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riparian vegetation

RECENT VEGETATION CHANGE NEAR QUITOBAQUITO SPRINGS,
ORGAN PIPE CACTUS NATIONAL MONUMENT

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Quitobaquito spring has been a focus of human activity for thousands of years. It is one of the few spring-fed sources of fresh water in hundreds of square miles of the most arid part of North America. Until the last family moved away in the 1950's it had been occupied for generations by Papago Indians and their close relatives the Sand Papagos (Bell, Anderson and Stewart 1980; Hayden 1967). Previous to settlement by Papagos, people of the Amargosa culture from the northwest had moved into the area, perhaps as much as 5,000 years ago (Ezell 1954). The first Europeans visited in 1540, and by 1698 Father Kino described "good pastures...with their irrigation ditches" along the Rio Sonoyta and at Quitobaquito (Hoy 1969, 1970). For over two hundred and fifty years -- until the Park Service bought the rights to Quitobaquito from Jim Orosco, the last Papago resident -- the spring was used to irrigate fields just south of what is now the pond, and to water livestock.

Although Quitobaquito is the most well known of the springs in Organ Pipe Cactus National Monument, the group of springs associated with it are perhaps equally important biologically. The series of 5 or 6 springs in this system is arranged along a southeast-northwest trending fault on the south side of the Quitobaquito Hills. The major springs in the system are, from the southeast, Aguajita, Quitobaquito, Burro, and Williams springs.

In addition, smaller unnamed springs lie between Quitobaquito and Burro and to the northwest of Williams Spring. Quitovac, another spring similar in size but of unknown hydrologic relation to Quitobaquito, is located approximately 50 km to the southeast in Sonora.

Quitobaquito has the greatest flow of the springs in the complex and probably also has received the greatest man-caused perturbation from its natural condition. Its spring source has been excavated, irrigation ditches dug, a dam constructed to capture the resulting increased flow, and fields plowed and cultivated in the flats below the dam. William's has also been developed to a small degree, with a cement trough installed to capture spring flow; however it apparently has not had agricultural disturbance. The other springs also have been heavily disturbed by man's activities, but to a large extent these disturbances have been restricted to the grazing of domestic livestock.

Springs such as those at Quitobaquito are unusual in the Sonoran Desert, and provide a dramatic contrast to the sparse arid scrub of the surrounding desert. The springs support a diversity of plants and animals that are found nowhere else within many miles (Anderson Warren and Nabhan, 1985; Bowers 1979; Huey, 1942). The marsh and surrounding mesquite woodland support a population of breeding bird species, such as yellow-breasted chat, hooded oriole, vermilion flycatcher, and western kingbird, as well as many migrants, that are rare or absent in the surrounding desert scrub (Johnson, Brown and Goldwasser, 1983). The pond itself is occupied by desert pupfish and Yellow and Sonoran mudturtles, all of which have very restricted distributions in the area.

The purpose of this paper is to document some of the changes in vegetation that have occurred in the Quitobaquito area following the removal of domestic livestock from the monument in 1978-79. The

discussion presented here focuses on William's, Burro and Aguajita springs but not on Quitobaquito itself for several reasons. Quitobaquito has been relatively intensively studied for several years and the other springs have to a large degree been ignored. Also, Quitobaquito and its counterpart in Sonora, Quitovac, are both maintained in an artificial condition: Quitovac due to agricultural development (Nabhan, et al, 1982), and Quitobaquito due to management for wildlife and visitor use. The remaining springs, especially William's and Burro, may tell us more about the natural ecology of isolated desert springs than the pond at Quitobaquito, despite its scenic beauty.

Methods

Between December, 1974 and April, 1976 several permanent vegetation study plots and numerous photo-points were established in the monument to document vegetation condition. We selected several of each in the Quitobaquito area for resampling and rephotography to document change during the eight to nine years between original sampling and our work in 1984.

Permanent Study Plots

One-tenth hectare permanent study plots were established in 1975 to provide baseline data for monitoring vegetation change in the monument subsequent to the removal of livestock (Steenbergh and Warren, 1977). Perennial vegetation cover was measured by the line intercept method of Canfield (1941; also see Mueller-Dombois and Ellenberg 1974) along 20m transect lines that were oriented perpendicular to the long axis of the 20 x 50 m plots at 5m intervals, providing a total of 11 parallel 20m transects per plot. The transect lines were also used to subdivide the plots into ten 20 x 5 m subplots. Within each of these subplots all

perennial plants were identified and counted, yielding data on total density and species presence.

Three plots were resampled in 1984. These are plot 200, 40 m north of Aguajita Spring; plot 2E1, 1/2 mile east of Aguajita Spring; and plot 2E2 1 1/2 mile east of Aguajita Spring. These plots were originally established on a livestock-use gradient from the heaviest use near Aguajita Spring to lighter use away from the spring. Soil texture also shows consistent variation among the plots with the siltiest, most poorly drained soils close to Aguajita Spring and rockier, more well drained soils away from the spring (Steenburgh and Warren, 1977). All plots were located upland desertscrub vegetation. Most of the photo points however, were located near springs in riparian vegetation that had been heavily disturbed.

The Student t-test (Sokal and Rohlf 1969) was used for statistical comparison of plots between years. Individual line-intercept transects were used as samples for calculating mean cover ($N = 11$), and density subplots were used as samples for calculating mean density ($N = 10$).

Photo Points

Photographs were taken from points established in 1975 to provide a permanent visual record of the vegetation in the monument. Selected points were rephotographed in April, 1984 to document changes in marsh vegetation around the springs that was not sampled with quantitative methods. Photos were taken with a 35mm camera and a 50mm lens. The photo points that we rephotographed were originally established near springs where livestock use was heaviest, and thus are not representative of the general condition of surrounding desertscrub.

Results and Discussion

The patterns of vegetation change observed in the vicinity of William's, Burro and Aguajita springs are to some extent similar at all three springs, but each spring also has unique physiographic features that have resulted in some differences in the patterns of change between springs. The extent and degree of vegetation change depend in part on the size of the springs and on the species composition of the desert vegetation surrounding them.

William's Spring

Three distinct vegetation and physiographic zones are recognizable at William's Spring. The first is the spring source itself and the permanently saturated soil immediately surrounding it. The spring source is located on a broad terrace that supports a stand of mesquite and seepweed. The terrace appears to have been formed by deposition associated with the spring, perhaps as the spring source moved from place to place, over a long period of time. Finally, a grassy saline flat lies below the shallow scarp that marks the edge of the terrace. Water is visible seeping to the surface here and there on the flat, but appears to not be permanent at the surface.

The spring source at William's was heavily disturbed by livestock. Photographs from 1974 and 1976 show that grass and shrubs at the source were severely cropped and that native marsh species were not present. The ground around the spring was trampled and devoid of herbaceous cover except on the wettest patch of ground and under the protection of a few shrubs (Figs. 1-3). Shaded areas under tree canopies were also trampled by livestock seeking shade. The remains of at least three dead cows were at the spring in 1976, attesting to the severity of the 1974-75 drought.

By 1984, only five years after livestock were removed, the spring source had grown in with several native marsh species of which bulrush and cattail are the most prominent. Around the margin of the saturated marsh area several woody species are increasing including alkali goldenbush, seepweed and mesquite. The moist swale below the spring that had been covered with grazed bermuda grass is now dominated by native shrubs.

The major changes observed on the terrace around the spring are an increase in the canopy size of hedged shrubs such as seepweed and an increase in the density of herbaceous annuals (Figs. 4-6 and 1), rather than the addition of perennial species as seen at the spring source. The overall result was a large increase in the vegetation cover on the previously trampled, silty soil of the terrace.

