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PAPAGO INFLUENCES ON HABITAT AND BIOTIC DIVERSITY: QUITOVAC OASIS ETHNOECOLOGY

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ABSTRACT.—Quitovac, Sonora, is an oasis and Papago Indian community in the U.S./Mexico borderlands, 54 km from an analagous oasis, Quitobaquito, in Organ Pipe Cactus National Monument. Comparison of the two sites provides insight into how traditional Papago subsistence and land use affects habitat and biotic diversity. Quitovac's springs and modified lagoon have been utilized by Papago farmers for centuries. Around these perennial water sources, Papago land and plant management practices created eight large scale and two small scale vegetation associations. These provided habitat for a diversity of plants, birds and mammals, many of which the Papago harvest for utilitarian or religious purposes. Over 138 species of plants, 14 mammals and 103 birds are documented from a 5 ha study site at the oasis. The concentration of utilized species in certain habitats clearly affects how these habitats are managed. Since the initiation of the study, however, a 125 ha area was cleared and levelled for irrigated agriculture. This has dramatically altered life at Quitovac.

INTRODUCTION

Native American influences on habitats and associated biotic diversity have been the subject of several, recent provocative essays (Linares 1976; Rea 1979; Emslie 1981). It has been hypothesized that the diversification of habitats associated with native agriculture has had a beneficial effect on faunal species richness, due to edge effect phenomena, increased insect and seed availability.

The values of diversified farmland habitats to fauna, and the potential edible or economic return to farmers, were active topics of research among American ecologists earlier in this century (see Dambach 1948). However, as agriculture has become more mechanized, larger fields of single crops with clean borders have taken the place of diversified family farms where the maintenance of cover crop borders, hedgerows, or windbreaks was not only practical but advisable (Burger 1978; Sampson 1981).

Despite the renewed interest in this topic from agricultural ecologists and ethnographers, there are few data with which to compare directly the richness of species (useful or otherwise) associated with native subsistence agricultural habitats with that found in nearby, uncultivated or modern cash crop agricultural ecosystems.

Through the Man and the Biosphere program, we have attempted to document qualitatively and quantatively the plant and wildlife diversity associated with various agro-ecosystems and comparable, uncultivated ecosystems in the Sonoran Desert. The habitat complex, and seed plant, bird and mammal diversity were surveyed at the Papago farming oasis of Quitovac, Sonora and at the similar Quitobaquito, Arizona in Organ Pipe Cactus National Monument, where cultivation has not occurred for over 25 years (Fig. 1). There are considerable differences in the biota associated with the sites. Since the two sites differ more in their management history than their physical character, we focus on Papago land use and subsistence practices at Quitovac which influence habitat and biotic diversity. We hope that this ethnoecological perspective on the last Papago oasis will aid in the archaeological and "natural" historical interpretation of other Sonoran Desert oases, as well as in their management. This study is also the most comprehensive treatment of the folk biology of the western Papago of Sonora, whose knowledge and uses of desert biota is in many ways different from the central Papago emphasized in Castetter and Underhill's (1935) classic work.

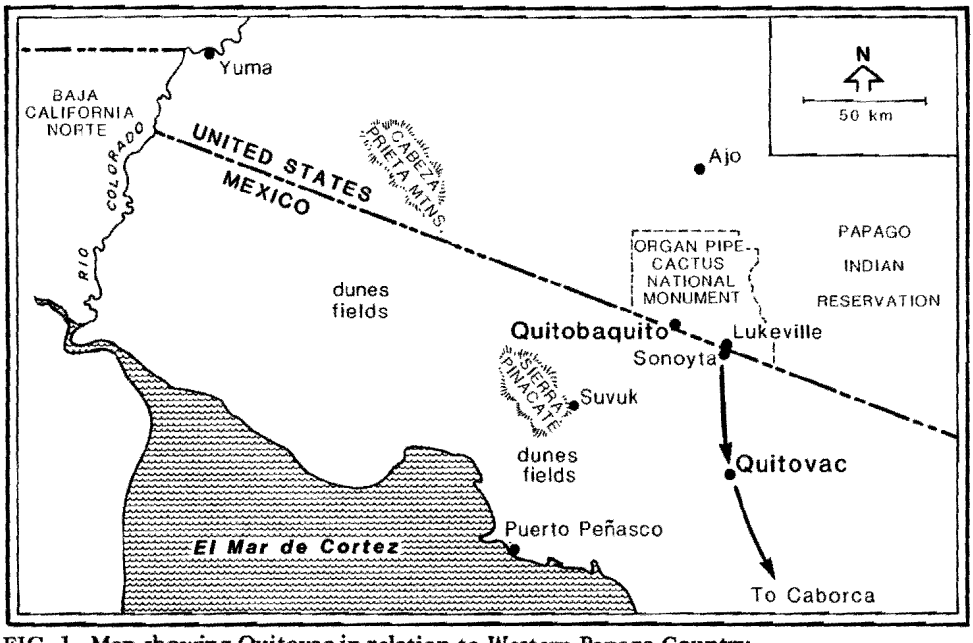

FIG. 1—Map showing Quitovac in relation to Western Papago Country.

THE STUDY AREAS

Quitovac is a spring fed oasis, at an elevation of 350 m, in the *municipio* of Puerto Peñasco, Sonora. It is found 41 km south-southeast of the Sonoyta-Lukeville border crossing, and 54 km southeast of Quitobaquito. Hastings and Humphrey (1969) reported its mean annual rainfall as 21.9 cm; it lies within the transition between the Lower Colorado and Arizona Upland vegetation subdivisions of the Sonoran Desert (Shreve 1951).

The presence of water deposited tufa and marl sediments, some of which contain calcified Rancholabrean megafaunal fossils, indicates that the springs of Quitovac have flowed for millenia. When Juan Manje visited the Papago at the site in 1694, calling it *San Luis de Bacapa,* and *Moicaqui* ('Soft Wash' in Papago), he described it as "close to a high peaked mountain at whose foot were some springs of water and some lakes" (Bolton 1948). In 1774, Anza described the site as "one of the best of all the *Papagueria,* because it has five springs of water . . . which they gather and use to irrigate some small pieces of

very sandy land where at most a half a *fanega* of maize can be planted . . . " (Bolton 1930). These observations indicate that Papago water control and agricultural management of Quitovac were well established prior to the introduction of Old World technology, draft animals, and crops.

Kino visited a Papago camp at another set of springs in 1698; his *San Serguio* is surely a site along the springs of the pre-Cambrian Quitobaquito Hills, on the present day U.S.-Mexico border. Kino did not explicitly mention a pond there, so some historians have assumed that one did not form until Anglos built a dam there in the 1860s. Others disagree, observing that the Papago improved springs and excavated basins elsewhere earlier; the Quitobaquito pupfish shows considerable divergence from Rio Sonoyta pupfish populations nearby, suggesting the antiquity of Quitobaquito pond habitat (Robert Rush Miller, pers. comm.). From the 1860s on, the presence of Papago pond-irrigated fields and orchards there are well known (Bell et al. 1980; Nabhan 1982). Organ Pipe National Monument was established in the 1930s, but the Papago continued farming and livestock raising there until 1957. The pond was then a 35 cm deep, swampy marsh edged by a grass flat, riparian trees and an orchard; it was ideal pupfish habitat (Robert Rush Miller, pers. comm.). In 1962, it was dredged to a 1-2 m depth, and has since been managed as a popular birdwatching area.

