THE ISLAND AND COASTAL VEGETATION AND FLORA OF THE NORTHERN PART OF THE GULF OF CALIFORNIA[1]

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ABSTRACT: The flora and vegetation of the eight major islands on the eastern (Sonoran) side of the Gulf of California are summarized, with comments on the coastal vegetation of Sonora and the gulf coast of Baja California. In order of decreasing size, the islands treated are Islas Tiburón, San Esteban, San Pedro Nolasco, San Pedro Mártir, Dátil (=Turners), Alcatraz, Patos, and Cholludo. The major plant communities are classified and characterized. These are: *Seagrass Meadow*, *Littoral Scrub* (mangrove scrub and salt scrub), *Desertscrub* (coast scrub, creosotebush scrub, mixed desertscrub, cactus scrub, riparian desertscrub, and riparian *aguajes* or *tinajas*), and *Thornscrub* (plains thornscrub, foothill thornscrub, and riparian thornscrub).

Three major disjunct thornscrub regions occur at higher elevations towards the southern part of the Sonoran Desert: (1) on Sierra de la Giganta, Baja California Sur, (2) the mountains northwest of Guaymas, Sonora, and (3) on Sierra Kunkaak, Isla Tiburón. Shreve's *Foothills of Sonora* subdivision of the Sonoran Desert is reclassified as thornscrub rather than desertscrub.

Checklists given for vascular plants on each of the eight islands are expected to be nearly complete except for Isla Tiburón, for which we estimate about 85 to 90 percent of the flora is known to us. The numbers of species for the islands are 286 on Tiburón, 107 on San Esteban, 55 on San Pedro Nolasco, 23 on San Pedro Mártir, 99 on Dátil, 43 on Alcatraz, 10 on Patos, and 28 on Cholludo. A ninth island, Isla San Jorge, is without vegetation.

Islands on the eastern side of the Gulf of California show stronger floristic relationships with Baja California than do the islands on the western side of the Gulf with the Sonoran mainland. Seven species, or 2.1 percent of the flora of the eight Sonoran islands, are endemic to one or more islands in the Gulf. In this island series single-island endemics occur only on Isla San Pedro Nolasco. There are no known endemic plants on Isla Tiburón, largest island in the Gulf of California.

Within the overall positive relationship of number of species to island area there is considerable variation among the smaller islands. Island size, isolation, topographic and habitat diversity, aridity, absence or presence of vertebrate herbivores, and guano deposits seem to be major factors influencing the evolution and distribution of the flora and vegetation of the islands in the Gulf of California.

Only 4 non-native plant species have become established on these islands, indicating that the agency of man, both ancient and modern, has had minimal impact on the natural biota. This is a rare situation for our times; protection of the natural ecosystems on the islands in the Gulf of California would be of great value for the future.

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INTRODUCTION

In this report we discuss the vegetation of the islands in the northern part of the Gulf of California and of the adjacent coastline of mainland Sonora and peninsular Baja California, and summarize the flora and vegetation of the eight major islands of the east side of the Gulf of California. In order of decreasing size, the islands are Tiburón, San Esteban, San Pedro Nolasco, San Pedro Mártir, Dátil, Alcatraz, Patos, and Cholludo (Fig. 1). A ninth island, Isla San Jorge near the head of the Gulf, is without vegetation. This report is based on our investigations in northwestern Mexico during the past two decades.

Principal modern works dealing with the vegetation and flora of the Gulf of California region are Johnston (1924), Gentry (1949), Shreve (1951), Wiggins (1964), Felger (1966), and Hastings et al. (1972). Johnston (1924) and Lindsay (1955) provide excellent accounts of botanical explorations in the region, and biological investigations in Sonora and the adjacent islands are reviewed by Felger (1976-a).

Various systematic treatments encompassing diverse taxa in the region have appeared since publication of the *Flora of the Sonoran Desert* (Wiggins 1964), and nomenclatural changes resulting from these works are generally reflected in the comprehensive floristic listing given for each island in Table 1. (See pp. 33-53). Nomenclature given here represents our interpretation of the literature and specimens which we have studied. Many new records for the islands are reported in this paper. Several of the new records are based on populations discovered by Reid Moran of the San Diego Museum of Natural History, who has made extensive collections on the Gulf Islands.

There is a need for many taxonomic new combinations to reduce the number of artificial genera, species, and trinomials in the flora (Felger and Lowe 1970). With notable exception of such apomictic plants as *Opuntia fulgida,* we confine recognition of taxa below the species level to geographic races. Thus the distinction of variety versus subspecies is semantic rather than biosystematic.

VEGETATION OF THE NORTHERN GULF OF CALIFORNIA

Most of the geographic region treated here lies within the Sonoran Desert subdivision of the North American Desert (Shreve 1942, 1951). We also discuss the northernmost reaches of the semi-arid subtropical scrub (i.e., thornscrub) in western North America, which occurs at the southern margins of the Sonoran Desert. The flora is organized into several natural sets of distinctive communities, with life-forms and phytosociological relations similar to those of other subtropical and maritime ecosystems in arid and semi-arid regions of the world. Many of the terrestrial plant species and genera are peculiar to the North American Southwest, and specifically to the Pacific Subtropical West. Numerous others are shared between the Americas (see Johnston 1940; Solbrig 1972). The communities are natural

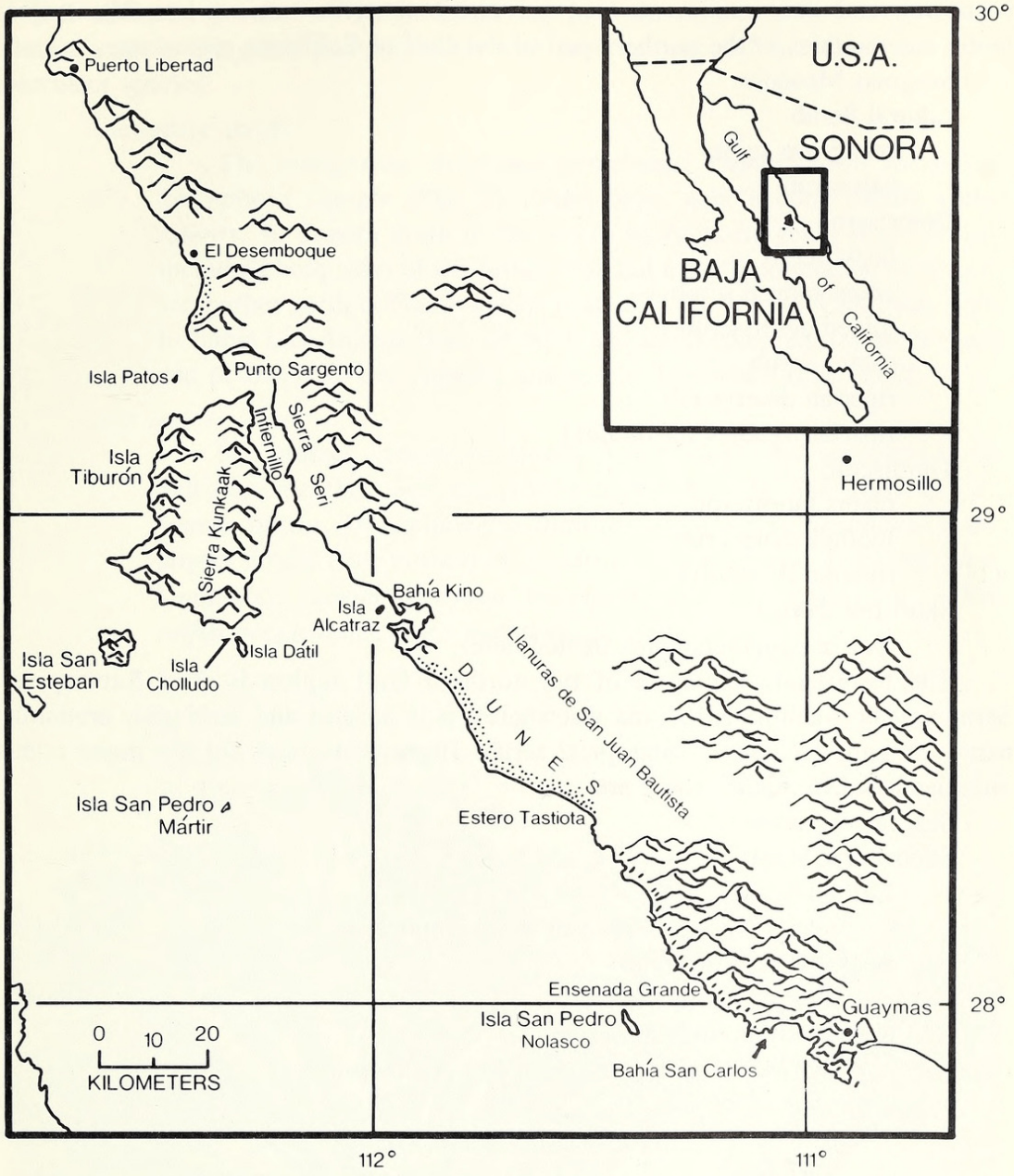

FIGURE 1. Central Gulf Coast of Sonora, and islands on the eastern side of the Gulf of California, Mexico.

biotic ones, but here, as elsewhere, the animals generally provide less critical information than do the plants for community delineation.

We find great variation in the community diversity in this region, which we attribute to the highly complex topography and correspondingly complex array of microenvironments. The major biotic communities are distributed as mosaics within a broader continuum from the littoral scrub of the tidelands across a highly varied desertscrub into the limited thornscrub of the better watered regions at higher elevations. The seagrass meadows are sharply differentiated from the adjacent tideland

vegetation and their microenvironmental distributions do not overlap. The major biotic communities of the northern part of the Gulf of California region are:

Seagrass Meadow
Littoral Scrub
    mangrove scrub
    salt scrub
Desertscrub
    coast scrub
    creosotebush scrub
    mixed desertscrub
    cactus scrub
    riparian desertscrub
    riparian *aguajes* (or *tinajas*)
Thornscrub
    plains thornscrub
    foothill thornscrub
    riparian thornscrub
Short-tree Forest
    (not in geographic area treated here).

The terrestrial vegetation of the northern Gulf region is Arid Subtropical Scrub (*sensu* Axelrod 1950, and elsewhere); it is an arid and semi-arid, predominantly drought-deciduous, subtropical scrub. Higher categories for the major communities listed in the foregoing are:

Seagrass Meadow
Subtropical Scrub
    Littoral Scrub
        mangrove scrub and salt scrub communities
    Arid Subtropical Scrub
        desertscrub communities
    Semi-arid Subtropical Scrub
        thornscrub and short-tree forest communities.

THE MAJOR COMMUNITIES

1. *Seagrass Meadow.*—Protected waters of the Gulf of California with muddy-sandy substrates at lower limits of subtidal zones, but mostly subtidal benthic zones to approximately 3 fathoms, and occasionally to approximately 5 fathoms: *Ruppia maritima* and *Zostera marina*. Northward about to the limits of the mangroves, with the most extensive seagrass meadows in the Canal del Infiernillo. For example, both species known from Bahía de Guaymas, Bacochibampo, and San Carlos, Estero Tastiota, and Canal del Infiernillo; *Zostera* from Bahía de la Concepción, several localities southward along the mainland to Altata, Sinaloa, and along the west coast of Baja California southward to Bahía Magdalena; and *Ruppia* from Bahía de la Paz (see Johnston 1924; den Hartog 1970; Felger and Moser 1973; and Felger and McRoy 1975).