The saline flat below the terrace was covered almost exclusively by a sparse stand of saltgrass in 1976, and, except for the immigration of alkali sacaton, has not undergone any major change in species composition. The biggest change is an increase in saltgrass cover and its expansion up onto the previously barren scarp of the terrace. The single patch of yerba mansa (Anemopsis californica) on the flat was expanding in 1976, but now appears to be shrinking, perhaps as a result of competition with saltgrass.

Burro Spring

Burro Spring is much smaller than William's Spring, with lower flow and a more restricted area of mesic vegetation. The area of vegetation influenced by the spring is approximately five to ten meters wide and twenty to thirty meters long. William's in comparison has an expanse of several hundred meters across its terrace and salt flat. Burro is composed of two main components: the saturated spring source and the strip of moist soil extending down the wash below the source.

In 1976 the spring source at Burro was an open mud hole with sparse plant growth (Figs. 10-12). The adjacent stand of arrowweed and mesquite was kept open by the browsing of livestock. Herbaceous plants growing in the spring source and in the moist wash below the spring were, with the exception of bermuda grass, largely unrecognizable due to grazing.

By 1984 the spring source was grown in with native species, mainly bulrush, arrowweed and Phragmites australis. The grassy strip along the moist wash, although it is still dominated by introduced bermuda grass and rabbitfoot grass, is now wider and more species are evident, including some relatively uncommon herbs such as Centaureum calycosum. The once-open understory of the arrowweed/mesquite thicket has completely filled in with marshy growth.

Although remarkable recovery from livestock disturbance at the spring has occurred in less than ten years, desertscrub on adjacent hillsides showed very little change over the same period of time. Most of the larger perennials are recognizable as the same individuals in the paired photographs. The greatest change appears to have occurred in the vigor and density of brittlebush, which have increased in size and number on hills both northeast and southwest of the spring. However, because brittlebush has low palatability for livestock this increase is probably a response to the high rainfall of 1982-83, rather than a recovery from disturbance.

Aguajita Spring

Aguajita Spring differs in one important respect from all the other springs of the Quitobaquito complex. Most of the springs occur high in the watersheds in which they are located, mostly within a few hundred meters of the crest of the watersheds. Because only a small runoff area exists above the springs they are rarely if ever exposed to flooding and the disturbance

flooding would have upon their vegetation. In contrast, Aguajita is located directly in the bottom of a major wash with a watershed of many square miles. As a result, Aguajita experiences heavy flooding almost yearly. Instead of being choked with marshy vegetation as the other springs now are, its source is scoured clear of dense herbaceous vegetation by periodic floods, resulting in a rivulet of free-flowing water several meters in length.

Unfortunately no documentation, photographic or otherwise, is available for the Aguajita Spring source from the same time period as that for the other springs. The information presented here is from a series of three permanent plots located approximately 40 meters north of the spring, and 1/2 and 1 1/2 miles east of the spring.

All plots showed a marked increase in total cover between 1976 and 1984 (Table 1). The greatest change occurred in plot 200, closest to Aguajita Spring where cover increased approximately six-fold (Fig. 13). Farther from Aguajita Spring the increase in vegetation cover is less, approximately two-fold in plot 2E1, and an increase in cover of 1 1/2 times in plot 2E2. The increase in perennial cover was restricted largely to just a few species at all three plots, primarily seepweed, two species of saltbush, white ratany, and bush muhly, all of which are palatable to livestock. Most of the less palatable species showed little or no change following livestock removal.

In plots where plants are clumped, variance in the plot mean is high and there may be no statistically significant difference between years even though the difference is biologically important. This is particularly evident in the case of species such as saltbush in which the flowers and fruit are the first part of the plant to be browsed, thus a grazing

intensity that may have a relatively small effect on species cover may significantly reduces its reproductive capabilities.

In spite of the large increase in cover on the plots, no comparable change in density was observed. Seepweed experienced an apparent large decrease in density on the plot where it had the greatest increase in cover, primarily as a result of adjacent canopies intermingling as they expanded to the point that they were counted as single individuals. In general new species that are now present on the plots are fast growing herbaceous plants rather than woody species.

Conclusions

The most striking observation was the unexpectedly rapid rate at which marsh vegetation surrounding each of the springs near Quitobaquito recovered in the five years since livestock were removed from the monument. This recovery is notable for two major reasons. First, on sites that were virtually barren soil or mud marsh vegetaton achieved almost complete physiognomoic recovery with close to 100 percent cover of mature, reproductive plants. Second, several of the dominant species in the now-luxuriant marsh growth were not in evidence at the springs in 1974-76, particularly Phragmites australis, cattail and bulrush. This apparently complete structural recovery was paralleled by an increase in species diversity, however the degree of recovery of species diversity is probably impossible to determine because there are no baseline data from undisturbed sites with which to compare the present species assemblage.

Table 1. Change in perennial plant cover (%) between 1975 and 1984 near Aguajita Spring.

Species	Plot 200		Plot 2E1		Plot 2E2	
	1975	1984	1975	1984	1975	1984
<u>Suaeda torreyana</u>	3.09	7.55*	0.98	2.11	0	0
<u>Atriplex polycarpa</u>	0.25	5.46**	4.80	12.26***	0.98	3.72*
<u>Atriplex linearis</u>	0.09	3.12***	1.34	2.97	1.02	0.93
<u>Muhlenbergia porteri</u>	0	2.72**	0	0.50	0	0
<u>Larrea divaricata</u>	0	0	0.98	1.61	6.84	5.87
<u>Ambrosia deltoidea</u>	0	0	2.41	2.69	1.91	5.72
<u>Machaeranthera arizonica</u>	0	0	0	0.70	0	0
<u>Ambrosia dumosa</u>	0	0	0	0	0.64	2.09
<u>Opuntia stanleyi</u>	0	0	0	0	0.27	0.48
<u>Cercidium microphyllum</u>	0	0	0	0	1.86	1.80
<u>Fouquieria splendens</u>	0	0	0	0	0.80	0.68
<u>Olneya tesota</u>	0	0	0	0	2.32	0
<u>Krameria gravi</u>	0	0	0	0	0	0.69
Total	3.43	18.85	10.51	23.11	16.64	21.98
* p<.05, t>1.72 ** p<.01, t>2.53 *** p<.001, t>3.55 df=20						

Table 2. Change in perennial plant density (individuals/0.1 ha) between 1975 and 1984 near Aguajita Spring.

Species	Plot 200		Plot 2E1		Plot 2E2	
	1975	1984	1975	1984	1975	1984
<u>Suaeda torreyana</u>	226	125***	11	12	0	0
<u>Atriplex polycarpa</u>	17	78*	137	150	54	103**
<u>Atriplex linearis</u>	50	61	90	127	73	95
<u>Larrea divaricata</u>	1	0	17	17	54	56
<u>Ambrosia deltoidea</u>	1	0	33	33	149	105
<u>Ambrosia dumosa</u>	0	0	1	3	82	72
<u>Muhlenbergia porteri</u>	0	84***	0	14*	0	0
<u>Aristida spp.</u>	0	3*	0	1	0	0
<u>Opuntia stanleyi</u>	0	0	2	2	6	14
<u>Olneya tesota</u>	0	0	1	1	2	1
<u>Prosopis glandulosa</u>	0	0	1	1	0	0
<u>Echinocereus engelmanni</u>	0	0	1	0	0	0
<u>Opuntia leptocaulis</u>	0	0	2	2	0	0
<u>Opuntia fulgida</u>	0	0	2	0	0	0
<u>Lycium andersoni</u>	0	0	1	1	0	0
<u>Lycium parishii</u>	0	0	0	2	0	0
<u>Machaeranthera arizonica</u>	0	0	0	24***	0	0
<u>Hymenothrix wislizenii</u>	0	0	0	2	0	0
<u>Dalea mollis</u>	0	0	0	1	0	0
<u>Cercidium microphyllum</u>	0	0	0	0	2	2
<u>Fouquieria splendens</u>	0	0	0	0	1	1
<u>Mammillaria microcarpa</u>	0	0	0	0	1	0
<u>Krameria gravi</u>	0	0	0	0	0	5
Total	295	351	299	393	424	467
* $p < .05$, $t > 1.73$ ** $p < .01$, $t > 2.55$ *** $p < .001$, $t > 3.61$ $df=18$						

Changes in non-riparian desertscrub near the springs was different from and less dramatic than that at the spring themselves. The primary difference in the change patterns was that although recovery in the desertscrub was characterized by an increase in cover, there was not a shift in the dominant species, as was the case in the marshy areas. Increase in non-riparian perennial cover resulted from an increase in the canopy size of existing plants rather than from the establishment of new plants. However, non-riparian sites did experience an increaseⁱⁿ abundance of annual species. This difference between marsh and desertscrub sites is due primarily to the fact that, aside from trampling by livestock seeking water, all of the marsh species are palatable whereas only a fraction of the desertscrub species are highly palatable to livestock. Thus marsh vegetation received uniformly heavy browsing but upland desertscrub was selectively browsed.