Not all Papago from the two oases consider themselves to be the distinctive Sand Papago—*(Hia C-ed O'odham*, 'In the Sand People'; *Hia Tadk Ku:mdam*, 'Sand Root Crushers'; or *S-'O'obmakam*, 'Apache-like Papago'). However, after an 1851 yellow fever epidemic, some surviving Sand Papago families moved out of the Pinacate region to these nearby oases, or to other western Papago settlements (Bell et al. 1980). At any rate, the Sand Papago regularly visited Quitovac historically, and shared with the people there the use of a number of plants and animals not found elsewhere in *Papagueria* (Nabhan 1980). Since the 1850s, a rain and cactus harvest ceremony called the *Vi'igita*, originally performed among Sand Papago in the Pinacate region to the west, has been observed at Quitovac (Davis 1920; Ives 1936; Bell et al. 1980). Within the following notes on the uses of biota, many of the religious uses are those associated with the *Vi'igita.*

Linguistically, the Quitovac Papago may be intermediate between the *Hia C-ed O'odham* and other *Tohono O'odham.* They regularly use the fricative [v] in certain sound environments where most Papagos make a sound closer to the English [w], and occasionally utilize [t] in place of the more commonly used [c] ([ch] in English). Both of these allophones are believed to be proto-Piman (Hale, pers. comm.). We are using the Alvarez and Hale (1970) orthography for *Tohono O'odham,* but are substituting [v] for [w] to reflect the above-mentioned dialect difference.

Currently, 16 houses are maintained by Papago and Papago-*mestizo* families at Quitovac, but not all are lived in year-round. Population has ranged from 27 to 38 individuals since 1960. Papago simply call the place *Vak,* and *Quitovac* is rapidly being replaced by *Bak* as the officially-recognized name for the oasis and the recently established indigenous land reserve there.

METHODS

Study of the plant and bird life, and ethnobiology of Quitovac began in November 1979, and has focused on a 10 ha area surrounding the oasis pond. Through July 1982, 12 visits to the area were made for 2-4 day periods, during which a number of data collecting activities were accomplished. In August, 1981, a more formal comparison of Quitobaquito and Quitovac was initiated, using a 5 ha study site centered on the pond. The study methodology also was used for Quitobaquito as well, with exceptions as noted. Agricultural clearing at Quitovac in autumn, 1981, destroyed the habitat on approximately 3 ha of the study site. Consequently, vegetation transects begun in one area were extended to adjacent areas within the same vegetation associations, and only half the original 5 ha area was sampled for mammals.

Habitat mapping utilized February 1982 hand-held aerial photos taken by Peter Kresan, July 1982 vertical aerial photos taken by Vern Palmer, and a sketched map based on paced distances drawn by Nabhan in September 1980. These three data sources were combined in an attempt to reconstruct the extent of habitat areas prior to the autumn 1981 clearing.

Each of these mappable habitat units was described in terms of plant species, vegetative cover, lifeform mixture, soils and land uses. The project's plant ecologist (K.L.R.) visually discerned discontinua in the vegetative cover of the site. Each unit was sampled for perennials, 75 cm tall or more, via five 30 m line transects placed randomly from a baseline, and via 250 point frame hits for annuals and perennials shorter than 75 cm. Following Karpiscak (1980), cover values from these two methods, including both August 1981 and May 1982 point frame samples, were combined to express a percent of sampled distance with vegetative cover within each habitat. If species were sampled using both methods or during both seasons, the highest value was used. These coverage values were used as indicators of species importance for calculating the diversity (i.e., heterogeneity) of each habitat's vegetation, utilizing both the Shannon-Weaver and Simpson indices as described by Peet (1974). To calculate a plant species heterogeneity value for the entire site, species values within each habitat unit were multiplied by the fraction of the total site area occupied by that habitat, and summed.

Within each habitat unit, either a soil or water sample was taken from a 30 cm column below the surface, and analyzed by the University of Arizona Soils, Water and Plant Tissue Testing Laboratory, from which methodological details may be obtained. Lifeform descriptions follow Shreve (1951). Land uses were observed during visits, and further documented by interviews with local informants. In addition to plants found on vegetation transects, an inventory was made of all seed plant species found within the 5 ha site. Over 300 voucher specimens were collected over a four year period during all seasons, and most have been deposited in the herbaria of the University of Arizona and San Diego Natural History Museum. Nomenclature follows Lehr (1978), to which non-botanists are referred for common English names. Determination of species native or introduced to North America follows Shetler and Skog (1978).

Ethnobotanical interviews were made in Spanish, with Papago frames and lexemes occasionally used to reinforce questions. Although six Quitovac Papago and one Arizona Papago visitor contributed knowledge of plant names and uses, the bulk of the information was derived from the community elder, Luciano Noriego. Over a 3-year period, information was volunteered by Noriego while walking the site with us or while vouchers were being pressed. Additional plants observed directly in use by other residents were noted.

Birds found on the 5 ha site were surveyed during one two-day visit during each of four seasons, and the highest visual or audial count for each species over the two day period taken as the best population estimate. Dawn and dusk surveys of 2-3 hour durations, with extended time spent in dense canopy areas, were sufficient for most idenfifications and population estimates. Dove population projections were based on half hour morning counts. It was assumed that dove visitation to the lagoon occurred at a consistent rate, throughout the morning, with no more than one extended watering per bird each half day. Thus, the half-hour count was multiplied by 8 to estimate the total dove population. Linnaean taxonomy for birds includes recent revisions by Rea (in press).

Notes were taken regarding the habitats in which each bird species spent most of its time, but since few species utilize space for foraging strictly upon the lines of our mappable habitat units, certain habitats were combined (or collapsed) in our calculations. Simpson and Shannon-Weaver diversity indices were then calculated for these revised habitat groupings more useful in discussing bird foraging, and for each 5 ha site (Quitovac and Quitobaquito) as a whole.

Mammal data gathering included the nocturnal setting of Sherman live traps baited with a commercial grain mixture (millet, oat and wheat), the diurnal setting of snap

gopher traps, and the visual counts of larger mammals. The Sherman live traps were set in the evening to capture small nocturnal rodents; they were checked and closed the next morning. Trapping took place one night each in December, 1981, March, 1982, and two nights in May, 1982. Traps were set in a grid pattern with 12 m between traps in the same line, and 20 m between lines. At Quitovac, 100 traps were set on the irregularly-shaped undisturbed half of the study area. At Quitobaquito, 200 traps were set each night. For each season, the sites and the habitats within the Quitovac site were compared using the Simpson and Shannon-Weaver indices. The comparisons utilize (a) animal numbers and (b) animal biomass based on individual weights in grams at the time of trapping. Identifications were made in the field utilizing Cockrum (1960), with vouchers collected and identifications confirmed for trapping mortalities. Linnaean taxonomy for mammals follows Hall (1981), with the exception of *Dama*, for which we retain *Odocoileus*.