2. *Littoral Scrub.*—Tidally inundated low scrub, halophytic vegetation, almost entirely evergreen and perennial, with predominance of succulent and semi-succulent species.

mangrove scrub

The mangroves: *Avicennia germinans, Laguncularia racemosa, Rhizophora mangle* (Fig. 2). Quiet bays, and lagoons locally called *esteros*. In Sonora north to the estero at Punta Sargento (Lat. 29°18′) including both sides of the Infiernillo, and a small population of *Avicennia* farther north at Puerto Lobos (Lat. 30°16′). In Baja California north to Bahía Las Animas (Lat. 28°50′), and small communities at the south end of Bahía de Los Angeles and nearby Isla Smith (Lat. 29°05′).

salt scrub

Salt grasses, halophytic shrubs (salt bushes), and succulent forbs. Salt-flats, beaches, and mangrove margins (Fig. 3). Salt grasses, e.g., *Jouvea pilosa, Monanthochloe littoralis, Sporobolus virginicus*. Halophytic shrubs (salt bushes), e.g., *Atriplex barclayana, Tricerma phyllanthoides, Suaeda torreyana*. Succulent herbs and shrubs, e.g., *Allenrolfea occidentalis, Batis maritima, Salicornia spp.*

FIGURE 2. White mangrove, *Laguncularia racemosa,* at low tide in Estero Sargento, Sonora. Note pneumatophore development of this solitary shrub.

FIGURE 3. Northeast side of Isla Alcatraz. Very sparse mixed desertscrub in foreground, with immature *Pachycereus pringlei (cardón), Lycium brevipes,* and *Viscainoa geniculata;* a single *Lemaireocereus thurberi* (organ-pipe) at lower right. *Amaranthus watsonii* nearly carpets the foreground. The low dense vegetation in background is salt scrub comprised largely of *Allenrolfea occidentalis.*

3. *Desertscrub.*—Covers most of the land surface of the northern Gulf region and is comprised of many distinctive communities. We classify the desertscrub of this region into six major community types, as follows:

coast scrub

Low monotonous coastal vegetation with few species, dominated by *Frankenia palmeri.* In Sonora from the head of the Gulf south to the vicinity of Punta Baja, and on Isla Tiburón.

creosotebush scrub

Simple communities dominated by *Larrea divaricata* (creosotebush). Widespread at the head of the Gulf, from near sea level to peak elevation on Sierra Pinacate. In the mid-Gulf, in the region of Isla Tiburón (Fig. 4) and the adjacent coast, occurring in limited zones at lower elevation, and to about 350 m on particularly dry slopes (e.g., Sierra Menor, Isla Tiburón). Near its southern limit in Sonora, in the vicinity of Guaymas, restricted to exposed low-elevation rolling hills

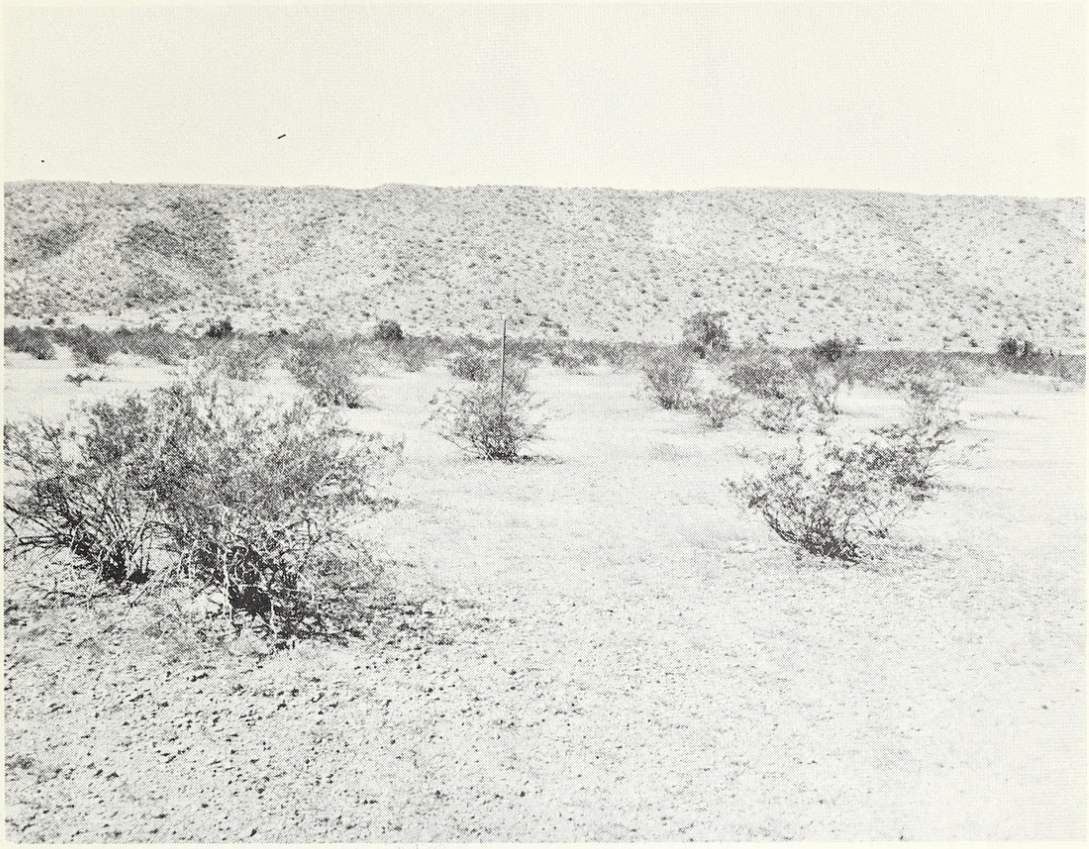

FIGURE 4. Creosotebush scrub *(Larrea divaricata),* Agua Dulce Valley, near center of Isla Tiburón. Lower slopes of Sierra Menor in background (looking west). The pole in center is 1.5 m tall.

and ridges; and at limited flatland sites south of Empalme, mostly on disturbed sites.

mixed desertscrub

The most widespread and characteristic terrestrial vegetation of the northern Gulf region (Figs. 3, 5, 6, 7). Highly varied in life-form of taxa, with numerous small-leaved and drought-deciduous shrubs and sub-shrubs. Seasonally rich development of ephemerals; each season with a different species spectrum although primarily differentiated into winter-spring and summer-fall sets. Dominance shared primarily by desert shrubs and small desert trees that comprise many distinctive, usually local community types. Representative species are:

Bursera microphylla
Cercidium microphyllum
Citharexylum flabellifolium
Colubrina viridis
Desmanthus fruticosus
Jatropha cuneata
Lippia palmeri
Pithecellobium confine
Ruellia californica
Viscainoa geniculata

FIGURE 5. Aerial view of the coastal bajada and dissected bluffs of the Infiernillo coast between Bahía Kino and Punta Chueca, Sonora, 1964. The relatively evenly spaced shrubs are mixed desertscrub. The watercourses here do not support distinct riparian vegetation.

cactus scrub

Dominance primarily or in part by columnar cacti, e.g., *Carnegiea gigantea, Lemaireocereus thurberi, Lophocereus schottii, Machaerocereus gummosus, Pachycereus pringlei, P. pecten-aboriginum*. Localized zones and regions primarily south of the vicinity of Puerto Lobos, Sonora, and on certain of the islands; particularly well-developed on Isla Cholludo (Fig. 8). Maximum regional development in coastal areas near the southern end of the desert. Often locally called *saguaral* (saguaro, *Carnegiea gigantea*) and *cardonal (cardón, Pachycereus pringlei)* (Fig. 9).

riparian desertscrub

Characterized by desert trees and shrubs peculiar to desert arroyos, washes, and their floodplains (Figs. 10, 11, 12). For example:

Acacia greggii
Ambrosia ambrosioides
Bumelia occidentalis
Cercidium floridum
Hymenoclea monogyra
Hyptis emoryi
Olneya tesota
Prosopis torreyana
Stegnosperma glandulosa
Vallesia glabra.

In addition, in desertscrub (e.g., creosotebush scrub), with less than about 125-150 mm (ca 5-6 inches) rainfall, many desert species

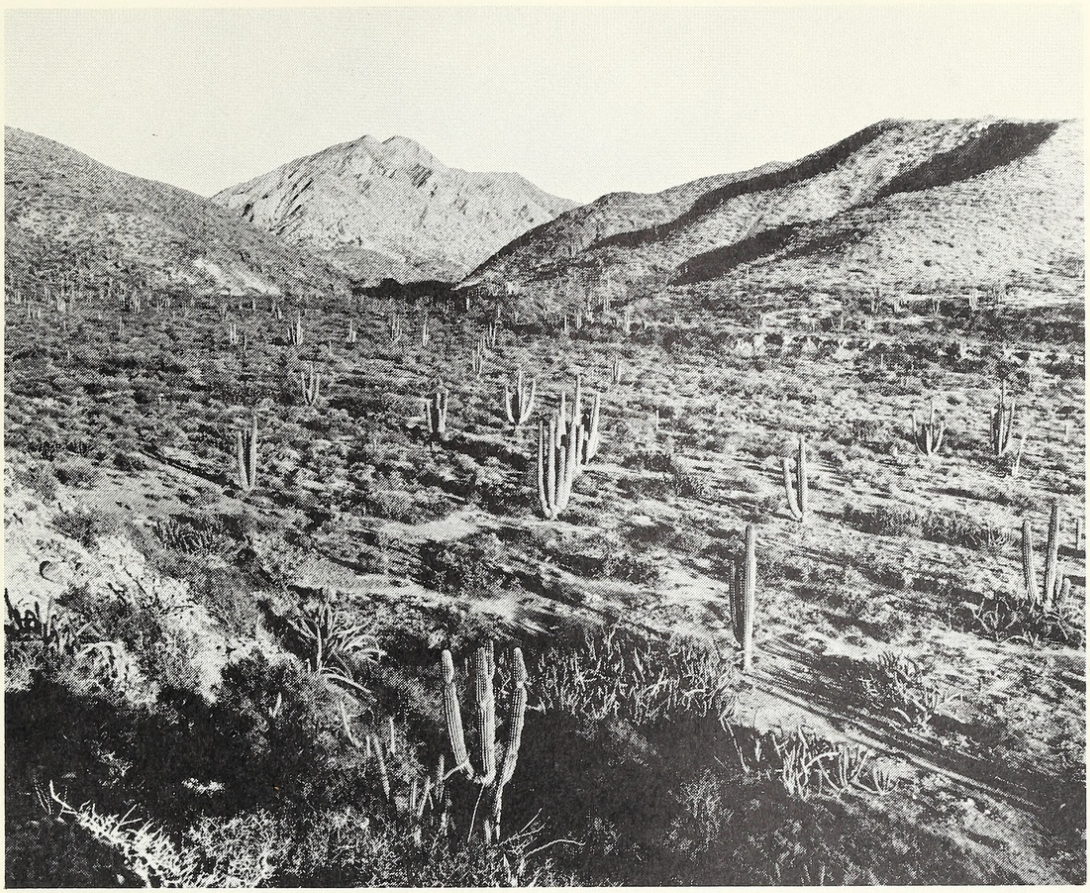

FIGURE 6. Arroyo Limantur, east side of Isla San Esteban. Sparse cactus scrub and mixed desertscrub elements, including *Pachycereus pringlei (cardón), Machaerocereus gummosus (pitahaya agria), Opuntia ciribe* (cholla), and *Atriplex barclayana.*

that are elsewhere non-riparian (e.g., *Cercidium microphyllum*) are often restricted to the dendritic (riparian) drainageways.

riparian aguajes, or *tinajas*

Desert fresh-water communities, usually highly localized at and near spring source "waterholes" that support the reed *Phragmites australis* and/or other spring supported species such as *Cyperus elegans, Eleocharis geniculata, Salix gooddingii,* and *Typha domingensis.*

Ecotones of Desertscrub and Thornscrub

In the area treated, particularly in its southern part, there are many ecotones between desertscrub and thornscrub. Some of the ecotones occur over relatively small areas that often involve local floodplains and arroyos. Others cover extensive areas of many hundred square kilometers. In fact, the entire arborescent subdivision of the Sonoran Desert, which Shreve (1951, p. 43) referred to as the Foothills of Sonora, is a broad inland Madrean foothill ecotone of thornscrub. It is situated between the Sonoran Desert proper and the more southerly Short-tree Forest (*sensu* Gentry 1942) of the coastal northwestern Mexican mainland (Felger 1976-2).