The observed changes will probably have several continuing ecological effects. Increased seed production by both marsh and desertscrub species increases the food resources of desert granivores such as pocket mice, kangaroo rats, ants and birds. Populations of these animals may change in response to increasing food resources. The new thick growth at the springs may also provide habitat to support previously excluded birds and mammals.

These changes may also contribute to further development of the marsh floras. A number of species, such as Phragmites australis, cattail, yerba mansa, and Centaurium calycosum, are present at one spring but not others. The relatively small distances between these springs suggests that these differences in species composition are due to either selective extinction of species at some springs, or^{to} a very low rate of movement of propagules between springs. We now expect to see higher visitation rates of birds to

the springs and greater seed production of marsh plants, which in combination should result in a convergence of spring floras due to exchange of propagules.

At springs which are located high on the watershed, such as Burro and William's, the spring source has become choked with vegetation and open standing water reduced after livestock were removed. The spring source at Aguajita Spring remained open because it is located in a large wash which is lower on the watershed and often scoured by periodic floods. This suggests that Quitobaquito, which is not subject to periodic scouring floods, would also be choked with vegetation under natural conditions. Since dense vegetation under these conditions would reduce the availability of ponded water, it is possible that the desert pupfish may not be able to survive without pond management at Quitobaquito, and may not be natural residents of the spring.

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Figure 1a. (December, 1974) William's Spring, looking southeast across the cement trough. The ground is heavily trampled and herbaceous ground cover is almost absent in the vicinity of the spring. A swath of closely-cropped bermuda grass extends downstream of the trough on damp soil.

Figure 1b. (April, 1984) The person is standing on the trough at William's Spring which has been partially broken out on one side. A shallow pool (2-4" deep) extends for 10-15 feet in diameter around it. Cattail, bulrush and alkali goldenbush have come in on the wet soil and seep weed has recovered on the uplands. Several herbaceous species, especially Macaeranthera arizonica, bush muhly and jackass clover have increased in the foreground along with many standing dead annuals.

Fig 1a.



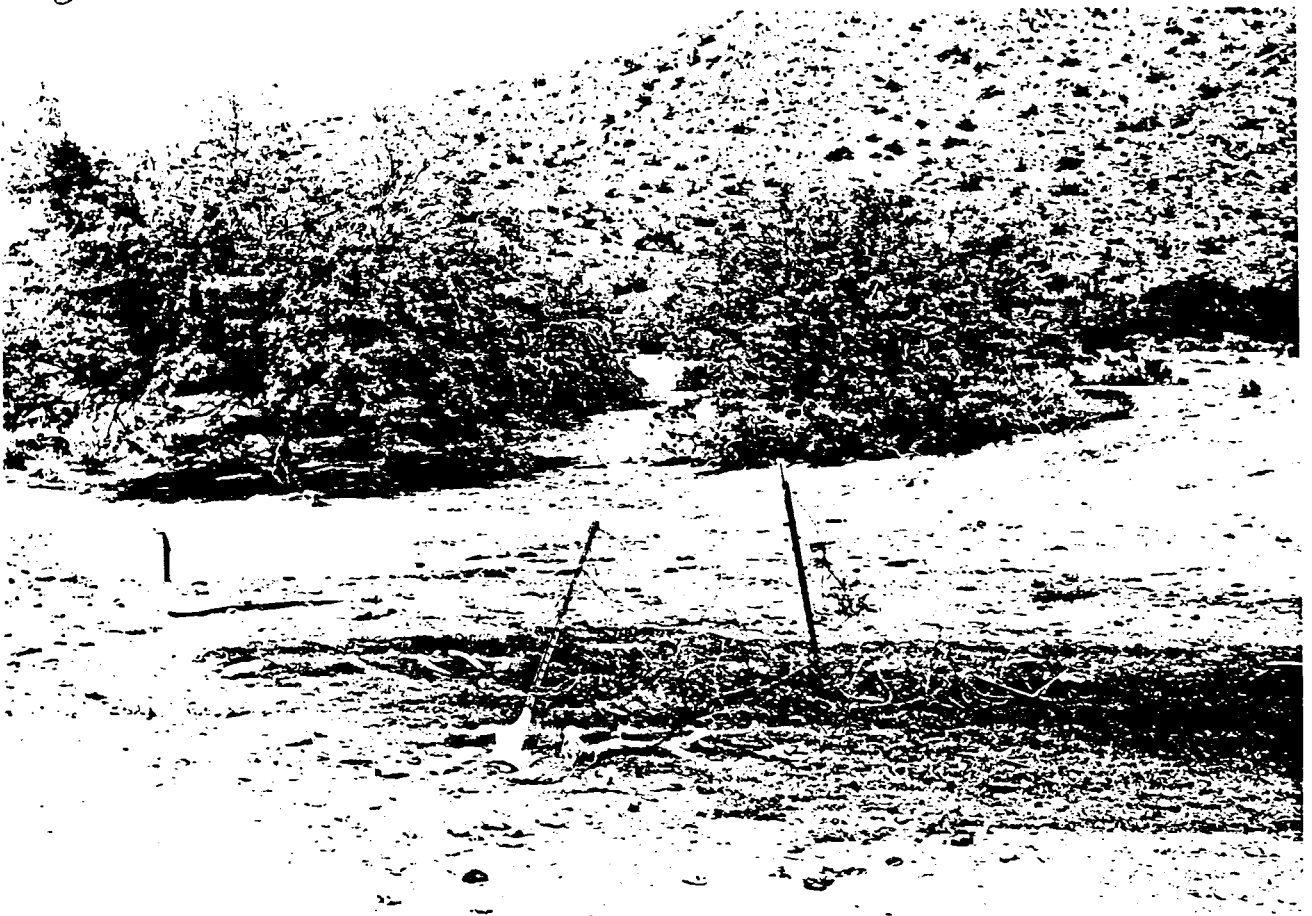
b



Figure 2a. (April, 1976) Looking north-east at the trough at William's Spring. Conditions have not changed noticeably since Figure 1a was taken with the exception of the cow skeleton in the foreground -- testimony of the 1974-1975 drought. The moist soil in the center is the only area of herbaceous vegetation on the photo and is dominated by bermuda grass.

Figure 2b. (April, 1984) The person is standing on the William's Spring trough. Dense bulrush and cattails have come up in the wet soil with alkali golden bush and seepweed around the marsh edges. The mesquite in the right has apparently grown from seed to 4 m in eight years.

Fig 2a.



b.



Figure 3a. (April, 1976) The view south from 20 m southwest of the William's Spring trough. The foreground shows severely browsed seepweed and bermuda grass in the wash bottom.

Figure 3b. (April, 1984) Woody species, especially mesquite, alkali goldenbush and seepweed, have increased markedly. Several mesquite have grown from seed to 4 m in height. Soil in the drainage is muddy with flow from the spring.

