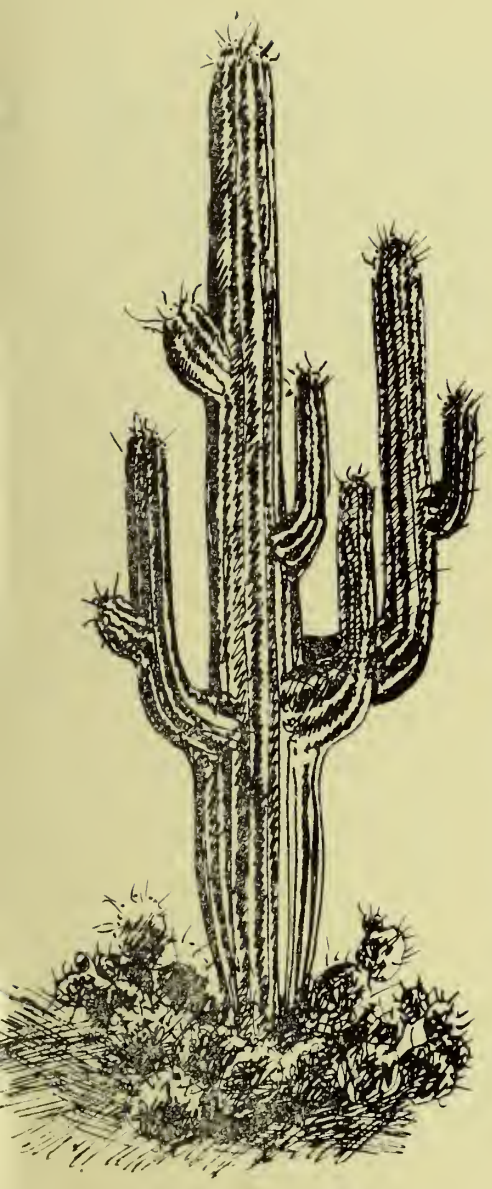

Cooperative National Park Resources Studies Unit

ARIZONA

TECHNICAL REPORT NO. 19

A DESCRIPTIVE ANALYSIS OF WOODY RIPARIAN VEGETATION
AT QUITOBAQUITO SPRINGS OASIS
ORGAN PIPE CACTUS NATIONAL MONUMENT, ARIZONA

University of Arizona
Tucson, Arizona 85721

Western Region
National Park Service
Department of the Interior
San Francisco, Ca. 94102

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
University of Arizona/Tucson - National Park Service

The Cooperative National Park Resources Studies Unit/University of Arizona (CPSU/UA) was established August 16, 1973. The unit is funded by the National Park Service and reports to the Western Regional Office, San Francisco; it is located on the campus of the University of Arizona and reports also to the Office of the Vice-President for Research. Administrative assistance is provided by the Western Archeological and Conservation Center, the School of Renewable Natural Resources, and the Department of Ecology and Evolutionary Biology. The unit's professional personnel hold adjunct faculty and/or research associate appointments with the University. The Materials and Ecological Testing Laboratory is maintained at the Western Archeological and Conservation Center, 1415 N. 6th Ave., Tucson, Arizona 85705.

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TECHNICAL REPORT NO. 19

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August 1986

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A DESCRIPTIVE ANALYSIS OF WOODY RIPARIAN VEGETATION AT QUITOBAQUITO SPRINGS OASIS, ORGAN PIPE CACTUS NATIONAL MONUMENT, ARIZONA

by

Bryan T. Brown and Peter L. Warren

August 1986

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ABSTRACT

Woody riparian vegetation of Quitobaquito Springs oasis was sampled during the spring and summer of 1983. The purposes of this study were threefold: 1) to provide a baseline documentation of the vegetation of the oasis; 2) to analyze the vegetation with special emphasis on the usefulness of this information to future studies of vegetational succession at Quitobaquito; and 3) to present monument managers with a descriptive analysis of this valuable interpretive site.

Prior to formal acquisition by the National Park Service in the 1950's, Quitobaquito Springs oasis was disturbed by human and livestock activities which maintained the surrounding riparian vegetation in a relatively open condition. National Park Service management eliminated most disturbances, resulting in the development of dense woodland and scrubland in the formerly open areas. This new habitat had an average canopy height of 3.3 m and was dominated by mesquite (Prosopis velutina) which average 452 individuals/ha. The vegetation of the oasis was characterized by a homogeneous stand of mesquite with a shrub understory. Large, isolated cottonwood trees (Populus fremontii) provided supplemental structural complexity and diversity. The density, diversity, frequency, height, and canopy volume of woody plants were compared between species and areas. These analyses revealed significant differences in the distribution of vegetation around the pond. Succession can be expected to cause future changes in the appearance and vegetative structure of Quitobaquito Springs oasis.