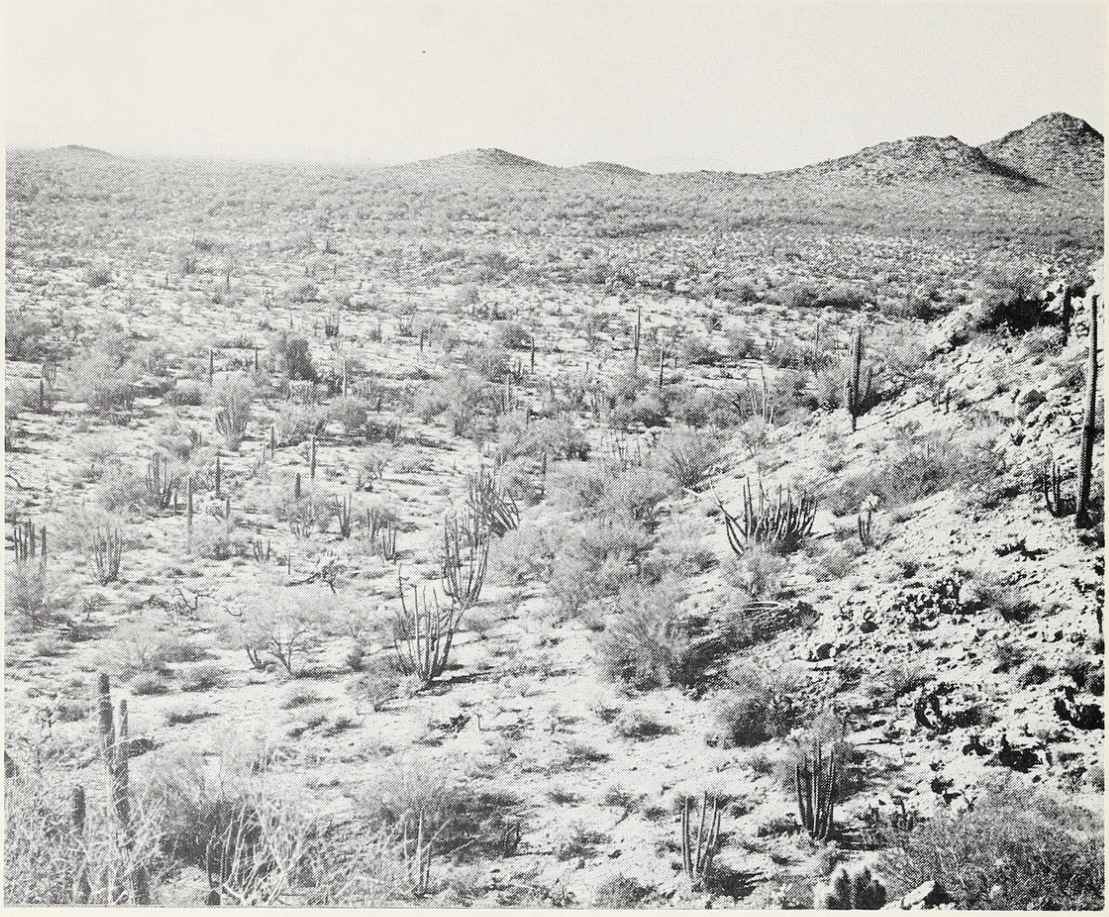

FIGURE 7. Mixed desertscrub and cactus scrub elements, ca 25 km inland from the vicinity of Puerto Libertad, Sonora. Prominent species here include *Cercidium microphyllum* (foothill palo verde), *Carnegiea gigantea* (saguaro), *Pachycereus pringlei (cardón), Lemaireocereus thurberi* (organ-pipe), *Lophocereus schottii* (senita), *Opuntia fulgida fulgida* (jumping cholla), and *Opuntia bigelovii* (teddybear cholla). Shallow arroyos or washes in center and background support poorly differentiated riparian desertscrub with *Cercidium microphyllum* and *Olneya tesota* (ironwood).

Within the Sonoran Desert proper, as restricted above, there are several areas of higher elevation with floristic and vegetative aspects of both thornscrub and desertscrub. Three of the principal ones are (1) north-facing slopes and higher elevations in the mountains northwest of Guaymas, between Bahía San Carlos and Ensenada Grande (=San Pedro Bay), Sonora, (2) Sierra Kunkaak on Isla Tiburón, and (3) intermediate elevations in the Sierra de la Giganta, Baja California Sur.

4. *Thornscrub.*—Complex dry-deciduous subtropical vegetation with dominance usually shared by many small trees and large shrubs. Seasonal aspects sharply distinctive, with wet-season perennial coverage on the order of 50-100 percent. The two major forms in the Gulf region are (1) plains thornscrub and (2) foothill thornscrub, with a larger component of tree species.

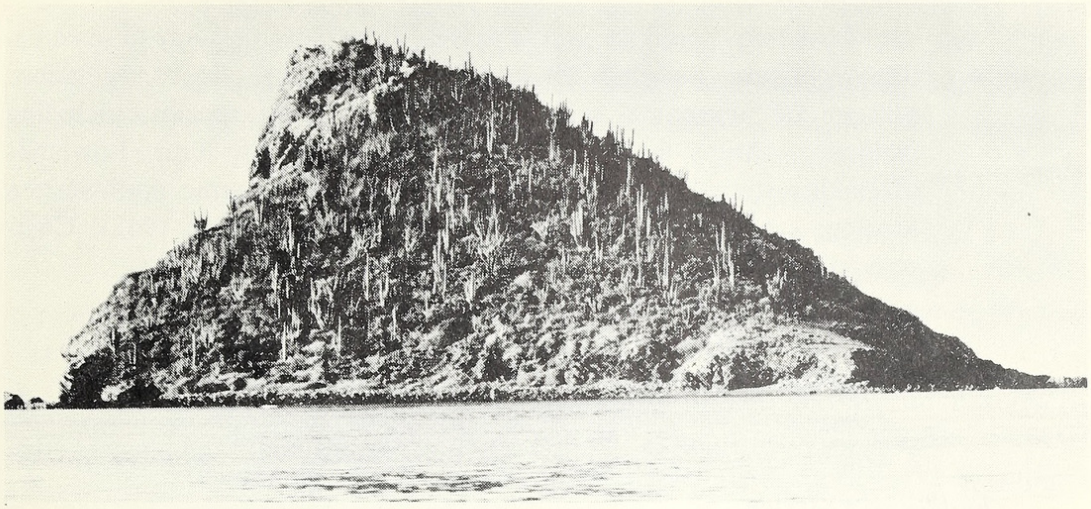

FIGURE 8. Isla Cholludo, showing about half of the northern portion of the island. Dense cactus scrub including *Pachycereus pringlei (cardón), Lemaireocereus thurberi* (organ-pipe), and *Opuntia fulgida* (jumping cholla).

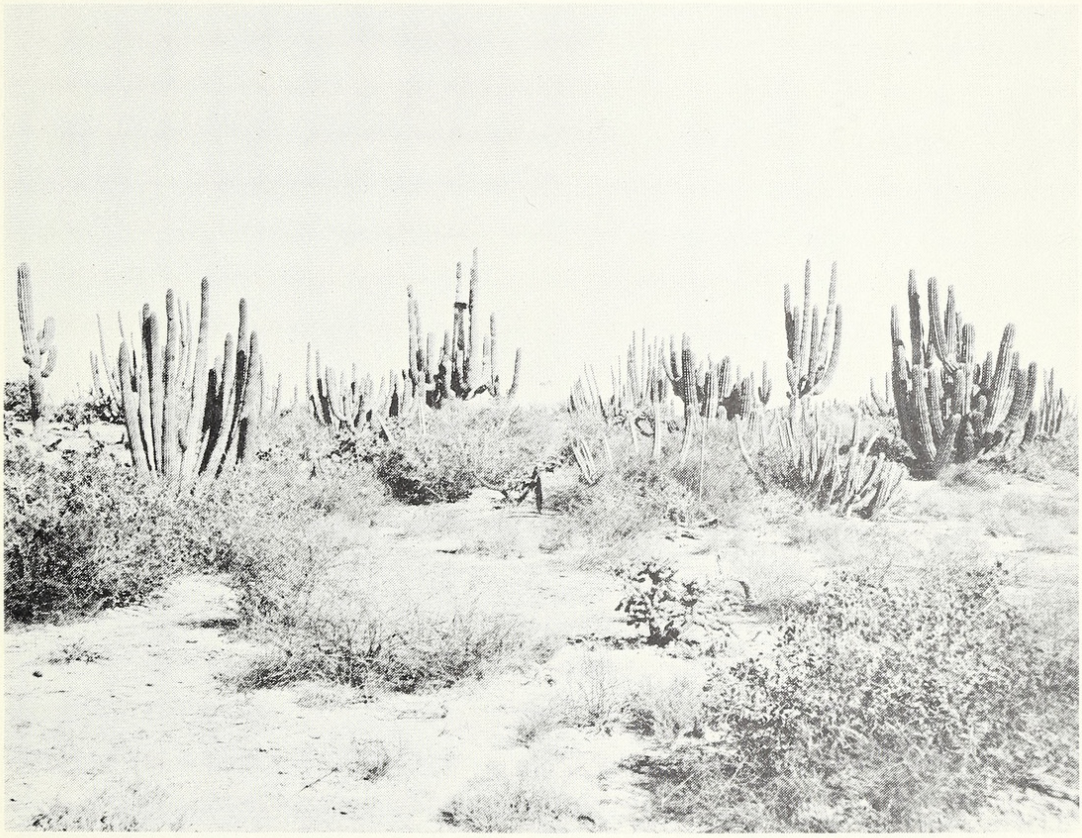

FIGURE 9. Cactus scrub *(cardonal)* on sandy soil at Punta Baja, Sonora. The cacti are *Pachycereus pringlei (cardón), Lemaireocereus thurberi* (organ-pipe), *Lophocereus schottii* (senita), and *Opuntia fulgida mammillata* (jumping cholla).

plains thornscrub

Low spiny scrub varying in density from closed canopy to savanna-like vegetation. Savanna-like areas are largely not climax vegetation. Mixture of subtropical scrub and southern desert species, including facultative shrubs that here assume arborescent life-form. Lowlands of southwestern Sonora and coastal margins of extreme northwestern Sinaloa; synonymous with Thorn Forest (*sensu* Gentry 1942). Characteristic species include:

Acacia cochliacantha
Cercidium praecox
Forchammeria watsonii
Fouquieria macdougalii
Guaiacum coulteri
Jacquinia pungens
Lemaireocereus thurberi
Opuntia wilcoxii
Pachycereus pecten-aboriginum
Pithecellobium sonorae.

foothill thornscrub

Low shrubby or semi-arborescent scrub, often with nearly closed canopy of small trees and large shrubs. Along the southeastern margin