Interviews on bird and mammal knowledge and uses were occasional throughout the study, but also included 3-4 hours of taped interviews in May 1982 with Luciano Noriego and his grandchildren. A scrapbook of photos or drawings of most bird and mammal species potentially present in the vicinity was shown to Noriego, with explanations of calls, behavior or eating habits discussed. Additional data on animal use come from inspecting hunted carcasses gathered by Papago youth, and from accounts of the Papago *Vi'igita* ceremony.

RESULTS

Through autumn, 1981, Quitovac was a traditional Sonoran Desert farming oasis which included eight large scale (mappable) vegetation associations, and two small scale vegetational features worthy of note (Fig. 2). The mapped vegetation associations provided one element of our descriptions of habitats. Soils, lifeform and seed plant species diversity, and land uses were also noted (Table 1). The two small scale associations, were (a) man-made ditches running into the orchard and field dominated by *Cyperus, Anemopsis, Heliotropium* and *Rumex;* and (b) living, fieldside fence rows including intentionally planted *Salix, Tamarix, Sambucus, Opuntia* and *Prosopis,* which had associated with them piled brush and self-sown *Ambrosia, Bebbia, Olneya,* and *Cercidium.*

These small scale features are best considered part of the diverse field/orchard complex in the south-center of the study site. In both diversity indices based on plant coverage data, the cultivated field is the most heterogeneous vegetation association, and the orchard the second most. The Shannon-Weaver index is typically most sensitive to changes in the importance of rare species in the sample, and the Simpson index to common species (Peet 1974). These cultivated habitats make up less than 10% of the area of the study site, which is important in the interpretation of whole-site diversity index comparisons of Quitovac and Quitobaquito. Because each habitat's coverage values are "weighted" by the percentage of the 5 ha upon which that habitat exists, and Quitovac's cultivated habitats are so relatively small in area, their influence is "diluted" in our whole site calculations. The contrasts between Quitovac's whole-site plant diversity values (.971, Shannon-Weaver; .813, Simpson), and those for Quitobaquito (.822, Shannon-Weaver; .764, Simpson) nevertheless suggest that Quitovac has more diverse vegetation. (Note that the higher the diversity index value, the higher the diversity or heteroteneity).

Floristically, there are considerably more plant species, genera and families represented at Quitovac than at Quitobaquito, no matter how large the areas examined are (Table 2). This is due in part to the number of domesticated species (17) intentionally cultivated within the Quitovac site, but cultivation contributes more than just intentionally sown plants to a flora. There are an additional 59 species of plants found in the field/orchard complex. Many of these can be considered "biologically [as] weeds which are evolutionary and ecological products adapted to survival in habitats disturbed by

FIG. 2–February 1982 oblique photo of Quitovac, four months after bulldozing (Pete Kresan, photo).

TABLE 1.—*Habitats at Quitovac, Sonora (5 ha study site).*

Location and % of total area	Soil or water characteristics	Dominant plant species (highest cover first)	Lifeform mixture	Diversity Indices: Shannon-Weaver	Simpson	Land Uses
A. Open water of lagoon and springs; 10% of area	Spring water: pH, 7.6; soluble salts, 689 ppm; EC x 10^3 1.10; NH_4-N, 0.10 ppm; K, 5.83 ppm	*Potamogeton pulvinatus* *Zannichellia palustris*	Submergent macrophytes and floating algae	–	–	Swimming; aquatic bird hunting; use of water for irrigation
B. Cultivated field of annual crops irrigated from pond and springs; 6.5% of area.	Sandy loam: pH, 8.4; soluble salts, 2121 ppm; EC x 10^3, 3.03; N, 3.75 ppm; P, 1.28 ppm; K; 1.15 meq/L	*Cynodon dactylon* *Cucurbita mixta* *Citrullus lanatus* *Ambrosia confertifolia*	Herbaceous weedy ephemerals, and perennials, plus crop annuals	.947	.856	Tillage, seed sowing, irrigating, and crop harvest, wild greens harvesting
C. Tufa mesa rimming the pond, and nearby scrubland, (including abandoned fields); 27.5% of area	Sandy loam: pH, 7.4; soluble salts, 994 ppm; EC x 10^3, 100; N, 32.13 ppm; P, 11.82 ppm; K, 2.27 meq/L	*Suaeda torreyana* *Prosopis velutina* *Lycium andersoni*	Open, mixed spinescent, drought-decidous and evergreen shrubs and trees	.526	.670	Wild fruit gathering; woodcutting; hunting and trapping
D. Cultivated orchard of irrigated fruit trees, and adjacent fieldside hedge; 2.5% of area	Sandy loam same as (B) cultivated field of annual crops	*Ambrosia confertifolia* *Ficus carica* *Sarcostemma cynanchoides* *Cynodon dactylon*	Broadleaf deciduous tree canopy with broadleaf deciduous shrubs, ephemerals and vines	.831	.818	Cultivated fruit harvesting; irrigation; wild and cultivated perennial transplanting; hunting
E. Ephemeral watercourse (arroyo) and adjacent uncultivated floodplain; 4.5% of area	Loamy sand: pH, 7.6; soluble salts, 504 ppm; EC x 10^3, 0.72; N, 10.2 ppm, P, 8.47 ppm, K, 1.26 meq/L	*Hymenoclea monogyra* *Lycium berlandieri* *Ambrosia ambrosioides*	Microphyllous shrubs, cacti, broadleaf shrubs, and few ephemerals	.514	.604	Grazing; hunting or trapping; cactus harvesting
F. Lagoon edge, shallow holding pond, and ditches, and spring to pond channels 15% of area	Silty loam: pH, 8.3; soluble salts, 6181 ppm; EC x 10^3, 8.83; N, 5.35 ppm; P, 8.23 ppm; K, 2.51 meq/L	*Typha domingensis* *Scirpus olneyi* *Distichlis spicata*	Emergent perennial reeds and grasses	.616	.736	Burning; grazing fiber gathering; medicinal plant gathering from ditches
G. Meadow-like flats with alkaline seeps; 34% of area	Sandy loam: pH, 9.1; soluble salts, 70, 427 ppm; EC x 10^3, 100.6; N, 6.32 ppm; P, 4.78 ppm; K, 31.48 meg/L	*Distichlis spicata* *Wislizenia refracta* *Heliotropium curassavicum*	Perrennial mat-forming grasses, few herbaceous root perennials and ephemerals	.089	.078	Grazing

human activity" (Bye 1981). We consider 18 of these species to be found at Quitovac only within the cultivated field/orchard complex. A complete flora of Quitovac is near completion, and will list each species by its habitats (Nabhan et al., in preparation). It is not surprising that more than 21 post-Columbian introduced species, in addition to 11 species of Old World domesticates, are part of the Quitovac flora, and are more numerous than at Quitobaquito today. These are primarily ephemerals that for millenia colonized fields, trails and roadsides in the Old World, before rapidly spreading through New World deserts (Naveh 1967; Young et al. 1972).