Fig 3a.



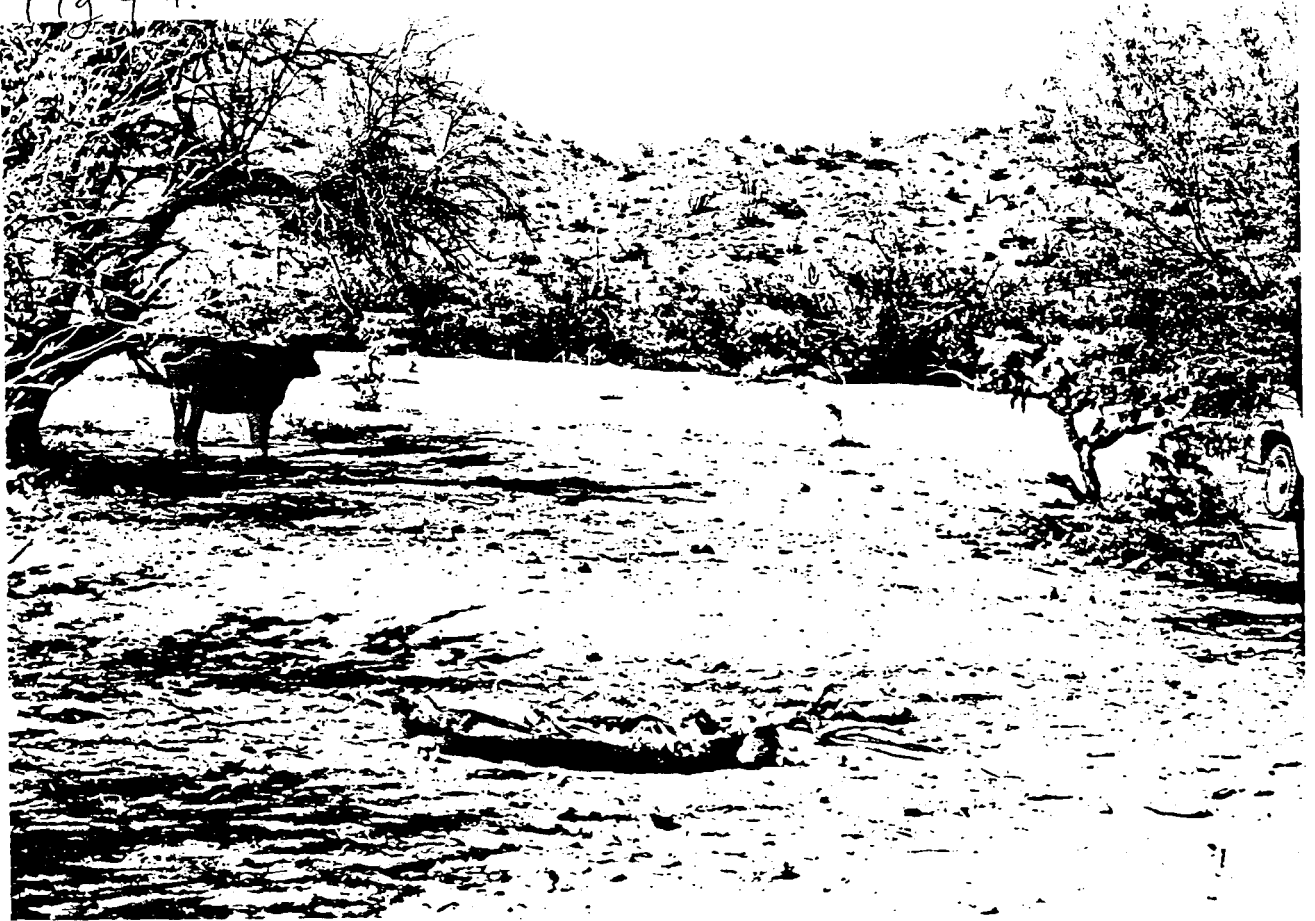
b.



Figure 4a. (April, 1976) View to the north from the same location as Figure 3a at William's Spring. The fence visible in the background encloses the spring source and excludes livestock from an area of approximately 15 m by 15 m. Water was piped from inside the fence to the trough approximately 20-25 m downstream. The ground is severely trampled, particularly under mesquite trees where livestock seek shade.

Figure 4b. (April, 1984) The luxuriant growth in the foreground is mostly seepweed, with some Macaeranthra arizonica on the right. Vegetation on the hill in back has not changed noticeably with many of the same individuals recognizable from both photos.

Fig 49.



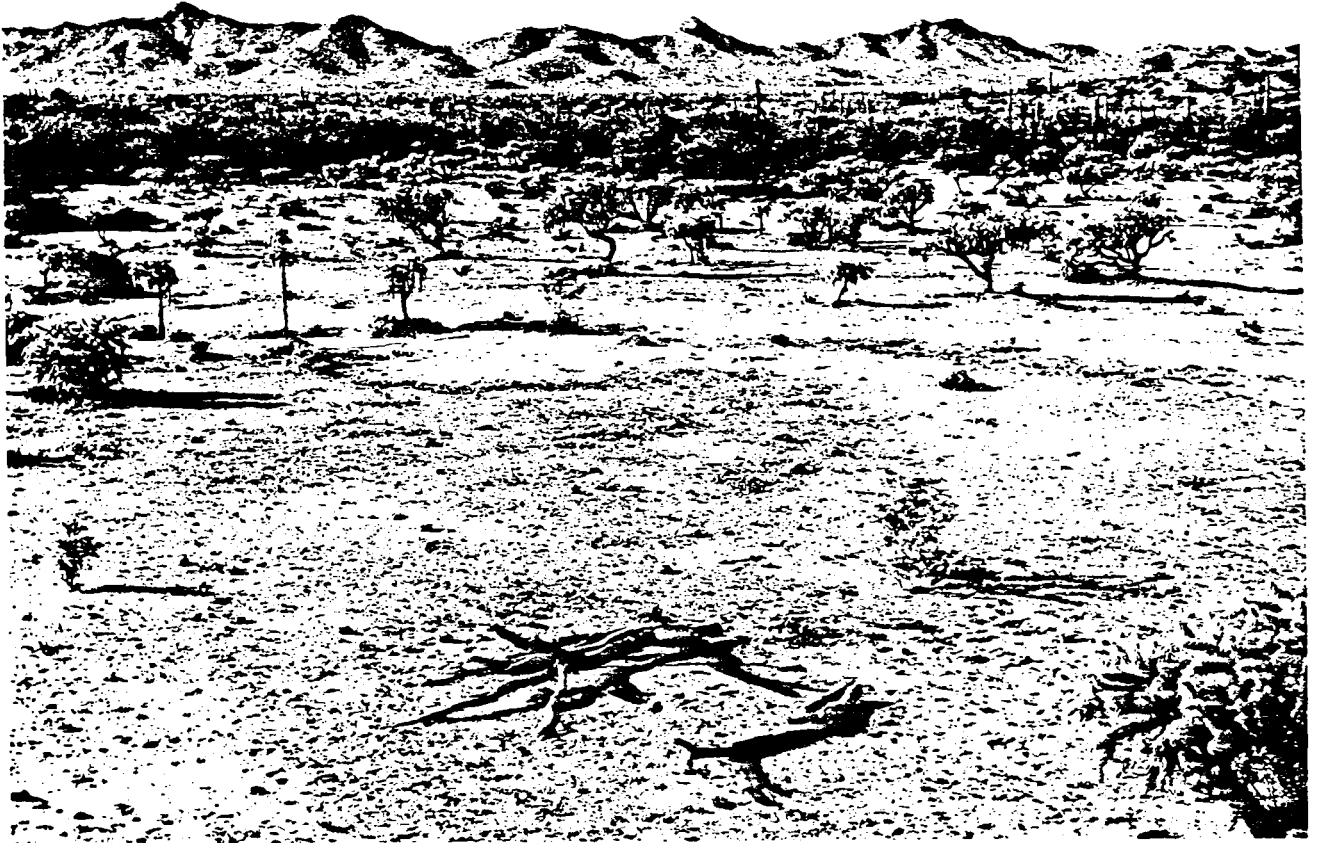
b.