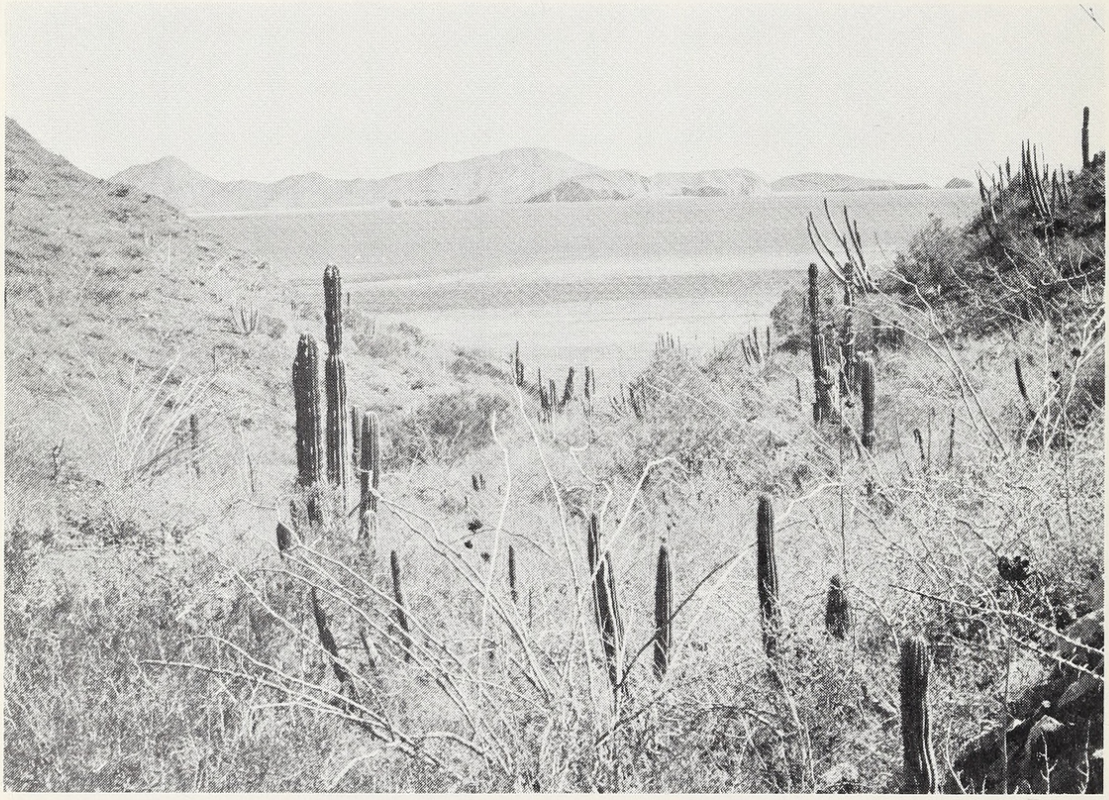

FIGURE 10. Northeast side of Isla Dátil (=Turners Island). Dense, brushy vegetation on north- and east-facing slopes at head of small canyon, with riparian desertscrub aspects. *Pachycereus pringlei (cardón), Fouquieria splendens* (ocotillo), *Lemaireocereus thurberi* (organ-pipe), and various shrubs including *Lycium brevipes, Colubrina viridis, Jatropha cuneata, Solanum hindsianum, Olneya tesota* (ironwood), and *Simmondsia chinensis* (jojoba).

of the Sonoran Desert it is largely synonymous with Shreve's (1951) Foothills of Sonora. Also locally in Baja California Sur and at higher elevations within the Sonoran Desert near its southern margins. For example:

Bursera fagaroides
Ceiba acuminata
Elytraria imbricata
Fouquieria macdougalii
Haematoxylon brasiletto
Jatropha cordata
Karwinskia humboldtiana
Ipomoea arborescens
Lysiloma divaricata
Pachycereus pecten-aboriginum.

riparian thornscrub

Thornscrub communities—and mixed thornscrub desertscrub communities—peculiar to certain types of arroyos, washes, and their floodplains. There are numerous characteristic species. For example:

Ambrosia ambrosioides
Coccoloba standleyi
Guazuma ulmifolia
Lysiloma candida

FIGURE 11. Agua Dulce Valley, near center of Isla Tiburón. Riparian desertscrub. The tree is *Bumelia occidentalis*, and the shrubs are *Olneya tesota* (ironwood) and *Hyptis emoryi* (desert lavender).

FIGURE 12. Riparian desertscrub at Ensenada Grande (=San Pedro Bay), Sonora. *Lysiloma candida (palo blanco)* with dense understory of small shrubs including *Randia, Ruellia,* and *Croton.* This is the only known locality for *Lysiloma candida* outside of Baja California.

Ficus petiolaris *Lysiloma divaricata*
Ficus paduifolia *Periskiopsis porteri*
Gouania rosei *Vallesia baileyana.*

5. *Short-tree Forest.*—Semi-arid subtropical dry-deciduous forest of small trees (Gentry 1942). Not in the northern part of the Gulf of California. Occurrence in the coastal border Gulf vegetation in southern and central Sinaloa. Also at intermediate elevations in southeastern Sonora, and the Cape Region of Baja California Sur.

SHORELINE VEGETATION

Shoreline vegetation in the Gulf of California occurs in several distinctive physical habitats that support highly distinctive plant communities. Three of the more distinct ecological situations—shoreline habitats—are (1) the *sea cliff,* (2) the *beach dune,* and (3) the *salt flat.* Lying between these edaphic extremes and the unique plant communities that they support, are the average sandy-gravelly-rocky desert substrata which stretch across the extensive coastal plains, hills and mountains and support desertscrub communities in a complex pattern of continua and mosaics.

Sea Cliff Vegetation.—On vertical rocky sea cliffs relatively free of bird guano (sea cliffs with bird rookeries often accumulate extensive deposits of guano), a unique group of rock-holding plant species comprise a very sparse vegetation. Prominent in these communities are *Ficus petiolaris palmeri, Hofmeisteria crassifolia, H. fasciculata, Eucnide rupestris, Pleurocornis laphamioides,* and in the vicinity of Bahía San Pedro, even the palm *Erythea clara.* The rock-face sea cliff community is a natural extension from that of the tropical and subtropical canyon rock cliff habitat. Thus a few of the hardiest canyon cliff species also persist on arid and semi-arid tropical and subtropical sea cliffs. The plant components of the sea-cliff vegetation in the Gulf of California region are highly predictable. They provide an especially clear-cut example of the fact that the natural community owes its existence to the simple overlap of the spans of the genetically controlled ecological tolerances of the comprised species.

Beach Dune Vegetation.—Coastal dunes occur along much of the Gulf Coast of Sonora and on Isla Tiburón, and on parts of the Gulf Coast of Baja California. High unstable dunes facing the sea are commonly built along extensive stretches of shore. Proceeding inland there may be progressively smaller and more stable dunes positioned in parallel series. The more inland ones are of older age than the present outer beach dune. Although there is a gradual geographic replacement or shift in the dune flora from north to south—and, to a lesser extent, on the climatically different east and west sides of Isla Tiburón—in any one Gulf Coast area (e.g., the Tastiota area, and Puerto Libertad area, etc.) the dune flora is highly predictable from dune to dune, depending on (1) dune size, (2) dune stability, and (3) exposure to maritime wind.

Many dune species have deep roots, and there is a preponderance of silvery or grey-pubescent leaved plants in the community. Certain characteristic dune species seldom occur elsewhere, e.g., *Astragalus magdalenae, Dicoria canescens,*

Euphorbia leucophylla, and *Triteliopsis palmeri.* Others on the dunes are characteristically sandy-soil species with wide distribution in sandy non-dune habitats, e.g., *Abronia maritima, A. villosa, Aristida californica, Croton californicus, Dalea emoryi, Helianthus niveus,* and *Jouvea pilosa.* Still other common species on dune sand occur over a conspicuously wider spectrum of substrata, e.g., *Atriplex canescens, Lycium brevipes, Palafoxia arida, Prosopis glandulosa torreyana,* and *Sesuvium verrucosum.* A few species, such as *Jouvea pilosa,* are confined exclusively to the sea-facing coastal dune slopes, and do not occur on the lee slopes. Ephemerals may be seasonally abundant and well developed, especially in the more stable areas of the coastal dunes.

Salt-flat Vegetation.—Where flat land slopes nearly imperceptibly toward the sea, salt flats occur with their characteristic halophytic vegetation. Very slight elevational differences, often on the order of much less than one meter, are capable of producing marked as well as abrupt vegetational and floristic transitions to desert-scrub adjacent to and within salt flat areas. Hence, these adjacent and divergent communities characteristically form a conspicuous mosaic pattern obviously under edaphic control.

Significant to the halophytic community composition are the length of time between floodings and the distance from the sea. Salt-flats behind beaches and coastal dunes may be subject to flooding only at the highest tides of the year or during summer rains, e.g., the Llanuras de San Juan Bautista. Elsewhere daily tides may inundate the soils near bays (e.g., in the vicinity of Bahía de la Cholla and Puerto Peñasco), and areas adjacent to mangrove inlets or esteros. Representative salt-flat species include *Allenrolfea occidentalis, Atriplex linearis, Batis maritima, Frankenia grandiflora, Monanthochloe littoralis, Tricerma phyllanthoides,* and *Suaeda torreyana.* Ephemerals are few and poorly developed or absent.

THE ISLANDS

There is no permanent settlement on the eight islands treated here, and the ecosystems of these islands remain in an essentially natural state. Checklists for the vascular plants known to us for each of the eight islands are given in Table 1, a statistical summary of the flora is presented in Table 2 (see pp. 54-56), and pertinent geographical information is given in Table 3 (see p. 57). Island areas given here are based on the most recent, available maps (also see Soulé and Sloan 1966, and Tamayo 1949).

THE SERI INDIANS AND ISLAND FRESH WATER

Since ancient times the Seri Indians occupied both Isla Tiburón and Isla San Esteban as well as the opposite Sonora coast (Bowen, in press; Moser 1963; Felger and Moser 1975-b, 1976). These people, traditionally a hunting and gathering and seafaring society, practiced no agriculture in this region. During traditional times their impact on the vegetation and fauna, from which they derived their subsistence, was probably minimal (see Felger and Moser 1970, etc.; Felger 1976-b). Permanent

watering places, all with limited supply of fresh water, are well distributed on Tiburón. Fresh water on Isla San Esteban was extremely limited, and sometimes gave out during periods of drought that forced the resident Seri to move temporarily across the channel to Isla Tiburón (Moser 1963). There is now, and was previously no permanent fresh water on any of the other Sonoran islands and, consequently, they were not occupied by native people. Brief bird guano mining operations were carried out with transported water on Isla San Pedro Mártir and on Isla Patos earlier in this century.

ISLA TIBURÓN

With an area of about 1210 km^2, Isla Tiburón is the largest island on the Pacific Coast of North America south of Canada. Its geology, topography, climate, and vegetation are complex. Peak elevation is 875 m. Gentry (1949, p. 94) provides the following sketch of the island:

> It is separated from the Sonoran mainland by a shallow narrow channel, "el infiernillo," two to five kilometers wide and only three to four meters deep. Roughly quadrangular in shape, the island contains about 1170 square kilometers. Although mountainous, there are extensive valleys. . . . There are two igneous ranges of mountains trending north and south and paralleling the adjacent ranges of Sonora. The western is Sierra Menor, the eastern and higher is Sierra Kunkaak . . . the shallow infiernillo channel was emerged repeatedly during the low sea levels of the glacial periods.

Through warfare and pestilence, Seri population greatly dwindled towards the latter part of the last century, and their numbers became even more drastically reduced in the first half of this century. During this time Tiburón remained their refuge and undisputed homeland, if for no other reason than because this insular desert provided an effective retreat from the military (see Spicer 1962). From about 1955 until the present time the island has been little occupied. Wildlife management and limited military installations and roads were established in 1967. During 1975 the president of Mexico decreed that the island be given to the Seri tribe.

The vegetation of Isla Tiburón includes extensive areas of littoral scrub, desertscrub, and thornscrub, as well as coastal seagrass meadows. Each major community-type occurring in the northern Gulf Coast of Sonora is found on the island.

The vegetation of Sierra Kunkaak (elevation 875 m) includes substantial areas of thornscrub and thornscrub-desertscrub ecotones. The higher elevations and portions of the east- and north-exposure slopes support extensive stands of nearly closed-canopy *Lysiloma divaricata (mauto)*. Their maximum height is considerably less than in the mainland short-tree forest (*sensu* Gentry 1942) of southeastern Sonora. Riparian thornscrub extends along major canyons into the lower elevations at the base of Sierra Kunkaak.

Most of the area of the island is covered with desertscrub of diverse structure and composition. Coast desertscrub communities dominated by *Frankenia palmeri* occur along all shores of the island that are of gentle topography. The most extensive development of coast desertscrub is along the east shore where the expansive island bajada gradually dips toward the sea.