TABLE 2.—*Floristic Richness at two Sonoran Desert oases.**

	5 hectare study site at oasis-pond	8-10 hectare plains around oasis-pond	oasis, plains and closest hills
Quitovac, Sonora			
plant families	45 (41)	49 (42)	55 (44)
genera	115 (100)	131 (106)	139 (114)
species	139 (122)	158 (131)	172 (143)
Quitobaquito, Ariz.			
plant families	32 (30)	37 (35)	38 (36)
genera	71 (69)	92 (90)	101 (99)
species	80 (78)	104 (102)	118 (116)

*Includes only seed plants. Data for Quitobaquito are from Adams (1971); Bowers (1980); and Nabhan and Reichhardt, field notes. Data for Quitovac are from Nabhan, Reichhardt and Rea, (in preparation). Values in parentheses represent adjusted totals that exclude intentionally planted domesticated species.

Table 3 lists the 78 taxa named by Quitovac Papago in their local dialect, as well as the uses of these plants. Over 40 of these utilized species can be found in the field/orchard complex. Even recently introduced species such as *Brassica tournefortii* are utilized in a similar manner to edible greens of considerable antiquity in the region. Terming such a species a "native" subsistence resource is somewhat of a misnomer. Numerous Old World crops and weeds are well-integrated into Papago cuisine even at the agricultural margins of Papagueria. A detailed discussion of how particular plants are used will be included in the Quitovac flora (Nabhan et al., in preparation), but from the data included here it is clear that named and utilized species are largely concentrated in and affect the management of three habitats more than the others: the field, the orchard and the adjacent scrubland. These three habitats are "off limits" to grazing animals most of the time. Such plant uses appear to parallel those which western Papago practiced at Quitobaquito earlier in this century (Bell et al. 1980).

Bird life at Quitovac includes 103 species observed on the 5 ha site during our eight days of survey in 1981-1982. Table 4 indicates that during every seasonal visit, species richness was higher at Quitovac than at Quitobaquito. The diversity indices for the two sites do not show such a clear picture; each site had a more heterogeneous avifauna in two of the seasons. Table 5 shows considerable seasonal variation in bird diversity within each habitat at Quitovac. It appears that the field-orchard complex, and the adjacent microphyllous shrubs in the wash provide the habitats with the most consistent diversity from season to season.

TABLE 3.—*Folk taxa and uses of plants at or near Quitovac, Sonora*

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
'a'uḍ	*Agave deserti*	Desert Agave	food, (fiber?)	X			hills
'auppa	*Populus fremontii*	Cottonwood	(wood?)	X			C
'aciˇ vipinoi	*Opuntia leptocaulis*	Desert Christmas Cactus	food, med.	X			E
'adaviˇ	*Cucurbita digitata*	Finger-leaved gourd	(med.?)	X			E
babaḍ i:vakiˇ	*Heliotropium curassavicum*	Heliotrope	med.	X			B,D_2,F,G
bahidaj	*Carnegiea gigantea (fruit)*	Saguaro	food, relig.	X			E, hills
ban manzanilla	*Dyssodia concinna*	Fetid Marigold		X			C
ban vi:v	*Nicotiana trigonophylla*	Desert Tobacco		X			E
bi:bhiag	*Merremia dissecta*	Ornamental Vine		X	?		D
ce:miˇ	*Lophocereus schottii*	Senita	food	X			E, hills
ce:'ul	*Salix gooddingii*	Goodding Willow	relig.		X		D, F
ciolim	*Opuntia acanthocarpa*	Cholla	food	X			E
cucuvis	*Stenocereus thurberi*	Organpipe Cactus	food, wood	X			E, hills
cuhukkia	*Amaranthus palmeri*	Amaranth	food	X			B
cukud ṣoṣa	*Phoenix dactylifera*	Date Palm	wood			X	C
cuvi u:piˇ	*Solanum nodiflorum*	Nightshade		X			D_2, F
galnayu	*Punica granatum*	Pomegranate				X	C, D
gepiˇ	*Citrullus lanatus*	Watermelon	food			X	B
gisokiˇ	*Opuntia violacea*	Purple Prickly Pear	food	X			E
hadsetkam	*Petalonyx thurberi*	Sandpaper Plant		X			E
hakowaḍ	*Phorandendron californicum*	Desert Mistletoe		X			C, E
ha:l	*Cucurbita mixta*	Cushaw Squash	food			X	B
ha:nam	*Opuntia fulgida*	Jumping Cholla	food	X	X		D_1, E
ha:sañ	*Carnegiea gigantea (plant)*	Saguaro	wood, util.	X			E, hills
hauk 'u'us	*Bebbia juncea*	Sweet Bush		X			B, D
heña hetam	*Sapium biloculare*	Mexican Jumping Bean	med.	X			E, hills
hoi'idkam	*Olneya tesota*	Ironwood	wood, util.	X			E, hills
hu:ñ	*Zea mays*	Corn	food, relig.			X	E
'i:bhai	*Opuntia phaecantha (fruit)*	Prickly Pear	food	X			D_1, E
'i:hug	*Proboscidea parviflora*	Devil's Claw	(util.?)	X			B
'i:svig	*Echinocereus fasciculatus*	Hedgehog Cactus	food	X	?		C (off area)
'i:watod	*Hymenoclea monogyra*	Burro Brush	"wood"	X			E
jiavul	*Ferocactus covillei*	Barrel Cactus	food	X			E

TABLE 3.—*Folk taxa and uses of plants at or near Quitovac, Sonora* (Continued)