Figure 5a. (December, 1974) View to the southwest from the rise 40 m west of William's Spring trough. The dominant plants are jumping cholla with a few small creosotebush and cropped saltbush. Herbaceous plants are lacking and the ground is heavily trampled.

Figure 5b. (April, 1984) The chollas and saltbush have increased in size. The greatest change can be found in the thick annual ground cover which is mostly Macaeranthra arizonica and jackass clover.

Fig 5 a.



b.



Figure 6a. (December, 1974) Looking northwest from the same location as Figure 5. The plants in the foreground are ocotillo, jumping cholla and heavily cropped seepweed and saltbush. The upper spring is just out of the picture in the thicket to the right rear.

Figure 6b. (April, 1984) Seepweed and saltbush canopies have grown out and several young cholla have come up. Two of the largest saguaros in the center and left rear, have died. The new herbaceous ground cover is mostly Macaeranthra arizonica, Euphorbia and tumbleweed.

Fig 6a.



b.

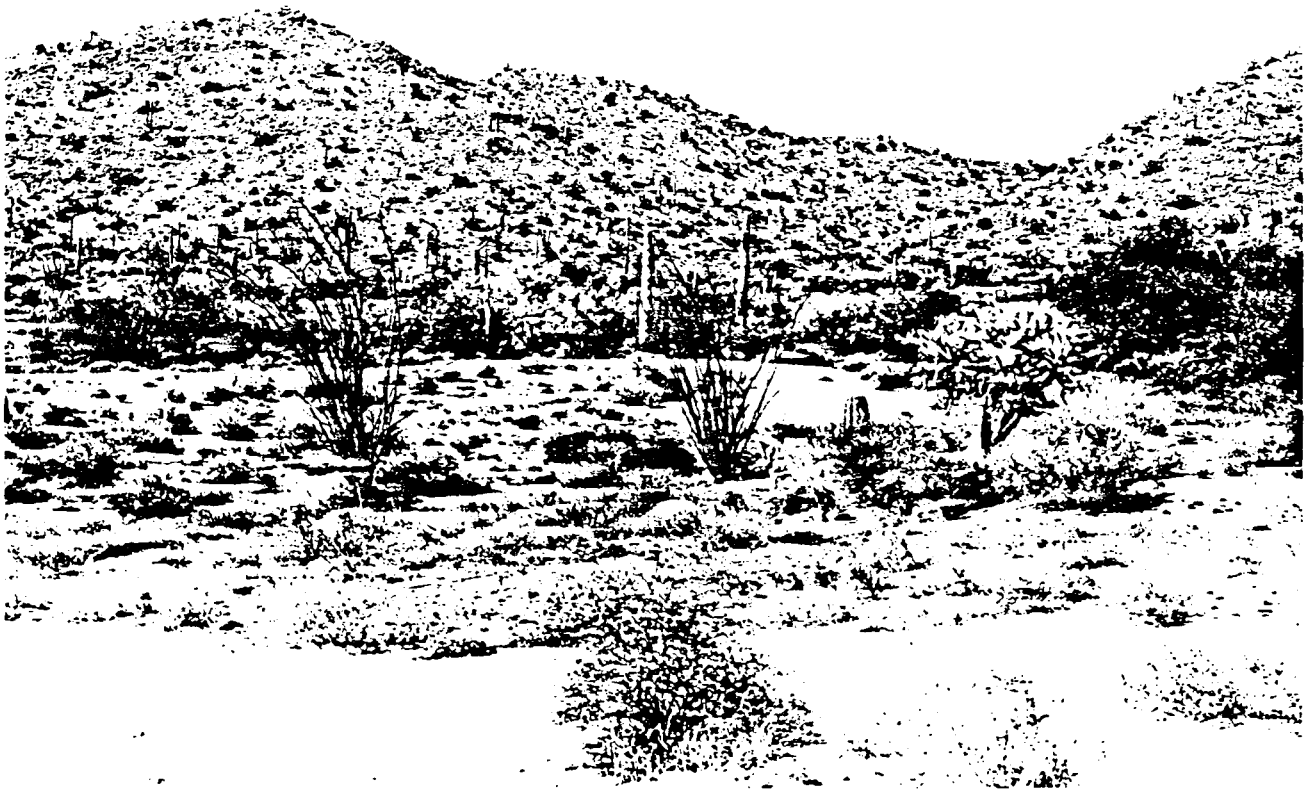


Figure 7a. (April, 1976) Looking east across the saline flat below William's Spring. The common grass on the flat is saltgrass and the flowering herb in the left front is yerba mansa. The trees in background are mesquite.

Figure 7b. (April, 1984) Grass cover has increased and a new species of bunch grass, alkali sacaton, has come in. Saltgrass has spread up onto the bare soil around the mesquite in the background. The yerba mansa has apparently grown smaller and has fewer spreading stolons than were visible in 1976.

Fig 7a.



b.