Extensive areas dominated by *Larrea divaricata* (creosotebush) occur on the plains of the Agua Dulce Valley towards the interior of the island (Fig. 4). These simple communities are located between shallow drainageways supporting small desert trees and shrubs. This mosaic involving creosotebush scrub, mixed desert-scrub, and riparian desertscrub is in a dendritic-reticulate pattern with the overall drainage coursing northward through the Agua Dulce Valley and issuing into the sea near Tecomate at the northeast end of the island. Another conspicuous area of creosotebush scrub occurs along the east side of the island. Here *Larrea* shares dominance with *Cordia parvifolia* in a narrow zone parallel to the Infiernillo shore and situated between coast desertscrub and the more inland, and complex mixed desertscrub communities.

Mixed desertscrub, with dominance shared by numerous desert shrubs, covers the majority of the lowlands and western mountains (Sierra Menor) of the island. The mixed desertscrub communities reach maximum species richness and highest density on the gentle upper reaches of the extensive bajada slope facing the Canal del Infiernillo, on the east side of the island. Distribution of major perennials across this bajada is surprisingly even, and more or less mirrors the pattern of that on the opposite mainland coast (see Fig. 5). On the more harsh and exposed portions of Sierra Kunkaak, such as southward- and westward-facing slopes, mixed desertscrub communities extend to peak elevation.

Cactus scrub with conspicuous "forests" of columnar cacti occur primarily along the east side of the Agua Dulce Valley which drains into Bahía Agua Dulce (vicinity of Tecomate). Here the valley floor slopes gradually westward and supports a relatively large population of *Carnegiea gigantea* (saguaro), small desert trees (e.g., *Cercidium microphyllum*), and an array of desert shrubs. Slope exposure compares well with that of the bajada of the mainland side of the Infiernillo where extensive stands of the more maritime *Pachycereus pringlei (cardón)* occur, rather than saguaro. Saguaros near the Gulf characteristically attain maximum development on more island sites, while *cardón* is relatively more abundant in immediate coastal situations. The fewer dense stands of *cardón*-dominated cactus "forest" *(cardonal)* on Tiburón may be due, in part, to the absence of extensive west-facing and south-facing coastal bajadas; it may be due also to subtle controls of topography and microclimate, including the east to west decreasing precipitation gradient on and near the island. Relatively dense but localized stands of *cardón* occur here and there on lower slopes within mixed desertscrub, such as in the vicinity of the Sauzal waterhole, and elsewhere as on the east side bajada facing the Infiernillo.

Riparian desertscrub is especially well developed along the extensive dendritic arroyo systems draining the island. The extensive Arroyo Agua Dulce system that drains the interior valley supports many miles of riparian desertscrub. Especially noteworthy are plant species in the upper reaches of the interior valley with individuals of enormous size relative to their usual maximum size elsewhere in the Sonoran Desert, e.g., *Bumelia occidentalis* at 11 m (36 feet) height (Fig. 11), *Condalia globosa* at 5.5 m (18 feet), and *Koeberlinia spinosa* at 5.5 m.

Isla Tiburón is the only Sonoran island with riparian *aguajes* or *tinajas*. One of the more permanent watering places is Sauzal, near the south-central end of the island. Most of the others occur scattered through Sierra Kunkaak.

Well developed littoral scrub occurs along the shores of the island, and reaches maximum development on the east shore bordering the protected Infiernillo coast, which has a number of lagoons and expansive beaches. There are three major esteros, all with extensive mangrove scrub, on the Infiernillo shore: Punta Perla at the north, Palo Fierro at about midway, and Santa Rosa at the south end of the Infiernillo. The three species of mangrove are present. Salt scrub occurs along the shores nearly throughout the island. It is absent only where sea cliffs and steep rock slopes reach directly down into the sea, such as along portions of the southern and western shores. Extensive seagrass meadows occur in the Canal del Infiernillo, and *Zostera marina* and *Ruppia maritima* are seasonally abundant in the beach drift on the east side of the island.

The central relief and area of Isla Tiburón are extensive enough to produce several distinctive climatic zones and hence distinctive phytogeographic areas. Two are especially noteworthy: (1) thornscrub and thornscrub-desertscrub ecotone at higher elevations on Sierra Kunkaak and (2) the relatively xeromorphic desertscrub on the drier western margin of the island.

Sierra Kunkaak.—The subtropical thornscrub of Sierra Kunkaak is comprised largely of species and communities that are often northern outliers disjunctive from subtropical regions much farther southward. Some of these populations are separated from their nearest conspecific populations by much or all of the intervening areas of the Sonoran Desert. Their insular distribution on Tiburón is like an island within an island. Examples are *Ayenia glabra, Croton magdalenae, Guaiacum coulteri,* and *Lasiacis sorghoides.*

The Western Margin.—The vegetation on Tiburón reveals a strong east-west climatic gradient, but only a slight one from north to south. The vegetation on the western Gulf side of the island lying in the summer rain-shadow of Sierra Kunkaak, is conspicuously more xeromorphic than that of the eastern (Sonora) side bordering the Infiernillo. The far western arid margin of Tiburón, largely on the western side of the crest of Sierra Menor, supports certain species which otherwise occur primarily on the Baja California side and/or at the arid head of the Gulf. Examples are *Ambrosia ilicifolia, Cassia confinis, Drymaria holosteoides,* and *Pelucha trifida.*

Baja California species occurring on Tiburón, and in some cases also on other Gulf islands, but not on the opposite mainland of Sonora include 4.2 percent of the flora. These are:

Acalypha comonduana
Antirrhinum kingii
Cassia confinis
Castela polyandra
Cryptantha angelica
Dalea vetula
Drymaria holosteoides
Euphorbia magdalenae
Fagonia palmeri
Passiflora palmeri
Pelucha trifida
Porophyllum crassifolium.

For the most part, however, the lowland regions of Tiburón support a flora which is almost identical with that of the Sonoran mainland directly opposite the island. Three Old World species, now widely naturalized in the New World, have become well established in the interior of the island: *Chenopodium murale, Mollugo cerviana,* and *Tamarix ramosissima.*

We have located 286 species on Tiburón (Table 1). An additional 10 to 15 percent may reasonably be expected to occur, and most of the new additions will come from the higher elevations of Sierra Kunkaak. The flora of this largest island in the Gulf of California contains no known endemic plant species. All of the species present also occur either on the mainland of Sonora and/or the peninsula of Baja California.

Isla San Esteban

Isla San Esteban lies in mid-Gulf 11.6 km south from the southwest shore of Isla Tiburón. Its more or less compact rectangular shape covers about 43 km^2. High sea cliffs edging the island are interrupted by widely-spaced canyons, and on the east side by a broad valley-like canyon known as Arroyo Limantur (Fig. 6). A rugged horseshoe-shaped series of mountains, rising to 550 m elevation, surround Arroyo Limantur.

The small band of Seri Indians inhabiting San Esteban were exterminated by the military in one tragic event during the 1860's (Moser 1963). The island has since been uninhabited and remains in a primordial state, scarcely altered by man.

Mixed desertscrub with a preponderance of cactus scrub elements dominates the landscape. The communities are xeromorphic, some extremely so, and surprisingly diverse and varied. Communities along the major arroyos, including Arroyo Limantur, are scarcely differentiated as distinctive riparian desertscrub. Some elevational zonation is apparent, although generally weaker than community differences along slope-exposure gradients (e.g., north-south). Very limited salt scrub communities, occupying restricted areas behind some of the high cobble beaches, consist primarily of *Suaeda torreyana* and *Atriplex barclayana.*

Among the most prominent elements of the desertscrub vegetation on San Esteban are:

Agave dentiens
Atriplex polycarpa
Bursera microphylla
Colubrina viridis
Echinocereus grandis
Jatropha cuneata
Machaerocereus gummosus
Mammillaria estebanensis
Olneya tesota
Opuntia ciribe
Pachycereus pringlei
Simmondsia chinensis
Solanum hindsianum.

We have collected 107 species on San Esteban (Table 1) and the flora may contain an additional 10 percent. Two cacti, *Echinocereus grandis* and *Mammillaria estebanensis,* are endemic to the Islas San Lorenzo and San Esteban. *Agave dentiens,* closely allied to *A. deserti* and probably not distinct at the specific level, occurs on several other islands on the Baja California side of the Gulf. *Lyrocarpa linearifolia* is otherwise known only from Isla Angel de la Guarda.

Most of the flora is common to both sides of the Gulf. However, the general physiognomy of the vegetation and phytogeography of a portion of the flora shows close affinity with the desertscrub of Baja California. Plants known otherwise only from Baja California and other Gulf islands represent 11.3 percent of the island's flora. These are:

Agave dentiens
Argemone subintegrifolia
Chloris brandegeei
Echinocereus grandis
Haplopappus spinulosus incisifolius
Lycium megacarpum
Lyrocarpa linearifolia
Mammillaria estebanensis
Opuntia ciribe
Passiflora palmeri
Porophyllum crassifolium
Sideroxylon leucophyllum.

ISLA SAN PEDRO NOLASCO

This rugged and precipitous island lies in deep water and geologically has long been isolated from the mainland. On either side of a prominent north-south ridgecrest running the length of the island, the terrain quickly falls away into the sea with many short, steep and highly eroded canyons. Maximum elevation is 318 m. High sea cliffs, edging the entire island, harbor extensive sea bird rookeries and are white with guano. The island area is approximately 3.5 km^2. There is no fresh water on the island and it has never been inhabited by man. Its terrestrial ecosystem is virgin.

The vegetation is comprised of desertscrub that is sharply divided into unique communities segregated according to slope exposure. The communities show a relatively discontinuous or mosaic pattern of distribution that is exceptionally clear where the environmental gradients on the slope exposures change abruptly. Otherwise a continuum pattern is evident.

The northerly oriented slopes on the east side of the island, exposed to strong sea moisture-laden breezes, support meadows of grasses and forbs. Ground coverage is generally at or near 100 percent. Comparable communities do not exist elsewhere in the Gulf Coast region of Sonora. Soil profiles are deep and rich in organic material. Soil erosion is at minimum, despite the steepness of these north-facing slopes. Yet the steepness of slope is noticeably less than on adjacent south-facing slopes, undoubtedly due to the lower rate of erosion. Some prominent north-facing

species are: *Amaranthus fimbriatus, Bothriochloa barbinodis, Coreocarpus arizonicus, Muhlenbergia microsperma, Perityle californica, Setaria macrostachya, Trichachne californica, Trichloris crinata,* and *Vaseyanthus insularis.*

East-facing slopes consist primarily of broad ridges separating north-facing and south-facing canyon slopes on the east side of the island. *Agave chrysoglossa, Opuntia wilcoxii, Salvia similis* and others are, with minor exception, restricted to these slopes. The smaller cacti *(Echinocereus* and *Mammillaria)* and various other species reach maximum development and density on east-facing slopes. Other prominent east slope species include *Acacia willardiana, Lemaireocereus thurberi, Pachycereus pringlei, Colubrina viridis,* and *Viguiera deltoidea.*

The general physiognomy and vegetation on south-facing slopes on the east side of the island and most of the west side of the island are closely akin. Large expanses of bedrock are exposed at the surface. Conspicuous plants are columnar cacti *(Lemaireocereus thurberi* and *Pachycereus pringlei),* simple-leaved and xerophytic desert shrubs (e.g., *Jatropha cuneata* and *Viguiera deltoidea),* and small cacti *(Echinocereus websterianus* and *Mammillaria multidigitata).* Ephemerals and grasses are usually poorly developed. The flora shows close affinity with the adjacent Sonoran coast.

We have found 55 species of plants on the island (Table 1). This is the only Sonoran island with single-island endemics. These are three species of cacti which seem to be derived from mainland Sonoran taxa: *Echinocereus websterianus* from *E. pectinatus* var. *scopularum* (Lindsay 1947), *Mammillaria multidigitata* possibly from *M. thornberi* (=*M. fasciculata*), and *M. tayloriorum* from the *M. sonorensis* complex (Glass and Foster 1975). Several extra-limital populations are noteworthy. *Salvia similis* is otherwise known only from Baja California, and *Euphorbia magdalenae* from Baja California and Isla Tiburón. *Metastelma pringlei* has previously not been reported from Sonora, and is primarily known from the Sierra Madre Occidental. [It may also occur in Baja California (Wiggins 1964, p. 1122)]. *Mollugo verticillata* is the only non-native species and has become well-established on the island.