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
kaṣvañ	*Trianthema portulacastrum*	Horse Purslane	food	X			B, C
kauk kuavul	*Condalia globosa*	Bitter Condalia	?	X			C
kek cehedagĭ	*Cercidium microphyllum*	Foothill Palo Verde	food	X			E (off area)
komagĭ 'u'us	*Tessaria sericea*	Arroweed	fiber, util.	X			F (off area)
ko'okomaḍk,kalisp	*Cercidium floridum*	Palo Verde	food	X			D_1, E
kotadopĭ	*Datura discolor*	Jimson Weed	(relig.?)	X			B, C
kuavul	*Lycium exsertum*	Wolfberry	food	X			C
	Lycium berlandieri		(food?)	X			E
	Lycium parishii		(food?)	X			E
	Celtis pallida	Hackberry	?	X			C
kui	*Prosopis velutina*	Mesquite	util., (med.?)	X			
	Prosopis glandulosa		food, wood	X	X?		C, D, E
kujul	*Prosopis pubescens*	Screwbean Mesquite	food	X	?		C (off area)
ku'ukpalk	*Portulaca oleracea*	Purslane	food	X			B
milon	*Cucumis melo*	Melon	food			X	B
mo:stas	*Brassica tournefortii*	Mustard	food	X			D2
mu:mṣam	*Plantago insularis*	Wooly Plantain	forage	X			B
mu:ñ	*Phaseolus vulgaris*	Bean	food			X	B
nav	*Opuntia phaecantha (pads)*	Prickly Pear	food	X	X		D1, E
niatum	*Sphaeralcea coulteri*	Coulter Globe Mallow		X			C
nonakam	*Agave murpheyi*	Maguey	food, (fiber?)		X?		C (of area)
ñuñui je:j	*Ambrosia ambrosiodes*	Ragweed	(med.?)	X			D, E
'olas pilkañ	*Triticum aestivum*	Wheat	food, fiber			X	B
'onk i:vakĭ	*Atriplex elegans*	Saltbush	food	X			C
	Atriplex polycarpa		food	X			C
	Atriplex wrightii		food	X			B
	Chenopodium murale		food	X			C
'oñk 'u'us	*Tamarix aphylla*	Tamarisk	wood		X		C, D
'oñk vaṣai	*Distichlis spicata*	Saltgrass	forage	X			D, G
pa:lma	*Washingtonia filifera*	Desert Palm	wood	X	?		C, D
pu:hl	*Trifolium repens*	White Clover	food	X			B, D
s-cuk' oñk	*Suaeda torreyana*	Desert seepweed	(food?)	X			C
si:lantlo	*Coriandrum sativum*	Coriander	food			X	B

TABLE 3.—*Folk taxa and uses of plants at or near Quitovac, Sonora* (Continued)

Papago name	Scientific name	Common name	Uses	Wild Self-Sown	Wild Trans-plant	Domes-ticated & Sown	Habitats
siwol	*Allium spp.*	Onion	food			X	B, D
s-toa bavĭ	*Phaseolus acutifolius*	Tepary Bean	food			X	B
s-toa kuavul	*Lycium andersonii*	Wolfberry	food	X			C, D
su:na	*Ficus carica*	Fig	food			X	D
ṣegai	*Larrea tridentata*	Creosote Bush	med.	X			C, E
tahapidam	*Sambucus mexicana*	Elderberry	food, med.		X		D, F
tohawes	*Encelia farinosa*	Brittlebush		X			B, C
toma:di	*Lycopersicon esculentum*	Tomato	food			X	B
'uduvaḍ	*Typha angustifolia*	Cattail	fiber, food	X			F
'u:dvis	*Vitis vinifera*	Grape	food			X	D (off area)
'u:paḍ	*Acacia greggii*	Catclaw	?	X			C, E
'u:spaḍ	*Zizyphus obtusifolia*	Graythorn	food	X			C
vak	*Scirpus olneya*	Bulrush	relig.	X			F
vakvandam	*Rumex crispus*	Dock	?	X			D2, F
vapko	*Lagenaria siceraria*	Bottlegourd	util.			X	B (off area)
va:s	*Jatropha cinerea*	Limber Bush	fiber	X			E, hills
va:visa	*Anemopsis californica*	Yerba del Mango	med.	X			D2, F
vi:bam	*Sarcostemma cynanchoides*	Climbing Milkweed	gum	X			C, D, E
vihol	*Pisum sativum*	Pea	food			X	B
vipinol	*Opuntia arbuscula*	Pencil Cholla	food	X			E
vipisimal	*Justicia californica*	Hummingbird Bush		X			C, E

A = open water; B = cultivated field; C = mesa scrubland; D = orchard; E = arroyo; F = lagoon edge and channels; G = alkaline flats. D1 = fencerow. D2 = irrigation ditches.

TABLE 4.—*Avian species richness and diversity at two Sonoran Desert oases.*

Locality & Season	No. of species recorded (5 ha)	Diversity Indices	
		Simpson	Shannon-Weaver
Quitovac, Sonora			
August 81	52	.177	.238
Dec.-Jan. 81-2	21	.923	1.202
March 82	42	.960	1.513
May 82	70	.112	.174
Quitobaquito, Ariz.			
August 81	42	.787	1.080
Dec.-Jan. 81-2	18	.870	1.048
March 82	39	.747	.909
May 82	53	.797	1.122

TABLE 5.—*Avian species diversity by habitat at Quitovac, Sonora.*

Index & Habitat	August	Dec.-Jan.	March	May
Simpson				
A	.689	—	.759	.585
C	.924	.444	.790	.922
B&D	.772	.776	.925	.913
E	.747	.864	.840	.929
F&G	.137	.796	.881	.053
Shannon-Weaver				
A	.568	—	.721	.608
C	1.136	.276	.728	1.217
B&D	.878	.673	1.163	1.272
E	.670	.911	.881	1.203
F&G	.170	.826	1.020	.067

The open water (A) and pond fringe habitats (F and G) varied drastically from season to season. This was due in part to the autumn, 1981, draining and clearing of the lagoon. It was too shallow for any swimming waterfowl in January, 1982, and most pond fringe cover was removed. The pond was being utilized again by waterfowl by early spring and refilled to over 1.2 m deep by May.

Quitovac is attractive to a number of species of wading shorebirds in addition to waterfowl; these include some migrants and vagrants that have no muddy, open shoreline upon which to land at Quitobaquito. Quitovac also serves as a drinking place for much larger populations of columbiforms, particularly White-winged Doves, than does Quitobaquito. Both sites support a large number of "desert riparian" insectivores, including icterids, flycatchers, woodpeckers and wood warblers.

Table 6 presents data on 30 species of birds known to be named and/or utilized by the Papago at Quitovac. This is not a particularly large percentage of the local avifauna. The poor eyesight of our primary Papago consultant, as well as the limited time spent on interviews regarding birds, may contribute to this low number.