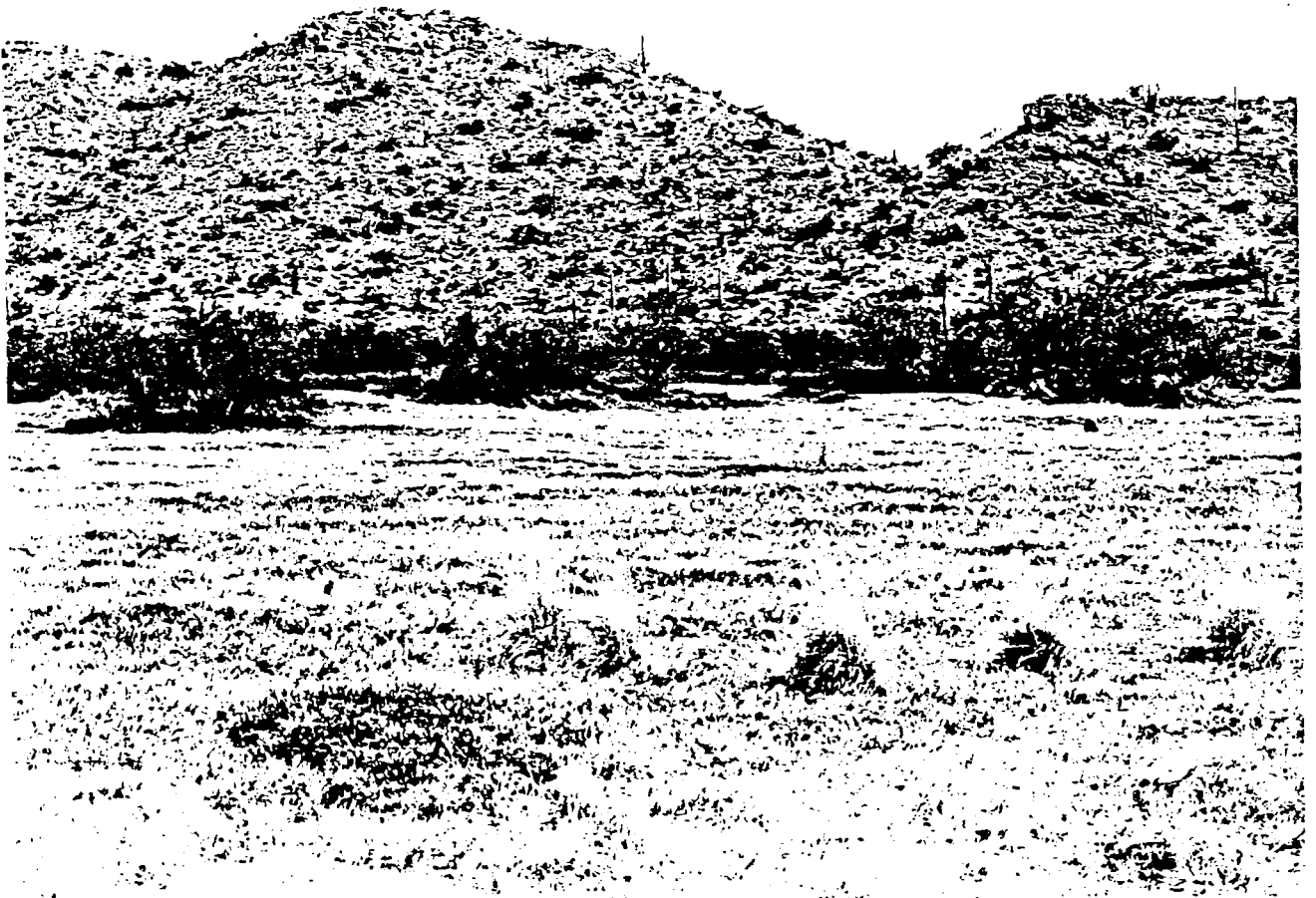


Figure 8a. (April, 1976) East side of the saline flat below William's Spring. This is a closer view of part of the background of Figure 7. Saltgrass is in the foreground and the dark area on the left is a moist seep. The hillside in back is dominated by foothill paloverde, brittlebush, saguaro, ocotillo, and organ pipe cactus.

Figure 8b. (April, 1984) Saltgrass cover has increased to 80-90 percent and has spread up the bare slopes to the mesquite in the background. The tall clump at left-center is alkali sacaton. The seepweed among the mesquite have grown out from a severely hedged condition. No apparent change has occurred on the hillside in the background and most of the larger plants are recognizable as the same individuals from 1976.

Fig 8a.



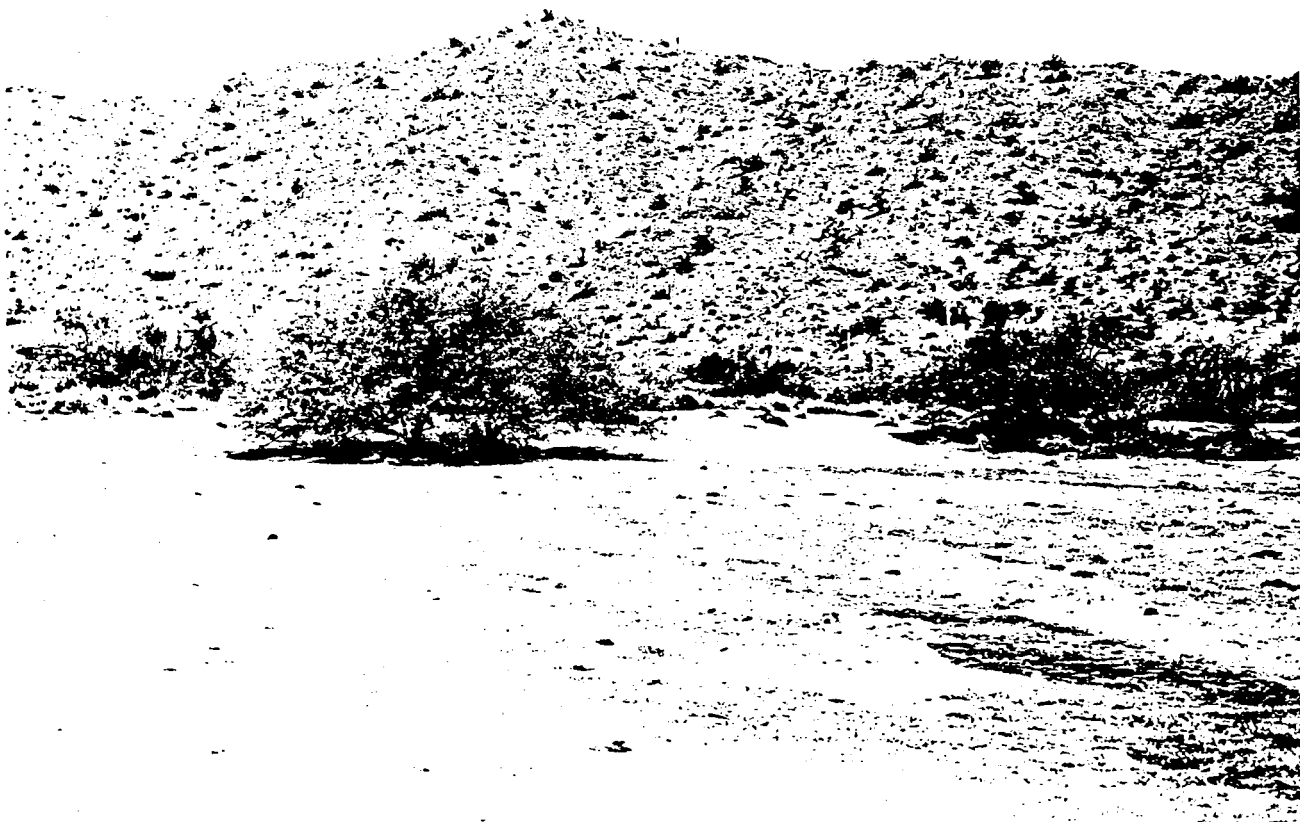
b.



Figure 9a. (April, 1976) This photo is taken from the same location as Figure 8 and overlaps with it slightly to the north (the seep is now on the left). The area under the canopy of the middle mesquite tree is relatively open due to trampling by livestock seeking shade.

Figure 9b. (April, 1984) Cover of saltgrass has increased from 20-30 percent to approximately 70-80 percent. The seepweed in the background have more than doubled in canopy volume. A new clump of alkali sacaton appears on the left. Growth of grass and shrubs has been proportionately greater under and adjacent to mesquite trees than in open areas.

Fig. 9a.