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ACKNOWLEDGEMENTS

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INTRODUCTION

The Quitobaquito Springs form a large oasis near the approximate center of the Sonoran Desert. The lush riparian vegetation surrounding the pond at the oasis has developed because of the abundance of water, providing a marked contrast to the arid desertscrub vegetation of the adjacent uplands. This lush vegetation is an important resource to native wildlife as well as man. Studies in progress indicate that the density and diversity of insects, birds, and mammals is higher in this riparian vegetation than in the surrounding desertscrub. Man currently uses this site as a tool to interpret the natural history of the Sonoran Desert in Organ Pipe Cactus National Monument. However, man has historically used the oasis for much different, more consumptive purposes. It is the recent cessation of those historic uses that has caused a change in the vegetation of the oasis, allowing the present-day vegetation to develop.

The presence of water and mesic vegetation at the oasis has been an attraction for man since prehistoric times. The human use and modification of the oasis, followed by the later recovery of the vegetation has been summarized by Johnson et al. (1983).

> Sand Papagos were using the site, at least on a seasonal basis, before European explorers visited the area (Bolton 1960, Nabhan et al. 1982). Aboriginal conditions at and around Quitobaquito remain unknown, but it is certain the Papagos, early explorers, soldiers, and later settlers modified the area and its vegetation. This was accomplished through the channeling and diking of the spring outflow, woodcutting for shelter and firewood, grazing of livestock, clearing of adjacent areas for agriculture, construction of dwellings, and the introduction of exotic plants for orchards and shade. Even the several large cottonwoods (Populus fremontii)...[may have been] introduced during this period. After the monument was established in 1937, Papagos continued to live and farm at Quitobaquito. This continued until the 1950's when the National Park Service formally acquired the site.
>
> As a result of historic consumptive uses, Quitobaquito Springs oasis passed to National Park Service management in a highly disturbed condition. Photographs of the area from the first half of the twentieth century show a shallow and broad expanse of water surrounded by a largely open area with little woody vegetation. Shortly after National Park Service acquisition, the open water area was drained, bulldozed, and diked into a discrete pond. Human disturbances were prevented after this time, eliminating the shallow, gravelly, open shore zone.....and allowing a dense thicket of water-loving vegetation to develop around the pond. In

summary, the vegetation around Quitobaquito Springs oasis has changed greatly within historic times.

Previous accounts of the vegetation surrounding the oasis have been anecdotal or only loosely descriptive. The purpose of this study is 1) to provide a baseline documentation of the vegetation of the oasis. In addition, 2) this study analyzes the vegetation of the site with special emphasis on the usefulness of this information to future studies of vegetational succession at Quitobaquito and 3) presents monument management with a descriptive analysis of this valuable interpretive site.

DESCRIPTION OF THE STUDY AREA

Quitobaquito Springs forms an oasis at an elevation of 332 m near the extreme southwestern corner of Organ Pipe Cactus National Monument, Pima County, Arizona. The springs themselves and the pond area are only 100 to 300 m north of the international boundary between the United States and Mexico. Riparian vegetation extends south of the border. Immediately to the south of the boundary is Mexican Highway 2.

Quitobaquito Springs and vicinity are thoroughly discussed by Bryan (1925), Cole and Whiteside (1965), Nabhan et al. (1982), and Brown et al. (1983). In an approximately 400 x 400 m area of flat to slightly rolling terrain north of the international boundary are found the two perennial springs that flow through a series of ditches and weirs into a man-made diked pond measuring approximately 60 x 70 m. Located to the east of the pond is an improved gravel parking lot. Forming a north-to-south oblong around the pond is the densely-vegetated area that is the subject of this report. Figure 1 presents a simplified cross-section of this riparian vegetation around the pond.