TABLE 6.—*Folk taxa and uses of birds at or near Quitovac, Sonora.*

Papago Name	Scientific Name	Common Name	Food	Relig.	Documented	
					On Site	Nearby
ba'ak	*Aguila chrysaetos*	Golden eagle		X		X
cem vahum	*Micrathene whitneyi*	Elf owl				X
ciwicuic	*Charadrius vociferus*	Killdeer			X	
cuhugam	*Dendrocopos scalaris*	Ladder-backed woodpecker			X	
cukud	*Bubo virginianus*	Great horned owl			X	
cuk vacuk	*Fulica americana*	American coot	X		X	
ge'e visag	*Pandion haliaetus*	Osprey				X
ge'e hawañ	*Corvus corax*	Common raven		?	X	
gi:dowal	*Progne subis*	Purple martin			X	
haupal	*Buteo jamaicensis*	Red-tailed hawk		X	X	
hewel mo:s	*Sayornis saya*	Say's Phoebe			X	
ho:hi	*Zenaida macroura*	Mourning dove	X		X	
ho:kud	*Campylorhynchus brunneicapillus*	Cactus wren				X
kakucu	*Callipepla gambeli*	Scaled quail	X		X	
kokova	*Athene cunicularia*	Burrowing owl				
ko:kud	*Ardea herodias*	Great Blue heron	X		X	
ko:logam	*Phalaenoptilus nuttalli*	Common Poor-will				X
ñui	*Cathartes aura*	Turkey vulture			X	
ñupud	*Chordeiles acutipennis*	Lesser night hawk			X	
si:pak	*Cardinalis* spp.	Cardinal, Pyrrhuloxia			X	
sasañ	*Agelaius phoeniceus*	Red-winged blackbird			X	
	Xanthocephalus xanthocephalus	Yellow-headed blackbird			X	
	Quiscalus mexicanus	Common grackle			X	
	Molothrus ater	Brown-headed cowbird			X	
	Molothrus aeneus	Bronzed cowbird			X	
su:g	*Mimus polyglottus*	Mockingbird			X	
tadi	*Geococcyx californianus*	Roadrunner			X	
toa u'uwhik	*Ardea alba*	White heron			X	
	Ardea thula				X	
tova*	*Meleagris gallopavo*	Turkey	X	X		X
va'akek	*Tyrannus* spp.?	Kingbirds			X	
vacukek	Anatidae	Ducks	X		X	
vahum	sp. in Strigidae or Tytonidae	Owls			?	
vakokam	*Icterus cucullatus*	Hooded oriole			X	
	Icterus galbula	Baltimore oriole			X	
vipismal	Trochilidae	Hummingbirds			X	

**Meleagris gallopavo* (turkey), though not now kept as a domesticated bird at Quitovac, is found at a nearby Sonoran Papago village.

TABLE 7.—*Folk taxa and uses of mammals at or near Quitovac, Sonora.*

Papago Name	Scientific Name	Common Name	Food	Relig.	Wild	Domestic	Reported On Site	Reaching Nearby
('alĭ)'u:phia	*Spologale putoris*	Spotted skunk			X			X
bain	*Canis latrans*	Coyote		X	X		X	
celkoli	*Spermophilus variegatus*	Rock squirrel	X		X			X
cu:avĭ	*Vulpes velox*	Kit fox			X			X
culk cu:vĭ	*Lepus californicus*	Black-tailed jackrabbit	X		X		X	
cu:soiñ	*Ovis canadensis*	Bighorn sheep	X		X			X
cu:vho	*Thomomys umbinus*	Pocket gopher			X		X	
dalhivo	*Dipodomys merriami**	Merriam's kangaroo rat			X		X	
ge:vo	*Lynx rufus*	Bobcat	X		X		X	
ge'eju koson	*Bassariscus astutus*	Ringtail	X	X	X			X
gogs	*Canis familiaris*	Dog				X		
hawañ	*Bos taurus*	Cattle	X			X		
holho'i	*Erethizon dorsatum*	Porcupine			X			X
hu:avĭ	*Odocoileus hemionus*	Mule deer	X	X	X			X
kaso	*Urocyon cinereoargenteus*	Gray fox			X			X
ka:vĭ	*Taxidea taxus*	Badger	X	X	X			X
kawiyu	*Equus caballus*	Horse				X	X	
kiñ's, misciñ ko:ji	*Dicotyles tajacu*	Javelina	X		X			X
ko:ji	*Sus scrofa*	Pig	X			X	X	
koson	*Neotoma albigula**	White-throated woodrat	X		X		X	
ku'wid	*Antilocapra americana*	Pronghorn	X	X	X			X
ma:vit	*Felis concolor*	Mountain lion			X			X
mu:la	*Equus caballus x E. asinus*	Mule				X	X	
nalhaggiu	*Peromyscus eremicus**	Cactus mouse			X		X	
	*Perognathus intermedius**	Desert pocket mouse			X		X	
narlakam	*Phyllostomatidae*	Leaf-nosed bats			X		?	
	Vespertilionidae	Vespertilionid bats			X		?	
selik	*Spermophilus tereticaudus*	Round-tailed ground squirrel			X		X	
si:kĭ	*Odocoileus virginianus*	White-tailed deer	X		X			X
toa cu:vĭ	*Lepus alleni*	Antelope jackrabbit	X		X		X	
to:bĭ	*Sylvilagus audobonii*	Desert cottontail	X		X		X	
'u:phia	*Mephitis mephitis*	Striped skunk			X			X
vavuk	*Procyon lotor*	Racoon			X			X

*Live-trapped in study site.

Waterfowl, doves and quail are the major bird foods utilized by Quitovac Papago. These are taken with .22 rifle, slingshot, or a trip-trigger deadfall box trap made of saguaro ribs, called a *kakast*. Feathers of several bird species are used ceremonially on staffs and prayersticks during the *Vi'igita*. These surely include Golden Eagle and turkey; probably Red-tailed Hawk and Great Horned Owl, and possibly raven. Unfortunately (for us!), some are painted bright colors, and others are old and misshapen from years of use, so that casual observation during the ceremony was not enough to confirm identifications noted in the literature (Cano-Avila 1979; Davis 1920).

The mammals which we consider to be present on Quitovac's 5 ha study site include the same four small rodent species live-trapped at Quitobaquito (see those marked with asterisks in Table 7); a trapped gopher; and nine other taxa observed during our visits. Five of these 14 species are domesticated mammals. The Papago report that 13 additional species can be found in nearby mountain ranges and valleys; particularly in times of drought, certain of these mammals may attempt to drink at the lagoon. Yet due to near-continuous human presence, we doubt whether mammals such as deer and javelina drink or browse at Quitovac as frequently as they do at Quitobaquito.

Although the same four rodent species were eventually trapped at both sites, trapping at Quitobaquito in December and March resulted in more species and individuals than at Quitovac (Table 8). Unfortunately, no trapping was done at Quitovac prior to the clearing; but mammal diversity was obviously less than at Quitobaquito in the first months following this habitat destruction. The May diversity indices based on mammal weights were higher for Quitovac, while those based on mammal numbers were higher for Quitobaquito. This is because packrats *(Neotoma)* contributed 70% of the weight of trapped mammals at Quitobaquito, but only 30% of the total number of individuals trapped.

Table 7 provides ethnozoological data on 31 mammal taxa occurring in the Quitovac vicinity which the Papago there name and/or utilize. Of the 15 taxa utilized for food, most are now shot with .22 rifle; it has been decades since bow hunting and on-foot drives were regularly used.

Of religious uses, the tail of the ringtail *(Bassaricus)* and many parts of the mule deer *(Odocoileus hemionus)* are apparently still utilized in the *Vi'igita*. We could neither confirm nor deny the *Vi'igita's* ceremonial enactment of killing other large mammals (such as pronghorn) in addition to mule deer, as Davis (1920) suggested.

Finally, dogs, horses, and cattle are ever-present at Quitovac, and in many ways limit the presence of other animals. Pigs and chickens as well as other domesticates are occassionally kept in the village, but their influence is not so obvious.