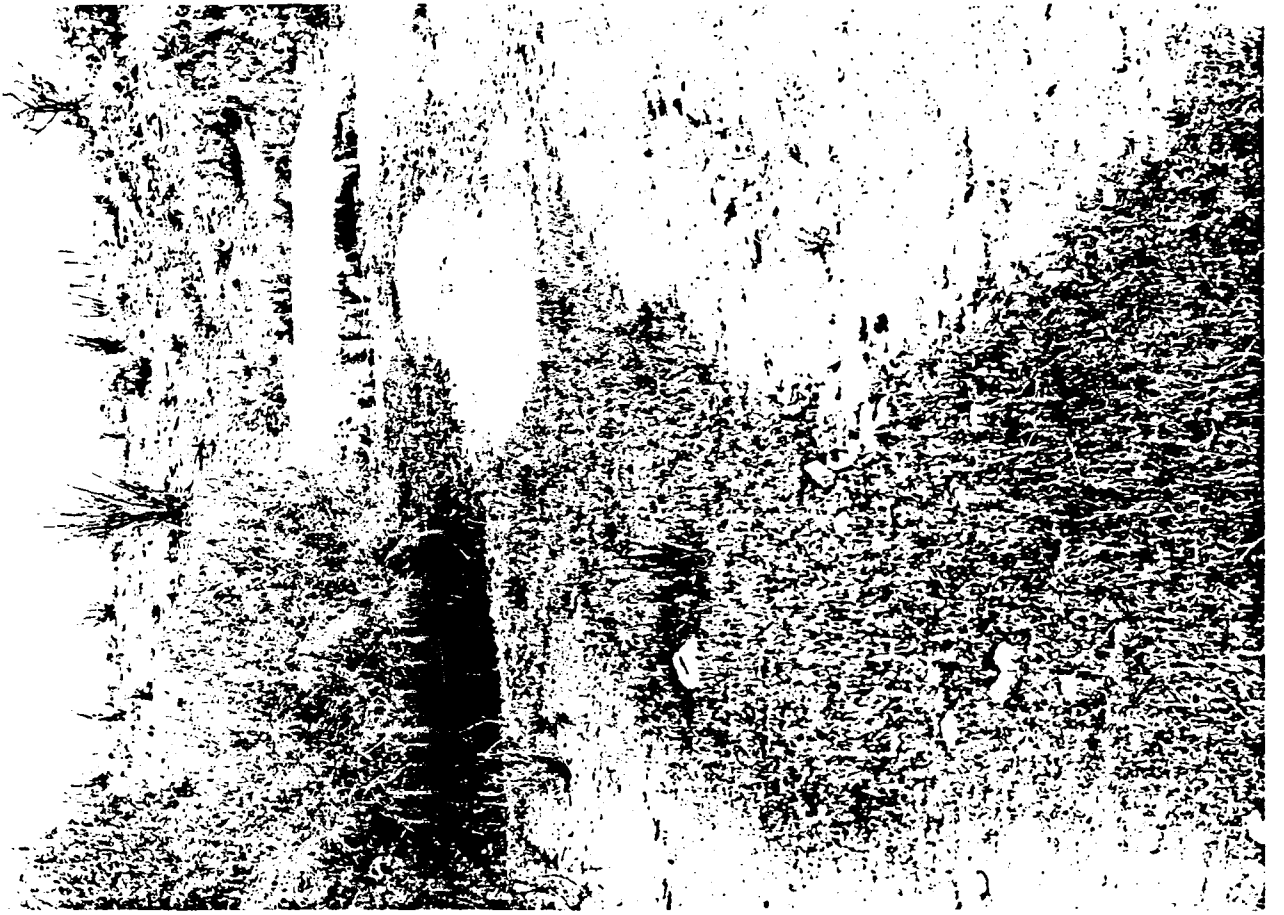


b.



Figure 10a. (April, 1976) Looking up at Burro Spring from the wash below the spring. Note the hedged browse-line on the thicket of arrowweed and mesquite at the left rear. The plants on the hillside in the background are ocotillo, foothill paloverde, brittlebush and organpipe cactus.

Figure 10b. (April, 1984) The spring has grown in with bulrush, arrowweed and Phragmites australis. Grass in the arroyo below the spring has spread and is dominated by bermuda grass and rabbitfoot grass in the left foreground, both introduced species. Other herbaceous species not apparent in 1976 are Centaureum calycosum, spreading fleabane, slender poreleaf, and jackass clover. The increase in brittle bush on the hillside is due mostly to increase in the size of existing plants, though a few new individuals have appeared since 1976.



a.

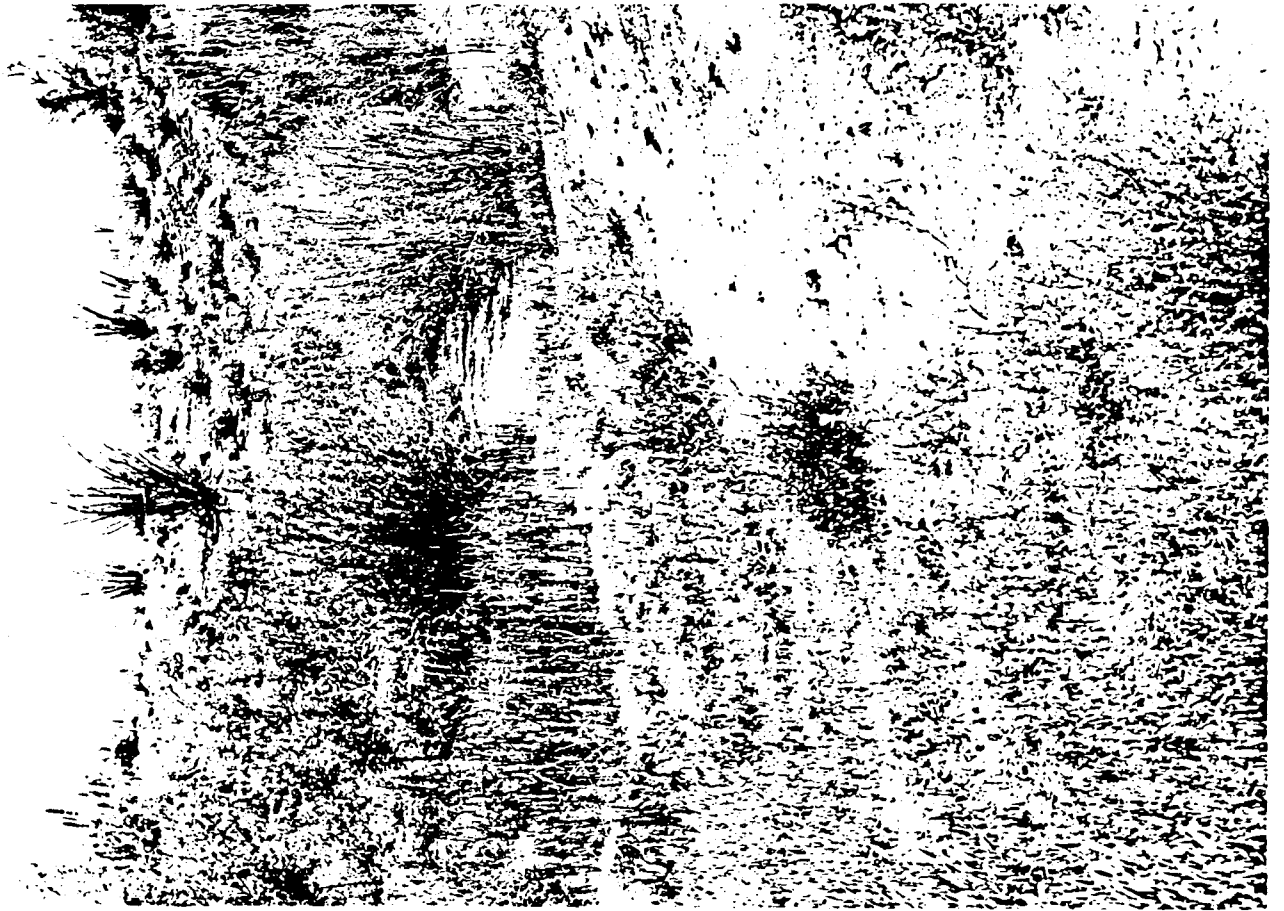


Fig. 10 b.

Figure 11a. (April, 1976) Looking southwest across Burro Spring from above the spring source. The thicket on the right is arrowweed and the grass in the arroyo is bermuda grass. The spring has been heavily trampled by livestock.

Figure 11b. (April, 1984) The person is standing on the bare mound at left center in the 1976 photo. The spring has grown in with bulrush, arrowweed, jackass clover, and Phragmites australis. An increase in the mesquite canopy is shown on the right. The hillside in back appears relatively unchanged with the exception of an increase in brittlebush.

Fig 11 a.



b.



Figure 12a. (April, 1976) The spring source at Burro Spring. The thicket in the rear is arrowweed with an overstory of mesquite which has been kept open by livestock seeking shade. The shrub in the right foreground is greythorn.

Figure 12b. (April, 1984) The spring is now choked with bulrush, arrowweed and Phragmites australis. Undergrowth in the thicket, now obscured by bulrushes, is so dense as to be virtually impenetrable.



a.