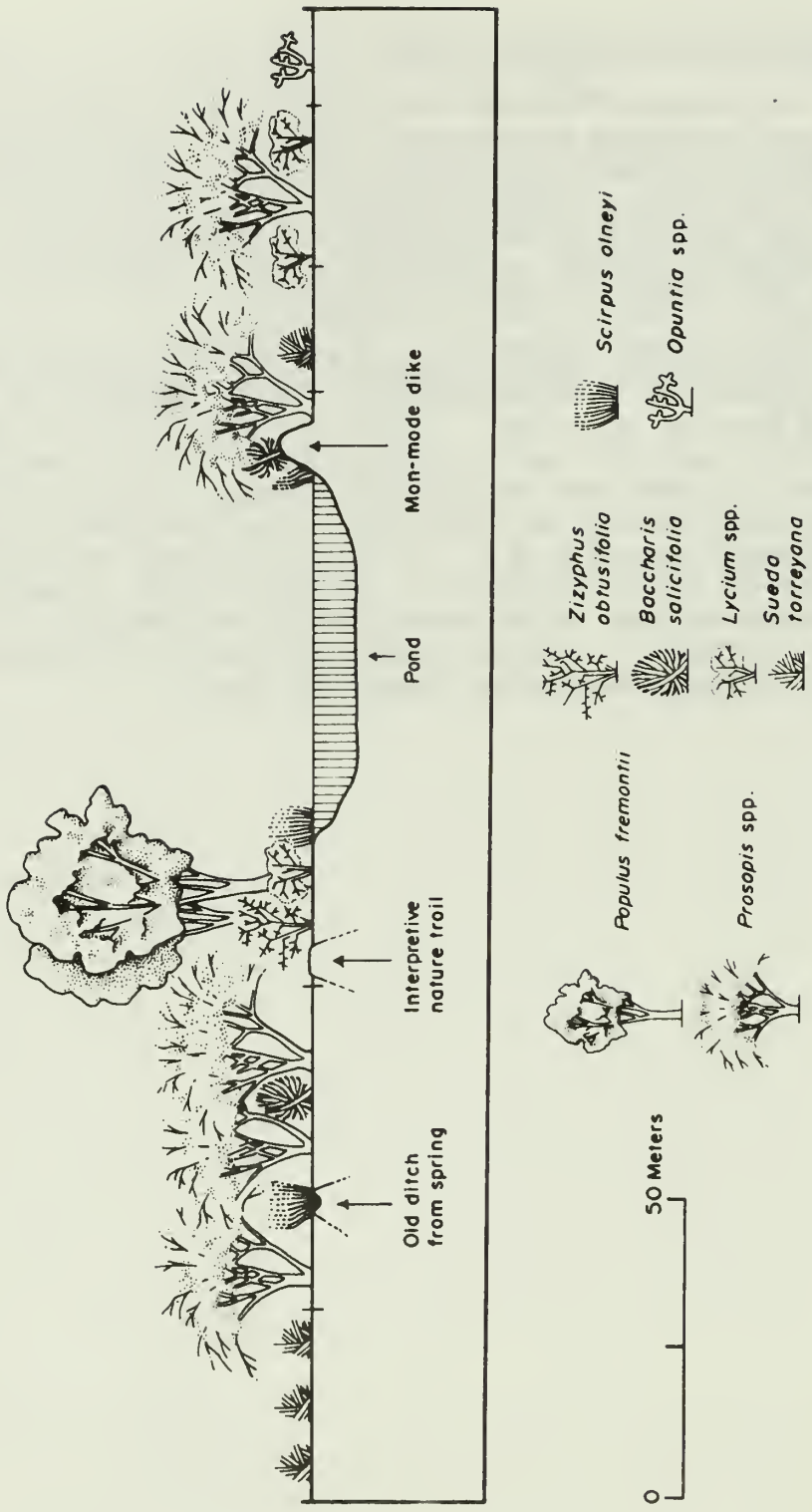

Figure 1. Cross section of riparian vegetation at Quitobaquito Springs oasis along a north south line drawn through the approximate center of the holding pond. The left side of the illustration is due north, while due south is to the right. This is a simplified portrayal of the vegetative structure present in the summer of 1983.

METHODS

Woody riparian vegetation was measured at two study plots around the pond at Quitobaquito Springs (Fig. 2) in the spring and summer of 1983. The study plots had a combined area of 1.7 ha: the study plot to the south of the pond encompassed 0.88 ha, while the plot to the north of the pond measured 0.82 ha. These plots included all of the woody riparian vegetation adjacent to the pond. Boundaries of the two plots were established at natural breaks in the dense riparian vegetation surrounding the pond.

The plots were subdivided into 12 smaller quadrats. Permanent stakes (iron reinforcing bars 45 cm long) were placed in the ground at major reference points on four permanent transect lines from which the quadrats were measured. Aluminum tags labelled with the transect number and distance along the transect were attached to each stake. Locations of quadrats, stakes, and transects are indicated in Figure 2.

The following measurements were taken on each woody plant greater than or equal to 1.8 m in height within the study plots: maximum height (nearest 0.3 m), maximum and minimum horizontal canopy dimensions (nearest 0.3 m), distance along the permanent transect (nearest 1.0 m), and perpendicular distance away from the transect (nearest 1.0 m). The last two measurements on actual plant location indicated the placement of each woody plant to within 1.0 m of the plant's actual locality relative to the permanent transects. This information provides baseline successional data on the vegetation of Quitobaquito Springs, data that will be useful for comparative purposes in the future. The actual plant location data has not been included in this report; instead, computer printouts of all the data have been placed on permanent file at Organ Pipe Cactus National Monument headquarters and at the Cooperative National Park Resources Studies Unit at the University of Arizona for future reference.

Canopy volume was calculated using the formula for determining the volume of an ellipse:

$$\text{volume} = 4/3 \times 3.14 \times \text{height}/2 \times \text{max. canopy dia.}/2 \times \text{min. canopy dia.}/2.$$

The minimum and maximum horizontal canopy values were each divided by half and then multiplied to obtain the values called for in the original formula:

$$4/3 \times 3.14 \times \text{height}/2 \times (r_1 \times r_2),$$

or:

$$4/3 \times 3.14 \times a \times b \times c.$$

Species names conform to those indicated by Lehr (1978). Common names are those given by Lehr (1978) and Kearney and Peebles (1960).