TABLE 8.—*Mammal species richness and diversity at two Sonoran Desert oases (based on live-trapping).*

Locality & Season	No. of species	Diversity Indices: Based on Weight		Based on Numbers	
		Simpson	Shannon-Weaver	Simpson	Shannon-Weaver
Quitovac, Sonora					
Dec. 81	0	—	—	—	—
March 82	1	0	0	0	0
May 82	4	.686	.545	.493	.410
Quitobaquito, Ariz.					
Dec. 81	1	0	0	0	0
March 82	4	.427	.332	.667	.477
May 82	4	.469	.393	.675	.532

CONCLUSIONS

Recently, human ecologists have hypothesized that native Americans formerly managed habitats in ways that encouraged diversity, resulting in benefits in environmental stability or food abundance and reliability (Nabhan and Sheridan 1977; Brush et al. 1981; Emslie 1981). The meaning of diversity, the best ways to measure it, and its relationship to environmental stability are all controversial among theoretical ecologists (Peet 1974, Murdoch 1975). Nevertheless, Altieri (1980) has demonstrated that in agricultural situations, there is clearly a positive correlation between plant diversity in fields, and stability with regard to vulnerability to animal pests.

Utilizing several measures of diversity, we have compared two oases: Quitovac, a "traditional" agricultural setting until the autumn, 1981 clearing in preparation for modern mechanized groundwater agriculture; and Quitobaquito, formerly much like Quitovac, but managed as a wildlife sanctuary in a National Monument since the late 1950s. Because of the removal of cattle and certain introduced plants, as well as the earlier cessation of farming, most Park Service managers would consider that Quitobaquito is undergoing secondary succession "back" to a more natural, perhaps more diverse, condition.

Yet when compared to Quitobaquito, Quitovac is more diverse in terms of plants, somewhat more diverse in birds, and not nearly as diverse in mammals, despite recent habitat disruption. The richness of biota at Quitovac has provided its inhabitants with a diversity of foods, medicines and ceremonial paraphernalia, over and above any cash crops produced there. At Quitobaquito, only dying figs and pomegranates, a few field weeds, and the outlines of ditches persist to suggest that additional species (and habitats?) may have been present a few decades ago. The implications of these differences should be well understood by archaeologists.

To fully explain the present differences between the two oases, it is necessary to consider Papago land use activities. Figure 4 illustrates subsistence-related land uses at Quitovac, some of which affect only target species, while others impact upon all species of one life-form, or a food chain based in a particular habitat. Since we feel that these activities account for the differences in biotic diversity between Quitovac and Quitobaquito more than do other historic or contemporary factors, we will discuss each activity in Figure 4 (according to its letters) in the context of both sites. The habitats in which these activities take place are shown in Figure 3 and described in Table 1. Some activities may take place in more than one habitat.

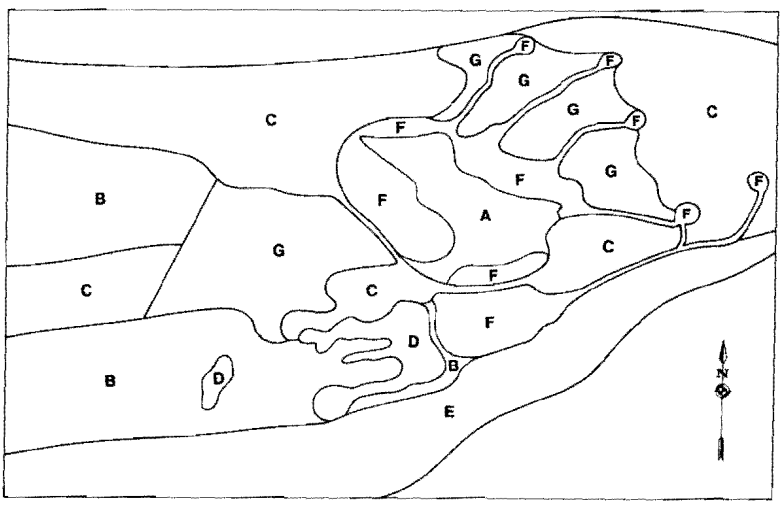

FIG. 3—Oblique map of habitats at Quitovac, reconstructing pre-August 1981 conditions, based on Figure 2.