ISLA SAN PEDRO MÁRTIR

Isla San Pedro Mártir, lying in deep water in the mid-Gulf, is the most isolated island in the Gulf of California. Apparently of volcanic origin, it is doubtful if it ever has been connected to any other landmass. There are no beaches, alluvial deposits, or outwashes. Most of the surface of the island is exposed and offers little or no shelter from wind. Maximum elevation is 320 m and most of the surface comprises high plateaus lying above 150 to 200 m. The island area is about 1.5 km^2. Sea cliffs are the principal coastal features and support enormous numbers of sea birds and thick guano deposits. During the cooler months of the year the upper elevations are often shrouded in fog which seems to provide the vegetation with significant moisture. The climate appears to be extremely arid.

There is no fresh water on the island. It was inhabited temporarily by guano miners, prior to World War II, whose activities centered around the guano-covered

periphery. On the whole, the island vegetation today appears to be natural and undisturbed.

The sparse desertscrub consists of cactus scrub and mixed desertscrub elements. Elevational zonation is apparent, with gradually increasing species richness and vegetation density towards higher elevation. At lower elevation, on the guano-covered sea cliff edges of the island, there is essentially no vegetation.

Among the most conspicuous and abundant perennials are *Pachycereus pringlei (cardón)* and *Sphaeralcea hainesii*. Ephemerals seasonally produce extensive ground cover, e.g., *Aristida adscensionis, Euphorbia petrina, Mentzelia adhaerans, Perityle californica,* and *Vaseyanthus insularis*.

The flora is relatively depauperate and the species known to us total 23 (Table 1). Further exploration will probably not yield more than a few additional species. Relatively extreme aridity and little habitat diversity are principal factors contributing to the depauperate flora for an island this large in the island series. Isolation by distance is undoubtedly another contributing factor. There are no endemic plants and most of the flora is common to both sides of the Gulf. Species occurring otherwise only on other Gulf islands and Baja California are *Sphaeralcea hainesii* and *Pelucha trifida*.

ISLA DÁTIL

Isla Dátil (=Turner's Island) is a narrow, north-south oriented, former mountain lying at the southern end of a partially submerged peninsula extending southward from the southeast shore of Isla Tiburón. Reefs connect Islas Dátil and Cholludo and both appear to be rather recent fragmentations from Tiburón (Lowe 1955).

The rugged topography offers a wide range of microenvironments. Peak elevation is 183 m, and the total area about 1.5 km^2. There are a few small rock beaches but most of the shore consists of high sea cliffs. There are several major canyons.

The vegetation consists almost wholly of mixed desertscrub and some riparian desertscrub. Salt scrub species, e.g., *Suaeda torreyana,* are present behind the few small cobble beaches, but do not form distinctive communities.

Vegetation on Isla Dátil is noticeably more dense and "brushy" than on the adjacent south shore of Isla Tiburón, and is likewise distinctive from other Gulf islands. East-facing and north-facing canyon slopes and canyon floors support dense desertscrub that may be termed riparian (Fig. 10). However, the distinction on this island between riparian and non-riparian vegetation is not sharp. The communities with maximum species richness occur on north-facing slopes near the summit on the east side of the island. Most of the island, however, supports relatively xeromorphic desertscrub, and south-facing slopes are sparsely vegetated.

The flora is surprisingly rich (99 species, Table 1) for this relatively small island satellite of Tiburón. An undescribed *Mammillaria* is endemic to both Isla Dátil and Isla Cholludo. It shows affinity with *M. dioeca* of Baja California and California (Robert Foster, *personal communication*), and appears to be distinct at the subspecific level. Otherwise there is no indication of endemism on the island. For the most part, the flora shows affinity with the nearby south side of Isla Tiburón;

although there are some notable extra-limital populations on Isla Dátil. *Calliandra californica* is an outlier from Baja California, while *Coldenia canescens,* a xerophytic species of the northern part of the Sonoran Desert, is widely disjunct southward onto Isla Dátil. The exceedingly rich flora seems to result from the locally favorable maritime climatic conditions, the highly varied island topography providing a relatively wide range of microenvironments, and the relative proximity of the island to major land masses including Isla Tiburón. Furthermore, larger herbivores, such as mule deer and rabbits, are absent on this island although present on Tiburón.

Isla Alcatraz

Isla Alcatraz (or Isla Pelícano, or Isla Tassne) lies 1.4 km offshore in Bahía Kino, with a channel not more than two fathoms deep. Its isolation from the mainland presumably has been of short duration.

The island has two distinctive topographic parts, each comprising roughly one-half of the island area. The northeastern part is relatively flat and not more than one to two meters above mean high tide level. The southwestern portion rises steeply into a rocky mountain mass of approximately 130 m elevation. The island area is about 0.5 km^2. Vegetation, flora, and white bird guano deposits from extensive sea bird rookeries are sharply distributed according to these major topographic features. There is no fresh water on the island, and although it has been frequently visited, it is not known to have been occupied by man.

The extensive low flat on the northeast side of the island supports salt scrub and meager isolates of desertscrub (Fig. 3). Much of the interior portion of this flat consists of a low-lying playa dominated by *Allenrolfea ooccidentalis*. Sparse stands of herbaceous salt scrub species are strewn along the upper beach. The low statured and very open mixed desertscrub occurs on low sandy rises between the small inland playa and the beaches.

The eastern slopes of the mountainous region supports a sparse cover of mixed desertscrub (Fig. 3). Differences in slope exposure, steepness, and drainage patterns produce moderately diverse but simplified communities of localized populations. Common species here are: *Amaranthus watsonii, Beloperone californica, Opuntia fulgida, O. phaeacantha, Nicotiana trigonophylla, Pachycereus pringlei,* and *Viscainoa geniculata.* Following periods of exceptional rains *Amaranthus watsonii* seasonally forms extensive and dense stands, which gives the island an appearance of being covered with grass as seen from the sea or the shore of Bahía Kino.

Aridity and extensive bird guano deposits render the southwestern and western portion of the island (or virtually all of the mountainous portion except its northeastern slopes) inhospitable to the development of vegetation. Principal plants found on this birdland are a few widely scattered *Pachycereus pringlei* and seasonally localized and relatively sparse stands of *Amaranthus watsonii.*

Proximity to the mainland and a moderate degree of habitat diversity allow a comparatively large number of species to exist over the eastern ⅔ of the island. The flora, moderately rich with 43 species (Table 1), shows obvious and close affinity

with the nearby mainland flora. Species of Amaranthaceae, Cactaceae, and Chenopodiaceae comprise the most widespread and dominant elements. Ephemerals (primarily *Amaranthus watsonii*) seasonally produce the major portion of the plant coverage of the desertscrub areas.

Opuntia phaeacantha is known from no other island, and the nearest population of this prickly-pear occurs near Punta Sargento. Several species are rare and probably not reproducing on the island, e.g., *Bursera microphylla, Encelia farinosa, Lophocereus schottii, Phaulothamnus spinescens, Prosopis glandulosa torreyana,* and *Tricerma phyllanthoides*. These appear to be recent arrivals.

Isla Patos

This small bird guano covered island lies in open water 7.3 km north of Isla Tiburón. A single conical peak rises 69 m above sea level. Total surface area is on the order of 0.4 km^2.

In 1946 the major perennials, mostly cacti, were deliberately destroyed and the island cleared to facilitate guano mining (see Gentry 1949). The commercial guano mining venture was short-lived. The island has otherwise remained uninhabited by man. There is no fresh water.

The highly xeromorphic desertscrub is very sparse and consists primarily of one chenopod *(Atriplex barclayana)* and two cacti *(Pachycereus pringlei* and *Opuntia fulgida)*. Other species present form small populations that comprise an insignificant role in the vegetation.

The flora of Patos is the most depauperate of the eight Sonoran islands considered here, and we know of ten species to have been present:

Amaranthus fimbriatus (Torr.) Benth.
Atriplex barclayana (Benth.) Dietr.
Bouteloua barbata Lag.
Carnegiea gigantea (Engelm.) Britt. & Rose
Encelia farinosa A. Gray var. *phenicodonta* (S. F. Blake) I. M. Johnst.
Lophocereus schottii (Engelm.) Britt. & Rose var. *schottii*
Machaerocereus gummosus (Engelm.) Britt. & Rose
Opuntia fulgida Engelm. var. *fulgida*
O. fulgida var. *mammillata* (Schott ex Engelm.) Coult.
Pachycereus pringlei (S. Wats.) Britt. & Rose
Trixis californica Kell.

We have found six vascular plant species on the island. *Carnegiea, Encelia, Machaerocereus,* and *Trixis* are now gone from Patos and apparently were not common even before 1946.

Additional exploration on the island will not yield at this time more than one or two additional species, and such, if present, will be ephemerals. A flora of ten species comprised of five cacti, three xeromorphic subshrubs, and two ephemerals indicates extreme aridity. Other major controlling factors may be small island target size and low relief.

ISLA CHOLLUDO

This tiny rock isle of roughly 0.1 km^2 is situated between Islas Tiburón and Dátil along a sunken peninsula that interconnects the three islands. Tamayo (1949) gives it the name Isla Lobos and some older American maps and papers use the name Isla Roca Foca or Seal Island. Cholludo is the name locally used. The south surface falls away abruptly to high sea cliffs. From the south ridge-crest, 75 to 100 m high, the surface of the island quickly slopes to the sea at the north shore. There are no arroyos and the isle is without a beach and without littoral scrub. The steep and rocky surface, with its northerly orientation, contains most of the surface area of the island and its vegetation. Isla Cholludo has never been occupied by man and is without fresh water. The biota remains in a virgin state.

The island is aptly named, for it is covered with a scarcely penetrable forest of cactus scrub, unique from its neighboring islands (Fig. 8). Dominant elements in this succulent landscape are *Pachycereus pringlei, Lemaireocereus thurberi, Opuntia fulgida,* and *Agave subsimplex. Perityle emoryi* seasonally produces a carpet of green among the spiny perennial cover.

The flora of this cactus garden isle is surprisingly rich. We have obtained 28 species (Table 1) on this small surface area, smallest of the eight islands in the series. Most of the species on Cholludo occur on neighboring Isla Tiburón and Isla Dátil. However, *Mammillaria dioeca,* common on Cholludo and Dátil, is unknown from Tiburón, and *Carnegiea* and several other species present on Cholludo have not been found on Dátil.

ISLA SAN JORGE

This vegetationless rocky guano-covered bird rookery is the northernmost of the islands discussed in this work. It is also known as Saint George Island or Georges Island. Johnston (1924, p. 1017) reported *Chenopodium murale* as ". . . the only phanerogam found on Georges Island . . . The plant was no doubt introduced . . . by guano workers and forms a few small colonies on talus loosened by blasting." Thus the only land plant ever recorded from the island is a species supposedly native to Europe and now extensively naturalized in North America. Our recent inspection of the island failed to reveal the presence of land plants.

FLORISTIC RELATIONSHIPS AND BIOGEOGRAPHY OF THE ISLANDS

Some accidental introduction of seeds from the mainland and from island to island by the continuing agency of man is likely, but intentional introduction by the Seri Indians is extremely doubtful (Felger and Moser, unpublished data). Only 4 species, or 1.2 percent of the flora of the Sonoran Islands, are non-native: *Chenopodium murale, Mollugo cerviana, M. verticillata,* and *Tamarix ramosissima.* These are indigenous to the Old World and are now widely naturalized in the New World. Their diseminules, in this case the seeds, are less than 1.5 mm in diameter. *Chenopodium murale,* an important traditional food of the Seri, was commonly

stored in pottery vessels (Felger and Moser 1976) and could have been accidentally introduced to new localities by the Indians. The small non-native component of the flora is undoubtedly related to the undisturbed, natural state of the islands' ecosystems. By way of comparison, the floras of San Clemente and Santa Catalina Islands, off Southern California, respectively contain 22.4 percent (69 species) and 29.7 percent (167 species) introduced species (Thorne 1969). The California islands have been extensively altered by man, livestock and other introduced exotics with devastating effects on the native ecosystems.