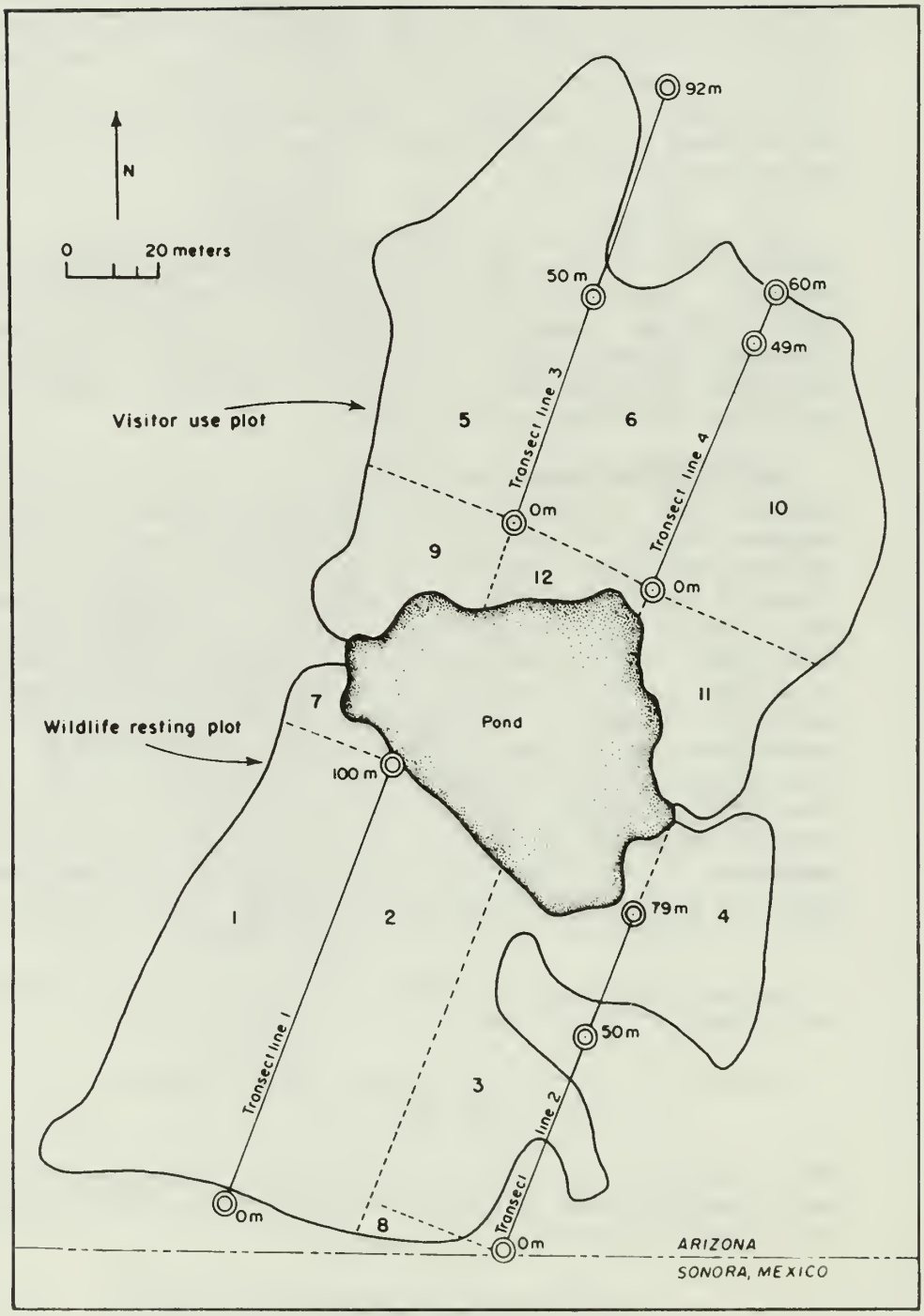

Figure 2. Location of the two study plots at Quitobaquito Springs oasis. Circled points represent the locations of permanent stakes marked with the distance of each along the roughly parallel transect lines. Dashed lines show the unstaked boundaries between the 12 individual quadrats.

RESULTS AND DISCUSSION

Diversity and Frequency of Woody Species. Woody riparian plants that were encountered in the study plots are indicated in Table 1. The absolute and relative frequencies (percent) and density/ha of these species are listed in Table 2. Mesquite dominated the vegetation of both study plots, as well as the overall oasis. The frequency and density of mesquite in the south plot, however, were greater than in the north plot. In contrast, the proportion of gray-thorn was much greater on the north plot. In spite of these few differences, the vegetative density of both plots was similar.