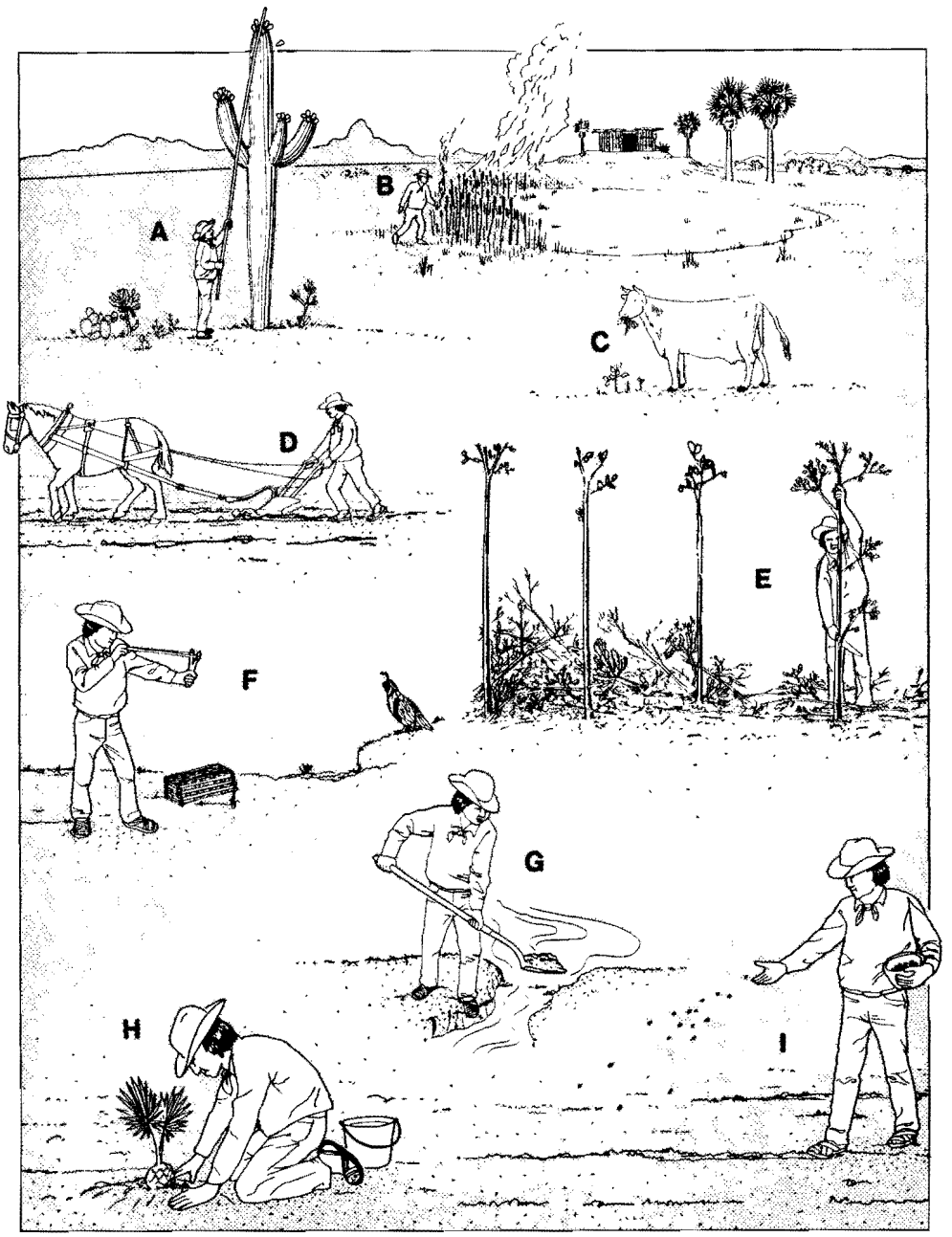

FIG. 4—Papago land uses affecting biotic diversity (see text for explanation). Illustration by Paul Mirocha.

At Quitovac, wild plant gathering occurs in the field as well as on the pond fringe and in the arroyo (A). Humans compete with birds for saguaro and wolfberry *(Lycium)* fruit; Davis (1920) reported that 120 gallons (454 l) of cactus wine was consumed at the *Vi'igita* alone. Since only a small percentage of the seeds produced naturally germinate in favorable sites, it is unlikely that wild fruit gathering reduces plant population sizes. Likewise, the wild greens (eg., *Chenopodium)* harvested are so abundant in good years and produce so many propagules that whole plant harvesting probably does not diminish populations.

The mosaic of disturbed soil, low shrub cover (fence rows and pomegranate bushes) and generally the greater availability of fruits and seeds (and presumably insects, which we did not monitor) at Quitovac promote larger numbers of grackles, Northern Cardinals, Pyrrhuloxia, Canyon Towhees, White-crowned Sparrows and certain transients such as Black-headed and Blue Grosbeaks. However, mistletoe and wolfberry fruits are more abundant, in season, at Quitobaquito. These are utilized by mimids, bombycillids, and several other semi-frugivorous groups.

Although intentional burning could locally-extirpate fire-susceptible species, it is largely practiced on the pond fringe (B). Emergent *Scirpus* and *Typha* stands with much accumulated dead standing crop are annually "cleaned out" at low water, in part so that newer tender shoots will be available to livestock. The plants regenerate, but the temporary openings between them provide habitat for rails, herons, and other wading birds.

Livestock grazing and browsing probably eliminates certain palatable species from the area altogether (C). Along channels from the springs to the lagaoon, Quitovac lacks the tender *Eustoma exaltam* and *Centaurium calycosum* found at Quitobaquito. Livestock disperse and "plant" seeds. They also compete with other mammals.

Plowing and other forms of periodic soil disturbance release the wild seed reservoir in the soil for germination (D). Some weed seeds, including *Amaranthus,* and *Proboscidea* have their dormancy broken by light exposure (Wiese and Davis 1967; Anderson 1968); a plow's superficial covering encourages germination. At Quitobaquito, due to lack of periodic soil disturbance, few ephemeral or weedy annuals germinate. Plowing also exposes invertebrates to blackbirds and grackles, that readily feed in open furrows (Carothers 1974).

The planting of living fence rows (E) provides field- and pond-edge borders that flycatchers (7 spp.) regularly utilize as perches from which to feed. The planting of *Salix*, *Prosopis* and *Tamarix* has provided some of the most intensively utilized habitat at Quitovac; at Quitobaquito, fewer *Salix* are regernating on their own. The brush woven between fieldside fence rows provides habitat for the few *Neotoma* at the Quitovac site.

Hunting and trapping, primarily of quail and dove, reduce population numbers only slightly today (F). Occasionally other, rarer bird species are killed with slingshots. Cottontails and jack rabbits are hunted around the fields, but their populations do not appear to be threatened.

Irrigation of selected areas (G) provides moisture to germinate and bring to seed numerous plant species. Plants such as *Anemopsis, Spergularia* and *Heliotropium* thrive in irrigation ditches. Flowing water, and increased humidity attract certain insects, and in turn attract birds (e.g., phoebes).

Transplanting and tending of domesticated perennials such as palms and figs provide Quitovac with its most diverse habitat (H). The shade, and multiple strata are heavily utilized by orioles, woodpeckers, cowbirds and migrating insectivores (flycatchers, vireos, and wood warblers). At Quitobaquito, the last dozen or so pomegranates and figs are dead or senescing, and palms have been removed.

Large carnivorous birds (families or flocks of Black Vultures, Turkey Vultures, Red-tailed Hawks, Harris' Hawks) were common and conspicuous throughout the day at Quitovac. They were attracted by several large dead or nearly dead cottonwoods formerly standing in open fields where the birds could drink and bathe. In spite of constant human activities, these large birds were quite at ease at Quitovac. In contrast, hawks and vultures only incidentally flew over the Quitobaquito oasis.

The large cottonwoods at Quitovac also attracted Purple Martins and several other swallow species. However, at Quitobaquito the immediate juxtaposition of open pond and mesquite bosque attracted much higher breeding and post-breeding populations of Phainopeplas than we found at Quitovac.

Finally, intentional seed sowing (I) provides grain, melons, legumes and forage utilized by humans and other animals. The only domesticated annual at Quitobaquito is safflower *(Carthamnus),* which is feral along roadsides in northern Mexico.

The dynamic habitats at Quitovac have provided food, water and shelter to humans and other lifeforms for centuries. Recently, however, much of this habitat was removed when 125 ha of land was cleared for groundwater irrigated agriculture. The project was promoted by governmental agencies to provide economic opportunities for Papagos. While Quitovac residents look forward to increased crop production in the future, to this date the development has not been completed due to political and economic problems. Residents clearly lament the unnecessary destruction of fence rows, abandoned houses, and other historic structures, as well as the disruption of the springs. Future pumping of groundwater will likely influence flow to the pond. Thus re-establishment of riparian habitat is questionable. As at Quitobaquito in the 1950s, sustainable, traditional agriculture, and the "wild" resources associated with it were not evaluated to any extent before a different course of management was initiated (Nabhan 1982).

Johnson et al. (1977) have argued that habitat destruction has contributed more to the post-1600 extinctions of 120 bird and mammal species than have hunting, trapping and other "direct causes." In doing so, Johnson and colleagues rightfully call for further efforts to protect "endangered" wild habitats. It may be worth considering that diverse agricultural habitats, including certain ones maintained by native American farmers for centuries, are also now endangered. It is unlikely that one could find environments more rare or more vulnerable than those found in desert oases like Quitovac or Quitobaquito. Their loss will affect not only the bird and mammal populations sustained by them, but may impoverish the life of the human community as well.

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