Most of the flora of the Sonoran islands is common to both sides of the Gulf of California. However, 7.6 percent of the flora of these islands is known otherwise only from Baja California and other Gulf islands. These are:

Acalypha comonduana
Agave dentiens
Antirrhinum kingii
Argemone subintegrifolia
Calliandra californica
Cassia confinis
Chloris brandegeei
Cryptantha angelica
Dalea vetula
Drymaria holosteoides
Echinocereus grandis
Euphorbia magdalenae
Fagonia palmeri
Haplopappus spinulosus incisifolius
Lycium megacarpum
Lyrocarpa linearifolia
Mammillaria estebanensis
M. dioeca
Opuntia ciribe
Passiflora palmeri
Pelucha trifida
Porophyllum crassifolium
Salvia similis
Sideroxylon leucophyllum
Sphaeralcea hainesii.

We expect additional botanical exploration will reveal that some of the Baja-insular "endemics" also occur on the Sonoran mainland. In contrast, we know of no plants from islands on the Baja California side of the Gulf which occur on the mainland of Sonora but not on Baja California—with the possible exception of *Opuntia fulgida*. On certain Gulf islands, such as Isla Angel de la Guarda, *Opuntia cholla* and *O. fulgida* are often confused; their biosystematic relationship is not clear.

Endemism on the eight Sonoran islands is low but not unusual for islands as close to shore as these and with small floras. It has long been known that endemism is much greater among the terrestrial vertebrates than for the flora on the Gulf islands

(Johnston 1924; Gentry 1949; Soulé and Sloan 1966). There are 8 taxa on the Sonoran islands which are endemic to one or more islands in the Gulf of California, representing 2.1 percent of the flora. These endemics are small cacti, one century plant, and one crucifer:

Agave dentiens, San Esteban and several other islands (?)
Lyrocarpa linearifolia, San Esteban and Angel de la Guarda
Echinocereus grandis, San Esteban and San Lorenzo
E. websterianus, San Pedro Nolasco
Mammillaria dioeca ssp. ?, Cholludo and Dátil
M. estebanensis, San Esteban and San Lorenzo
M. multidigitata, San Pedro Nolasco
M. tayloriorum, San Pedro Nolasco.

Throughout their extensive ranges in North America, *Agave, Mammillaria,* and other small cacti such as *Echinocereus,* show extensive speciation with numerous taxa of limited geographic distribution. Although we list *Agave dentiens* as an endemic, its systematic status is in need of clarification.

San Pedro Nolasco, the only Sonoran island with single-island endemics, contains 3 endemics, representing 5.5 percent of the flora. The 4 island endemics on San Esteban, 3.7 percent of the flora, are shared with Islas San Lorenzo and Angel de la Guarda. While the number of endemics for all eight islands is low, the percentage of endemism for San Pedro Nolasco is comparable to that of certain islands off southern California. For example, San Clemente, lying 79 km offshore, has 13 endemics (5.4 percent of the flora), and Santa Catalina, 34 km offshore, has 7 endemics (1.8 percent) (Raven 1967; Thorne 1969).

As indicated by its specific name, *Lycrocarpa linearifolia* has leaves with reduced surface area relative to its congenerics, an adaptation to the arid environment. Absence of large mammalian herbivores and different pollination ecology are probably among the strongest biotic selection factors acting on the remaining seven endemics. All of these are long-lived succulents and are animal-pollinated. *Echinocereus grandis* and *Mammillaria estebanensis* have unusually thick stems, or low surface-volume ratios—an adaptation well-suited for this extremely arid environment (see Felger and Lowe 1967).

There are no endemics on Islas San Pedro Mártir, Alcatraz, or Patos. None are known from Tiburón. However, Sierra Kunkaak has not extensively been explored botanically and it is a likely place for endemics. The lack of endemism on San Pedro Mártir may seem unusual as it is the most isolated island in the Gulf of California. However, with a hypothetical endemism of 5 percent, which would be comparable to that of San Pedro Nolasco, or San Clemente island off southern California, there would be only one endemic land plant on San Pedro Mártir. Furthermore, the genera to which the Gulf island endemics belong do not occur on San Pedro Mártir.

The positive relationship between the number of species on each island and island area is shown in Fig. 13. Figures 13 and 14 allow comparison of our floristic data with Soulé and Sloan's (1966) analysis of the biogeography of the terrestrial vertebrates of the Gulf of California (we treat several small islands which they do not, and we do not cover the Baja California islands which they do). In figure 13 ". . . the curve drawn . . . between the highest points (the greatest species abun-

dance for their area) is a conservative estimate of the relationship between maximum species abundance and island area'' (Soulé and Sloan 1966, p. 152). The percent saturation value given in figure 14 is the ratio of the actual number of species present on an island to a theoretical maximum predicted by the saturation curve.

Soulé and Sloan (1966, p. 151) report ''. . . relative paucity of [terrestrial vertebrate] species on the deepwater, distant (from the mainland) islands.'' However, depauperate floras occur on the deepwater, isolated Isla San Pedro Mártir, as well as on the shallow-water Isla Patos and the scarcely isolated Isla Alcatraz. Although isolation seems to be a strong factor regulating species richness for certain of the Sonoran islands, it is well known that other factors such as habitat diversity are also highly significant in regulation of the size of insular biotas (for example see Hamilton, et al 1963). Some of the more obvious factors contributing to the regulation of species richness for the Sonoran islands are summarized below.

Isla Tiburón, scarcely isolated from the mainland, and with a high and complex topographic relief, is floristically a mainland ''sample'' of the flora rather than an island ''isolate'' (*sensu* Preston 1962). Thus Tiburón appears to be floristically saturated, retaining mainland species richness. Most striking are the impoverished floras on Islas San Pedro Mártir and Patos, and the exceedingly rich flora on Isla Dátil. Islas San Pedro Mártir and especially Patos have harsh environments, with relatively little habitat diversity, and extensive guano deposits which undoubtedly exert strong chemical control of the flora, preventing establishment of many species. Isla Alcatraz likewise has extensive guano deposits, and its flora is depauperate despite nearness to the mainland. Isla Dátil has the topography and microenvironments (see discussion on the islands above) which characteristically support maximum

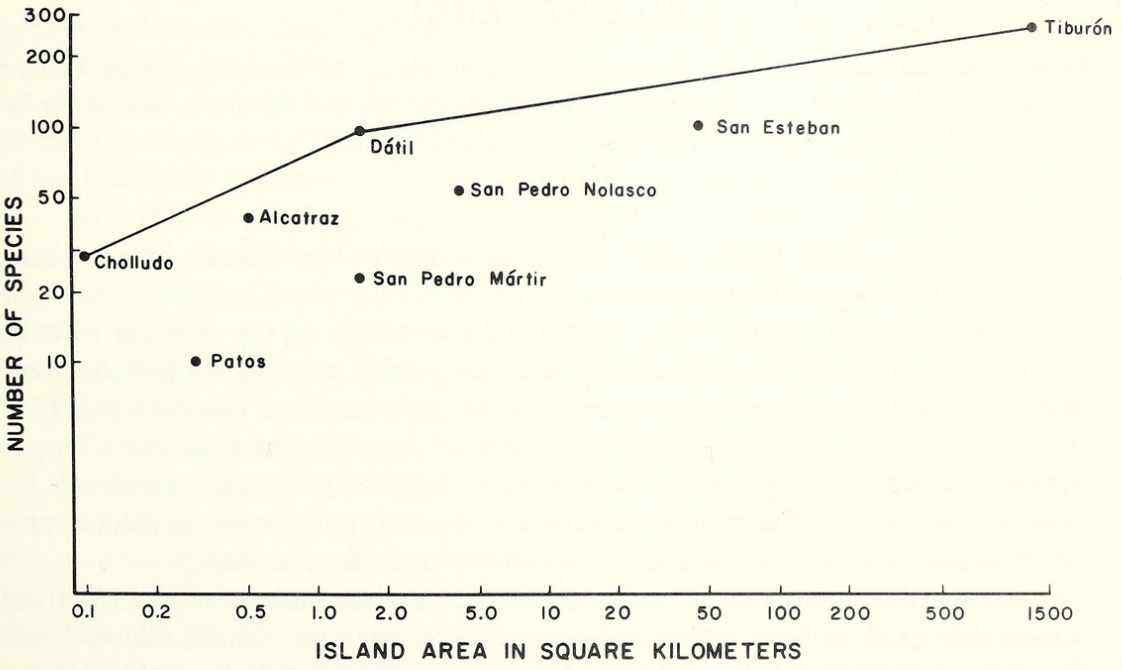

FIGURE 13. Species-area relationships of vascular plants on 8 islands on the eastern side of the Gulf of California. The line drawn through the upper points is a conservative ''saturation curve'' (see text).

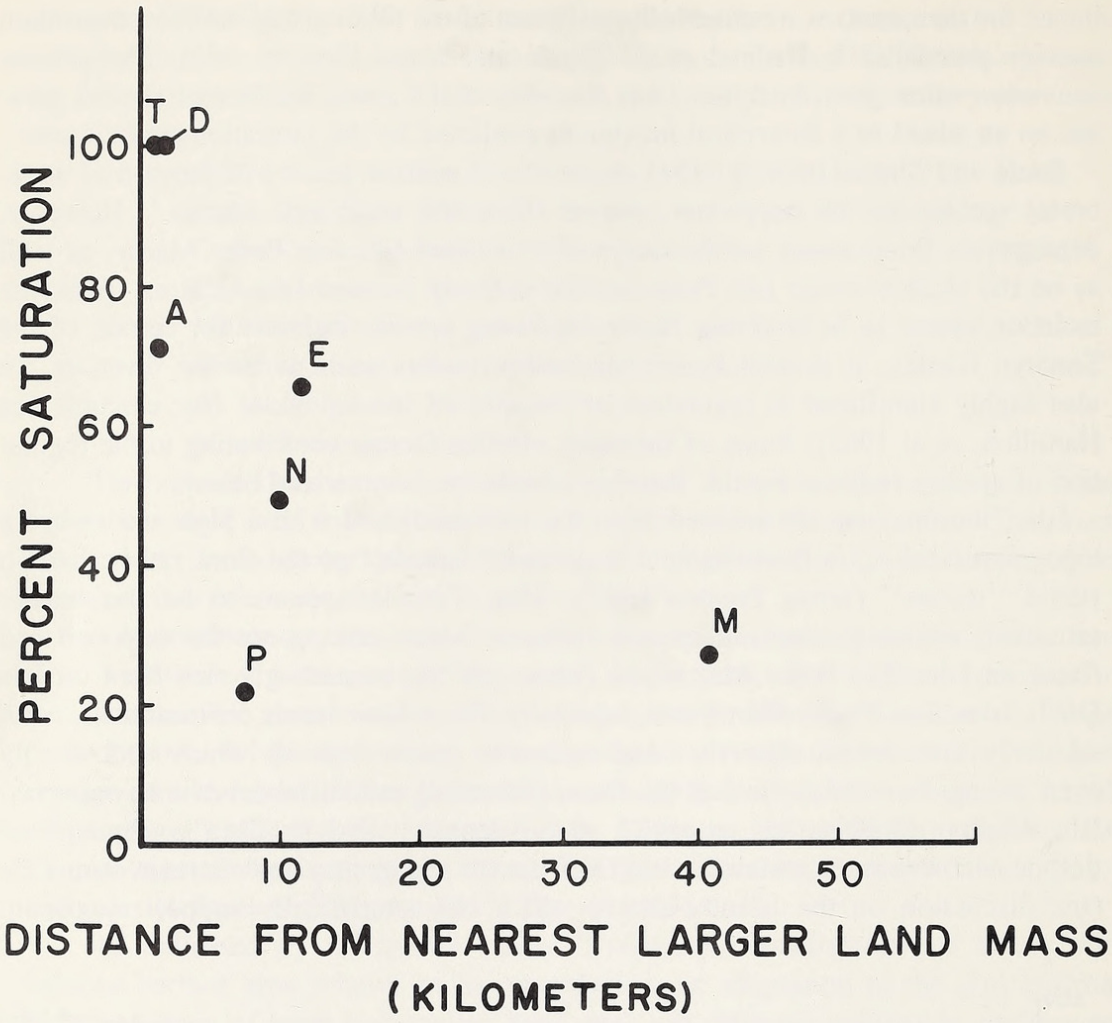

FIGURE 14. Percentage saturation of the floras on 8 islands on the eastern side of the Gulf of California (see Table 3). T=Tiburón, E=San Esteban, N=San Pedro Nolasco, M=San Pedro Mártir, D=Dátil (Turner's), A=Alcatraz, P=Patos, C=Cholludo.

species richness in the Gulf region, and its closeness to Isla Tiburón likewise contributes to the observed floristic richness.