The diversity of tree and shrub species was greater on the south plot (Table 2): 18 species were present on the south plot, while only 12 were present to the north. This difference was largely due to the presence of three introduced shrubs on the south side, including pomegranate, common fig, and tamarisk. Other native shrubs occurring only in the south plot were cattle spinach, wire lettuce, and bitter condalia, all of which were rare. There were no species which occurred only in the north plot.

Vegetation Height. The mean and range of vegetation heights by species are presented in Table 3. Mean height of all vegetation in the north plot was significantly greater than that of the south plot, this difference was largely due to two factors. First, mesquite had a significantly greater mean height on the north side, and second, there were more large cottonwoods on the north side (Table 2). The mean height of shrubs was greater on the south side due to the presence of significantly higher wolfberry and gray-thorn in that plot. Figure 3 illustrates the occurrence of woody plants by height classes and the contribution made to each by mesquite.

Vegetation height serves to identify age classes of species such as cottonwood, whose height roughly correlates to its age in earlier stages of development. The absence of cottonwood seedlings and saplings (Table 3) indicated a lack of cottonwood regeneration at the oasis. All cottonwoods in 1983 were mature female individuals; seeds produced were probably not viable due to the lack of males at the site. At some point in the future, living cottonwoods may no longer be a component of the area's vegetation unless plantings are made or other means of propagation undertaken.

Canopy Volume. Canopy volume values are listed by species and plot in Table 4. The total volume figures for both sides of the oasis were similar, considering the nearly identical size of the plots. However, the distribution and spatial arrangement of canopy volume differed between the two plots (Fig. 4). Mesquite was the most important contributor to total canopy volume at the

TABLE 1. Common and scientific names of woody riparian vegetation over 1.8 m in height in the two study plots at Quitobaquito Springs oasis, Organ Pipe Cactus National Monument.

Scientific Name	Common Name
Prosopis velutina	mesquite
Lycium spp.	wolfberry
Zizyphus obtusifolia	gray-thorn
Baccharis salicifolia	seep willow
Punica granatum*	pomegranate
Isocoma acradenia	alkali goldenbush
Suaeda torreyana	desert sheepweed
Prosopis pubescens	screwbean mesquite
Sarcostemma cynanchoides	climbing milkweed
Atriplex polycarpa	cattle spinach
Populus fremontii	Fremont cottonwood
Salix gooddingii	Goodding willow
Ficus carica*	common fig
Atamisquea emarginata	atamisquea
Larrea tridentata	creosote bush
Tamarix chinensis*	tamarisk
Stephanomeria sp.	wire lettuce
Condalia globosa	bitter condalia

*introduced species

Table 2. Density, diversity, and frequency of tree and shrub species at Quitobaquito Springs oasis, Organ Pipe Cactus National Monument

Species	SOUTH PLOT No.	%	Density /ha.	NORTH PLOT No.	%	Density /ha.	BOTH PLOTS No.	%	Density /ha.
Prosopis velutina	481	70.0	546	319	54.0	384	800	62.5	470
Lycium spp.	97	14.1	110	104	17.6	125	201	15.7	118
Zizyphus obtusifolia	21	3.1	24	103	17.4	124	124	9.7	73
Baccharis salicifolia	27	3.9	31	21	3.6	25	48	3.8	28
Punica granatum	19	2.8	22	–	–	–	19	1.5	11
Isocoma acradenia	2	0.3	3	15	2.5	18	17	1.3	10
Suaeda torreyana	4	0.6	5	10	1.7	12	14	1.1	8
Prosopis pubescens	5	0.7	6	6	1.0	7	11	0.9	6
Sarcostemma cynanchoides	8	1.2	9	2	0.3	2	10	0.8	6
Atriplex polycarpa	8	1.2	9	–	–	–	8	0.6	5
Populus fremontii	1	0.1	1	5	0.8	6	6	0.5	3
Salix gooddingii	2	0.3	3	4	0.7	5	6	0.5	3
Ficus carica	4	0.6	5	–	–	–	4	0.3	3
Atamisquea emarginata	2	0.3	3	1	0.2	1	3	0.2	2
Larrea tridentata	1	0.1	1	1	0.2	1	2	0.2	1
Tamarix chinensis	2	0.3	3	–	–	–	2	0.2	1
Stephanomeria sp.	1	0.1	1	–	–	–	1	0.1	1
Condalia globosa	2	0.3	3	–	–	–	2	0.2	1
TOTALS	687	100%	785	591	100%	710	1278	100%	750

Table 3. Vegetation height by species of woody riparian vegetation in two study plots, Quitobaquito Springs oasis, Organ Pipe Cactus National Monument.