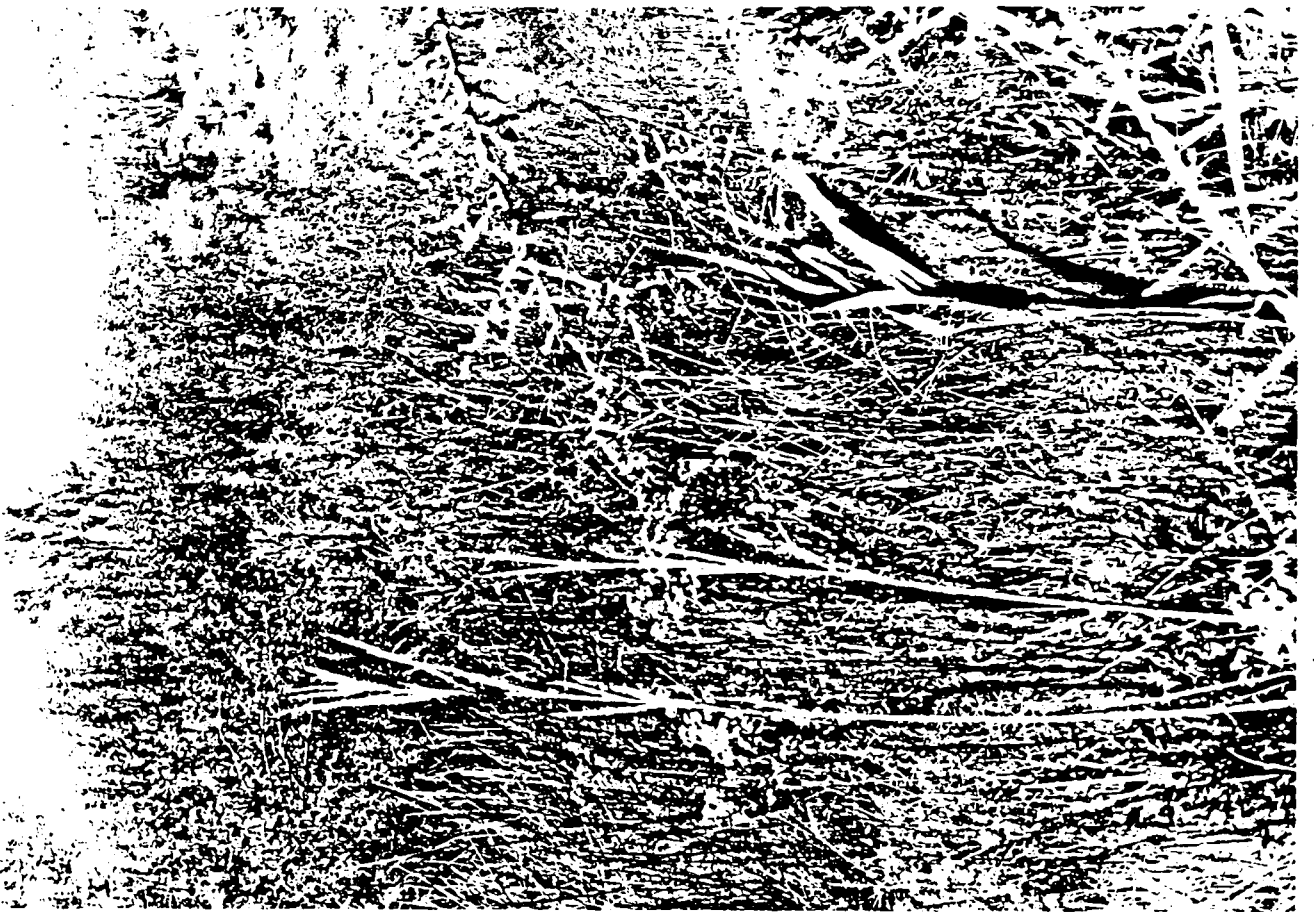
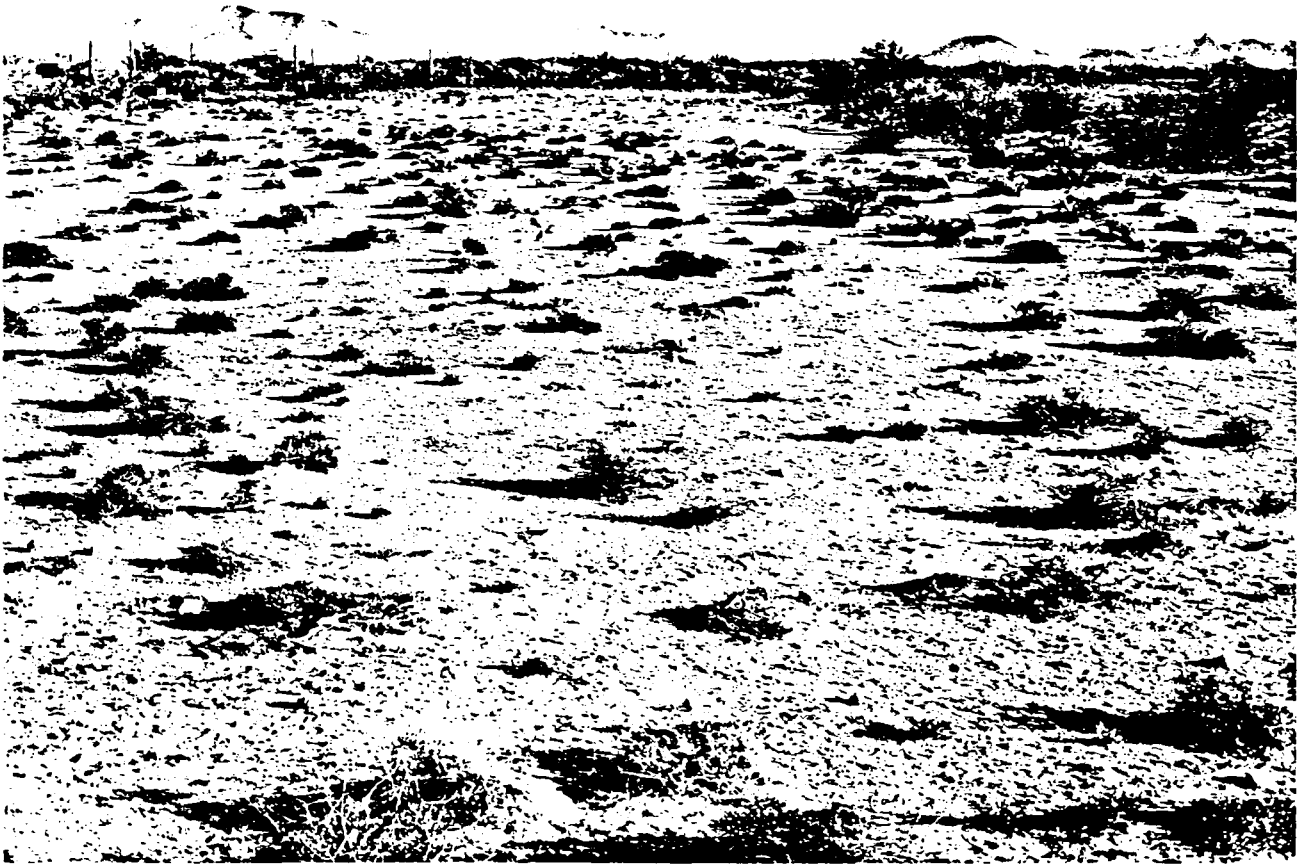


Fig 12 b.

Figure 13a. (December, 1974) Looking north from the road approximately 40 m northeast of Aguajita Spring. This is the location of plot 200. The browsed-hedged shrubs are seepweed and saltbush. The dark tree at the right rear is ironwood, but most of the others are mesquite.

Figure 13b. (April, 1984) The biggest change here is an increase in the size of seepweed and saltbush individuals (see also Tables 1 and 2). However, annual ground cover has also increased from almost nothing to approximately 50 percent. It is composed mostly of wooly plantain, mediterranean grass, six-weeks needle grama, and globe mallow. The change in the viewing angle resulted from standing on the ground instead of standing on a truck roof as was done for the original photo.

Fig 13 a.



b.

