood-willow forests have much the same history as their neighbors. Present in a few places when early travellers passed through our region, they quickly expanded following the downcutting of the late 19th century. Some of these have disappeared in recent years. For example, the dense mesquite forest on the Santa Cruz near San Xavier Mission slowly died as groundwater pumping depleted the aquifer beneath it.

In many ways the Santa Cruz River presents a special case when evaluating vegetation change. The impact of man is especially strong along the reach between Nogales and Tucson's north side. Sewage effluent from the treatment plant at Nogales flows aboveground as it drifts northward. Although underground by the time it reaches Pima County, this artificial contribution probably has an impact on the hydrology of part of the Santa Cruz Valley. In addition, early in the 20th century, a dike was built to direct flow diagonally from the natural channel on the valley's west side across the valley to a lesser channel. Furthermore, part of this valley segment just south of San Xavier Mission had been used for irrigated agriculture for centuries, which by itself greatly altered the vegetation composition. Another man-induced change arose when the Santa Cruz captured a deeply eroded wagon road, abandoning its natural course for several miles along the valley. In recent years, heavy groundwater pumping has had a pronounced influence on vegetation growing along some parts of the valley floor. And over its course past Tucson, the banks of the Santa Cruz are shored up by cement walls that control both flooding and growth of riparian vegetation.

Whether our forests and creosotebush stands are shrinking or expanding, whether bird and fish populations are declining or irrupting are all judgments that must be made in the context of appropriate time intervals. The starting point of an ongoing biological or hydrological process often must be arbitrarily assigned. Quite different conclusions can be reached depending on when the biological stopwatch is started. For example, if pre-downcutting conditions along our river valleys are considered the starting point from which to judge change, then we might begin with grassland and end with forest today. By beginning at a post-downcutting time, we might begin with forest and then end with forest of lesser quality today. More forest would be one conclusion; less forest the other.

As we have seen in various photographic pairs, changes can be rapid or slow and may involve increases in some species and decreases in others. Location and areal extent are also important qualifiers when describing change. As noted above, changes over the past century in the cottonwood-willow forests are in opposite directions on the lower Colorado River compared to the headwaters of its undammed tributaries. And along the Santa Cruz River, where human impacts have been especially severe during recent decades, anthropogenic forces have reversed the trends seen along neighboring rivers of the region.

Photographic comparisons may be relatively accurate measures of change but nonetheless leave open the question of causation. The technique of repeat photography leaves little doubt about what change has occurred, but often fails to answer the question of just how the change occurred.

[17] Cooke and Reeves (1976), Betancourt (1990), Betancourt and Turner (1985).

[18] Steinhart (1994).

[19] McNamee (1994).

Acknowledgements

Several people have given support to this project by providing archival access, by helping to locate old camera stations and to repeat old photographs taken from those stations, by supplying computer graphics assistance, and by giving advice and direction when most needed. For this backing, we especially thank Chris Baisan, Janice Bowers, Art Brandt, Ed Carter, Calvin Farris, Julia Fonseca, Peter Griffiths, Dominic Oldershaw, Nathan Sayre, Jeanne Turner, Martin Turner, Seth Turner, Robert Webb, Brian White, and Roger Wolf.

Literature Cited

Baisan, C. H., and T. W. Swetnam. 1990. Fire history on a desert mountain range: Rincon Mountain Wilderness, Arizona, U.S.A. Canadian Journal of Forest Research 20:1559-1569.

Betancourt, J. L. 1990. Tucson's Santa Cruz River and the Arroyo Legacy. Ph.D. Dissertation, University of Arizona, Tucson.

Betancourt, J. L., and R. M. Turner. 1988. Historic arroyo-cutting and subsequent channel changes at the Congress Street crossing, Santa Cruz River, Tucson, Arizona. Pages 1353-1371, in E. E. Whitehead, C. F. Hutchinson, B. N. Timmermann, and R. G. Varady (eds.), Arid Lands: Today and Tomorrow. Westview Press: Boulder, Colorado.

Bowers, J. E., and R. M. Turner. 2001. Dieback and episodic mortality of *Cercidium microphyllum* (foothill palo verde), a dominant Sonoran Desert Tree. Journal of the Torrey Botanical Society 128(2):128-140.

Cooke, R. U., and R. W. Reeves. 1976. Arroyos and Environmental Change in the American Southwest. Clarendon Press: Oxford.

Glinski, R. L., and D. E. Brown, 1982, Mesquite (*Prosopis juliflora*) response to severe freezing in southeastern Arizona. Journal of the Arizona-Nevada Academy of Science 17:15-18.

Griffiths, D. 1904. Range Investigations in Arizona. USDA, Bureau of Plant Industry Bulletin no. 67.

Griffiths, D. 1910. A Protected Stock Range in Arizona. USDA, Bureau of Plant Industry Bulletin no. 177.

Griffiths, D. 1912. The Grama Grasses, Smithsonian Institution, U. S. National Museum, Vol. 14, Part 3.

McNamee, G. 1994. Gila: The Life and Death of An American River. Orion Books:New York.

Parker, J. T. C. 1995. Channel Change on the Santa Cruz River, Pima County, Arizona, 1936-1986. U.S. Geological Survey Water-Supply Paper 2429.

Rogers, G. F., H. E. Malde, and R. M. Turner. 1984. Bibliography of Repeat Photography for Evaluating Landscape Change. University of Utah Press: Salt Lake City.

Shantz, H. L., and B. L. Turner. 1958. Photographic Documentation of Vegetational Changes in Africa over a Third of a Century. The University of Arizona, College of Agriculture Report 16 9.

Shreve, F. 1911. Establishment behavior of the palo verde. Plant World 14:289-296.

Shreve, F. 1924/25. An unusually arid season in southern Arizona, p. 164-165 in Carnegie Yearbook, Vol. 24. Carnegie Institution of Washington, Washington, D.C.

Steinhart, P. 1994. Two Eagles/Dos Aguilas: The Natural World of the United States-Mexico Borderlands. University of California Press: Berkeley.

Swetnam, T. W., and J. L. Betancourt. 1998. Mesoscale disturbance and ecological response to decadal climatic variability in the American Southwest. Journal of Climate 11:3128-3147.

Turner, R. M., R. H. Webb, and J. E. Bowers. 2003. The Changing Mile Revisited, University of Arizona Press: Tucson.