SPECIES	SOUTH PLOT No.	SOUTH PLOT Mean Ht.(m)	SOUTH PLOT Range (m)	NORTH PLOT No.	NORTH PLOT Mean Ht.(m)	NORTH PLOT Range (m)	BOTH PLOTS No.	BOTH PLOTS Mean Ht.(m)	BOTH PLOTS Range (m)
Prosopis velutina	481	3.5	1.8-7.0	319	4.0**	1.8-7.6	800	3.7	1.8-7.6
Lycium spp.	97	2.3+	1.8-4.3	104	2.1	1.8-4.0	201	2.2	1.8-4.3
Zizyphus obtusifolia	21	3.4+	1.8-4.9	103	2.9	1.8-6.1	124	3.0	1.8-6.1
Baccharis salicifolia	27	2.4	1.8-3.4	21	2.7	1.8-4.6	48	2.5	1.8-4.6
Punica granatum	19	3.0	1.8-4.3	-	-	-	19	3.0	1.8-4.3
Isocoma acradenia	2	1.8	1.8	15	2.0*	1.8-2.8	17	1.0	1.8-2.0
Suaeda torreyana	4	2.0	1.8-2.1	10	1.8	1.8	14	1.9	1.8-2.1
Prosopis pubescens	5	3.7	1.8-4.5	6	4.3	2.1-5.5	11	4.1	1.8-5.5
Sarcostemma cynanchoides	8	3.3	2.4-4.8	2	3.2	3.1-3.4	10	3.3	2.4-4.8
Atriplex polycarpa	8	2.1	1.8-2.4	-	-	-	8	2.1	1.8-2.4
Populus fremontii	1	9.1	9.1	5	10.2	8.2-12.2	6	9.5	8.2-12.2
Salix gooddingii	2	2.9	2.1-3.6	4	4.2	2.4-6.1	6	3.7	2.1-6.1
Ficus carica	4	2.2	1.8-3.4	-	-	-	4	2.2	1.8-3.4
Atamisquea emarginata	2	2.9	2.4-3.4	1	2.8	2.8	3	2.8	2.4-3.4
Larrea tridentata	1	3.4	3.4	1	1.8	1.8	2	2.7	1.8-3.4
Tamarix chinensis	2	2.7	2.1-3.4	-	-	-	2	2.7	2.1-3.4
Stephanomeria sp.	1	1.8	1.8	-	-	-	1	1.8	1.8
Condalia globosa	2	4.3	3.7-4.9	-	-	-	2	4.3	3.7-4.9
TOTALS	687	3.2	1.8-9.1	591	3.4*	1.8-12.2	1278	3.3	1.8-12.2

* Mean height on north side greater than on south side (T-test, P less than 0.05.)
** Mean height on north side greater than on south side (T-test, P less than 0.001.)
+ Mean height on south side greater than on north side (T-test, P less than 0.05.)

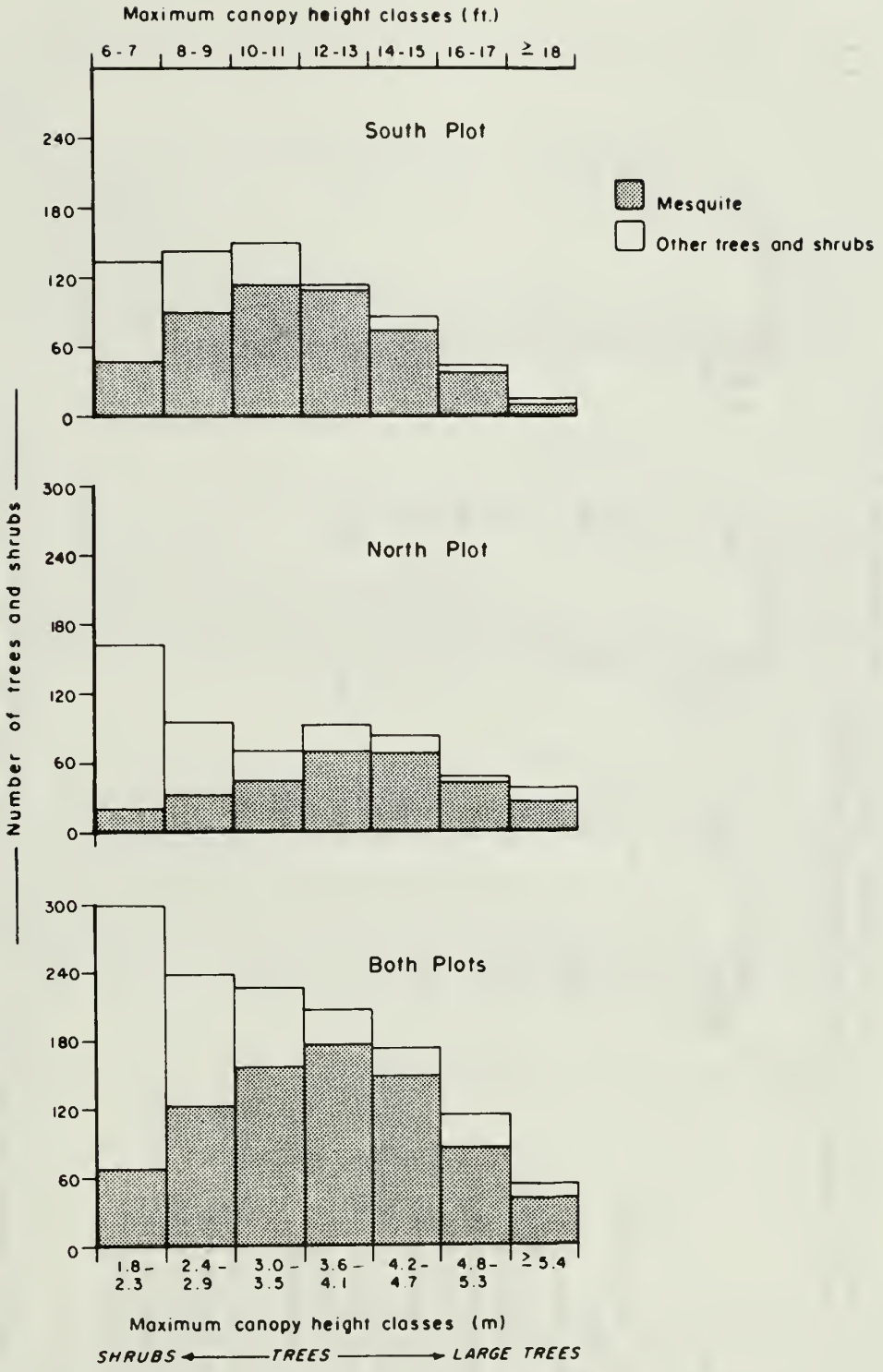

Figure 3. Distribution of riparian trees and shrubs by canopy height classes at Quitobaquito Springs oasis. Mesquite contributes significantly to the composition of each height class, with the exception of lower height classes comprised largely of wolfberry and gray thorn.

Table 4. Canopy volume of tree and shrub species at Quitobaquito Springs oasis, Organ Pipe Cactus National Monument.

Species	SOUTH PLOT Mean (m^3)	SOUTH PLOT Total (m^3)	NORTH PLOT Mean (m^3)	NORTH PLOT Total (m^3)	BOTH PLOTS Mean (m^3)	BOTH PLOTS Total (m^3)
Prosopis velutina	29	14,000	36	11,550*	31	25,550
Lycium spp.	7	711**	5	568	6	1,279
Zizyphus obtusifolia	10	225	9	968	9	1,193
Baccharis salicifolia	6	177	9	199	8	376
Punica granatum	15	291	-	-	15	291
Isocoma acradenia	2	4	3	55	3	59
Suaeda torreyana	2	9	2	22	2	31
Prosopis pubescens	23	117	29	174	26	291
Sarcostemma cynanchoides	11	93	10	21	11	114
Atriplex polycarpa	4	36	-	-	4	36
Populus fremontii	235	470	1385	6927	1056	7397
Salix gooddingii	12	24	53	214	39	238
Ficus carica	5	21	-	-	5	21
Atamisquea emarginata	12	24	6	6	10	30
Larrea tridentata	2	2	2	2	2	4
Tamarix chinensis	2	3	-	-	2	3
Stephanomeria sp.	1	1	-	-	1	1
Condalia globosa	7	13	-	-	7	13
TOTALS***	23	16,221	35	20,706	28	36,927

* Canopy volume on the north side is greater than on the south side (pooled variance T-test, two-tailed probability less than 0.05)

** Canopy volume on the south side is greater than on the north side (pooled variance T-test, two-tailed probability less than 0.05)

*** Means calculated from raw data, not from above total of means.

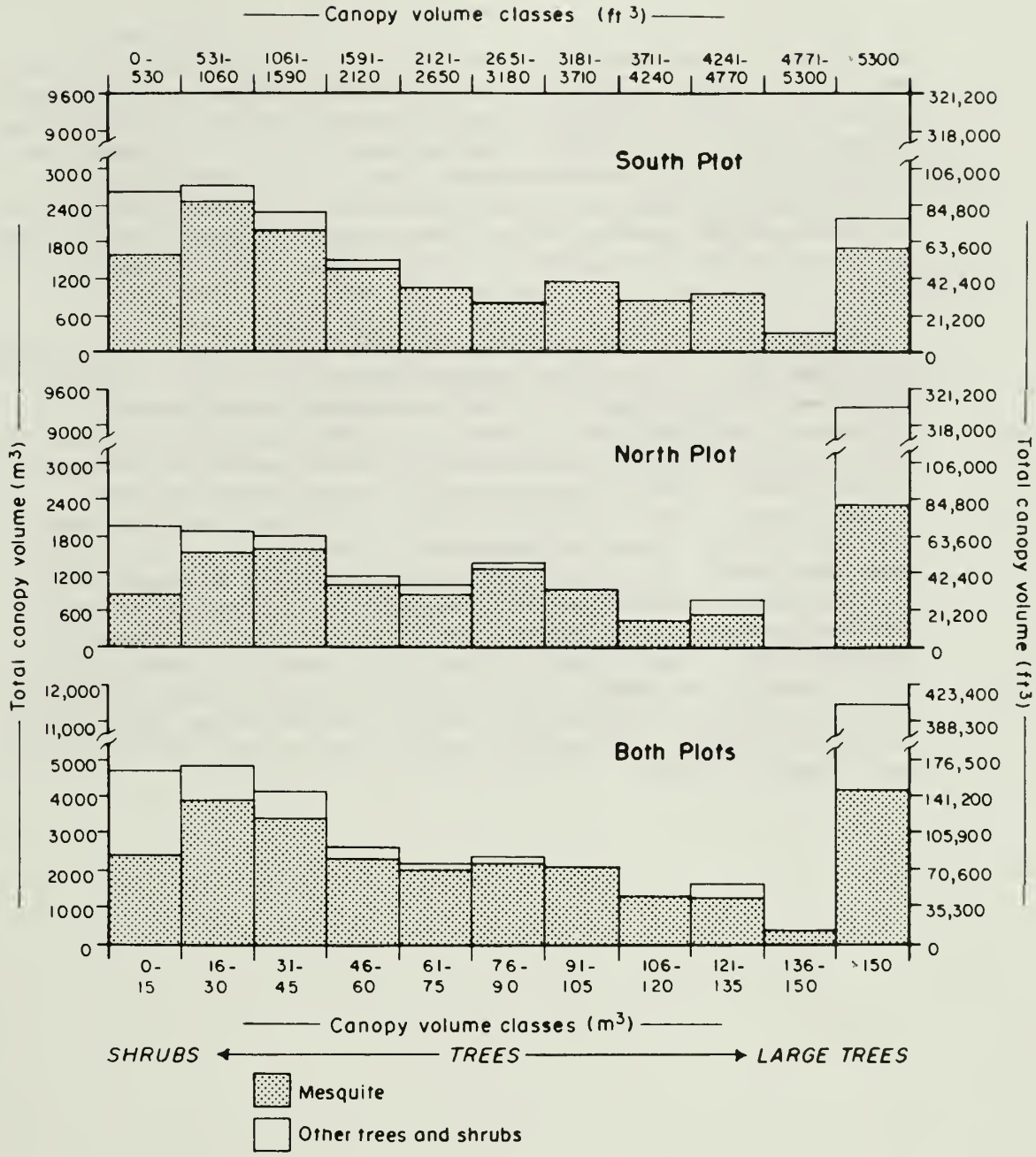

Figure 4. Distribution of canopy volume by size classes for riparian vegetation at Quitobaquito Springs oasis. The majority of canopy volume is present in the smallest and largest size classes of which mesquite is a major contributor. The large proportion of total canopy volume in the largest volume category on the north plot is due to several large cottonwood trees.

oasis, as it comprised well over half of the total in each plot. The canopy volume of mesquite on the north side was significantly greater, however. Wolfberry contributed a smaller, but important amount of the total canopy volume of each plot. Its volume was significantly greater on the south side. Both cottonwood and gray-thorn exhibited a greater total volume on the north plot due to their greater density there. Mean canopy volume, an indicator of the relative size of woody plants, was greater in the north plot.

Canopy volume is an important aspect of the overall vegetative structure for certain animal groups, especially birds. Canopy volume at different levels above the ground is important in increasing the structural diversity of the area and increasing resources such as nesting and foraging sites for birds (Johnson et al. 1983). Cottonwoods were major contributors to canopy volume between 6 and 12 m at the oasis, although mesquite dominated the overall canopy volume when all levels above the ground were considered. The canopy volume exhibited by a single large cottonwood was substantial when compared to the volume of surrounding mesquite individuals (Table 4). Although cottonwood comprised only a small part of the total number of woody plants of the oasis, its canopy volume contribution was large in proportion. Cottonwoods made up less than 1% of the total individuals in the north plot, for example, while they contributed 25% of the total canopy volume.

CONCLUSIONS

This report documents the vegetative structure and woody plant species composition of two study plots at Quitobaquito Springs oasis in 1983. The vegetation of the oasis has changed greatly in historic times. This change has resulted in a large increase in the amount of woody riparian vegetation present around the pond. Vegetation around the pond was characterized by a relatively even-aged, homogeneous woodland and scrubland dominated by mesquite. Most of this vegetation has developed on areas which were, prior to 1950, relatively open, or even devoid of woody vegetation. The dynamic process of vegetative succession can be expected to cause further changes in the appearance, diversity, and structure of the woody vegetation at the oasis. This report provides a point-in-time description and analysis of the vegetation that will be useful in future successional studies.

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