Climatic variation among the smaller islands, and even on the different parts of Isla Tiburón, appear to be sufficient to influence species richness and floristic composition as well as vegetational aspects. For example we have observed that Islas Dátil and Cholludo, lying on the windward side of Sierra Kunkaak on Isla Tiburón, receive summer rains more often than do Islas Patos and Alcatraz, which are far more isolated from any mountain of sufficient mass to produce an orographic precipitation effect. However, there are no weather records for the islands.

Isla San Pedro Nolasco is nearly as complex topographically as Isla Dátil and is more than twice as large in area and more massive, yet it has a much smaller flora. This appears to be largely a function of the greater isolation of Nolasco than Dátil.

In summary, we consider island size, isolation, habitat diversity, aridity, and biotic factors such as absence or presence of mammallian herbivores and guano

deposits to be important factors controlling the evolution and distribution of the flora and vegetation of the islands in the Gulf of California.

CONSERVATION

The ecosystems of the islands in the Gulf of California remain mostly in a natural state. Development is accelerating and rapid environmental degradation is well underway throughout much of the region. Destruction of mangrove and other wetland coastal vegetation on the mainland is occurring at an alarming rate. Development in such areas needs to be contained and carefully planned; these unique tidal wetlands are essential to the continuation of the already threatened fisheries in the Gulf (Findley 1976). The great seabird rookery of Isla Raza has already received protection from the Mexican government. It is not too late for a realistic action plan to set aside the remaining uninhabited islands in the Gulf of California for natural wildlife or ecosystem reservations. This would result in no economic hardship and would be of great future value.

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RESUMEN

Se resumen flora y vegetación de las ocho islas mayores del lado oriental (Sonorense) del Golfo de California, con comentarios sobre la vegetación costera del Golfo en Sonora y Baja California. En orden de tamaño decreciente las islas estudiadas son Tiburón, San Esteban, San Pedro Nolasco, San Pedro Mártir, Dátil (Turner's), Alcatraz, Patos y Cholludo.

Se caracterizan y clasifican las comunidades vegetales mayores, a saber: *Pastizal de zacate marino, matorral del litoral* (manglares arbustivos y arbustos salados), *matorral desértico* (matorral costero, matorral de hediondilla, matorral desértico mixto, matorral de cactus, matorral desértico ribereño y aguajes o tinajas ribereñas) y *matorral espinoso* (matorral espinoso de los llanos, de piedemonte y ribereño).

En las mayores elevaciones de la parte Sur del Desierto Sonorense ocurren tres regiones disjuntas fundamentales de matorral espinoso: 1) sobre la Sierra de la Giganta, en el Sur de Baja California; 2) en la Sierra Kunkaak de la Isla Tiburón y; 3) en las montañas del Noroeste de Guaymas, en Sonora. La subdivisión que Shreve denomina *Piedemonte de Sonora* para este Desierto, se reclasifica como matorral espinoso en lugar de arbustal del desierto.

Se supone que las listas de plantas vasculares que se han dado para cada región están completas excepto en el caso de la Isla Tiburón para la cual estimamos conocer un 85 a 90%. Las cantidades de especies para cada una de las islas son las siguientes: Tiburón 286, San Esteban 107, San Pedro Nolasco 55, San Pedro Mártir 23, Dátil 99, Alcatraz 43, Patos 10 y Cholludo 28. Una novena isla, San Jorge, no tiene vegetación terrestre.

Son mayores las relaciones florísticas entre las islas del lado oriental del Golfo y Baja California que las de las islas del laso occidental y Sonora. Siete especies son endémicas en una o más islas del Golfo, (es decir, el 2, 1 por ciento de la flora de las ocho islas sonorenses). Solamente en la Isla San Pedro Nolasco ocurren endemismos únicos. En la Isla Tiburón, la más grande del Golfo de California, no se conocen plantas endémicas.

La relación positiva entre el área de la isla y el número de especies sufre considerables variaciones en las islas más pequeñas. El tamaño de las islas, el aislamiento, la diversidad topográfica y de habitat, la aridez, la presencia o ausencia de vertebrados herbívoros y los depósitos de guano parecen ser los factores principales que influyen sobre la evolución y distribución de la flora y vegetación de las islas del Golfo de California.

Sólo cuatro especies vegetales no nativas se han establecido en estas islas, lo que indica que tanto la acción del hombre antiguo como la del moderno tuvieron una mínima influencia sobre la biota natural. Esta es una situación rara en nuestros tiempos: la protección de los ecosistemas naturales de las islas del Golfo de California será de gran valor para el futuro.

TABLE 1

Distribution of Vascular Plants on Islas Tiburón, San Esteban, San Pedro Nolasco, San Pedro Mártir, Dátil, Alcatraz, and Cholludo

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Lycopsida								
Selaginellaceae								
Selaginella arizonica Maxon	T[5]							TS ?
Filicae								
Pteridaceae								
Cheilanthes wrightii Hook.	T							RD
Notholaena californica D.C. Eaton	T							MX, RD
N. lemmonii D.C. Eaton			N					MX
Gnetae								
Ephedraceae								
Ephedra aspera Engelm. ex S. Wats.		E						MX
Dicotyledoneae Angiospermae[6]								
Acanthaceae								
Beloperone californica Brandeg.	T	E				A	C	RD, MX
Berginia virgata Harv. ex. Benth. & Hook. var. virgata	T				D			MX, RD, TS
Carlowrightia arizonica A. Gray	T	E			D			MD, RD
Dicliptera resupinata (Vahl) Juss.	T							RD
Elytraria imbricata (Vahl) Pers.	T							RD, TS
Jacobinia ovata A. Gray var. ovata	T							RD, TS
Ruellia californica (Rose) I.M. Johnst.	T							MX, RD, TS
Siphonoglossa longiflora (Torr.) A. Gray	T							MX, RD, TS

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Aizoaceae								
Mollugo cerviana (L.) Ser.	T							CR, MX
M. verticillata L.			N					MX
Sesuvium verrucosum Raf.	T					A		SS
Trianthema portulacastrum L.	T					A		CR, MX, RD
Amaranthaceae								
Amaranthus fimbriatus (Torr.) Benth. ex S. Wats.	T		N		D	A		MX, RD, TS
A. watsonii Standl.	T	E			D	A		MX, RD
Tidestromia lanuginosa (Nutt.) Standl.	T							MX, RD, TS
Apocynaceae (incl. *Asclepiadaceae*)								
Asclepias albicans S. Wats.	T	E			D			MX
A. subulata Dcne. in A. DC.	T							MX
Haplophyton cimicidum A. DC. var. crooksii L. Bens.	T							RD, TS
Marsdenia edulis S. Wats.	T							RD, TS
Matelea pringlei (A. Gray) Woods.	T				D			MX, RD
M. cordifolia (A. Gray) Woods.	T							RD
Metastelma pringlei A. Gray			N					MX
Vallesia glabra (Cav.) Link var. glabra	T							RD
Araliaceae (incl. *Apiaceae*)								
Daucus pusillus Michx.	T							MX, RD

Aristolochiaceae							
Aristolochia brevipes Benth. var. acuminata S. Wats.	T						RD
Asteraceae							
Ambrosia divaricata (Brandeg.) Payne	T				D		MX
A. dumosa (A. Gray) Payne	T						CR, MX
A. ilicifolia (A. Gray) Payne	T	E					MX, RD
Baccharis glutinosa Pers.	T						RA
B. sarothroides A. Gray				M			MX
Bebbia juncea (Benth.) Greene var. aspera Greene	T	E	N		D		MX, RD
Brickellia coulteri A. Gray	T	E					RD
Coreocarpus arizonicus (A. Gray) S. F. Blake var. filiformis (Greenm.) S. F. Blake			N				MX
C. parthenioides Benth. var. parthenioides	T	E			D		MX, RD
Dyssodia concinna (A. Gray) Robinson	T						CR, MX
Encelia farinosa A. Gray ex. Torr.					D	A	CR, MX, CS, RD
E. farinosa var. phenicodonta (S. F. Blake) I. M. Johnst.	T						CR, MX, CS, RD
Eupatorium sagittatum A. Gray	T						RD
Haplopappus sonoriensis (A. Gray) S. F. Blake	T						MX
H. spinulosus (Pursh) DC. ssp. incisifolius (I. M. Johnst.) Hall		E					MX
H. spinulosus (Pursh) DC. ssp. ?	T						MX, CR

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Helianthus niveus (Benth.) Brandeg. cf. ssp. tephrodes (Gray) Heiser	T							CO
Hofmeisteria crassifolia S. Wats.			N					MX, CS
H. fasciculata (Benth). Walp. var. fasciculata	T	E			D		C	MX, CS
Hymenoclea monogyra T. & G.	T							RD
H. pentalepis Rydb.	T							RD
Palafoxia arida Turner & Morris var. arida	T					A		CO, MX
Pectis palmeri S. Wats.	T						C	RD, MX, CS
P. papposa Harv. & Gray var. papposa	T							CR, MX, RD
Pelucha trifida S. Wats.	T			M				MX, CS
Perityle aurea Rose	T							MX, RD
P. cf. aurea Rose		E						MX, RD
P. californica Benth.			N					MX, RD
P. emoryi Torr.	T	E	N	M	D	A	C	MX, RD, CR, CS
Peucephyllum schottii (A. Gray) A. Gray		E						MX
Pleurocornis laphamiodes (Rose) King & Robins.	T	E	N	M	D	A		MX, CS
Porophyllum crassifolium S. Wats.	T	E			D			SS, MX
P. gracile Benth.	T	E			D			MX, RD
P. pausodynum Robins. & Greenm.			N					MX

Trixis californica Kell. var. californica	T	E	N	M	D	MX, RD, TS
Verbesina palmeri S. Wats. ssp. oligocephala (I. M. Johnst.) Felger & Lowe	T					MX, TS
Viguiera deltoidea A. Gray var. chenopodina (Greene) S. F. Blake	T		N	M	D	MX, RD
V. deltoidea var. parishii (Greene) Vasey & Rose		E				MX, RD
Bataceae						
Batis maritima L.	T					MS, SS
Boraginaceae						
Coldenia canescens DC.					D	MX
C. palmeri A. Gray	T					CO
Cordia parvifolia A. DC.	T					MX, CR
Cryptantha angelica I. M. Johnst.	T					MX
C. angustifolia (Torr.) Greene	T	E				CR, MX, RD
C. fastigiata I. M. Johnst.	T	E			D	MX, RD, TS
C. maritima (Greene) Greene	T	E				CR, MD, RD
Heliotropium curassavicum L.	T					RA, SS
Tournefortia hartwegiana Steud.	T					RA
Brassicaceae						
Descurainia pinnata (Walt.) Britt. ssp. halictorum (Cockerell) Detl.	T	E			D	MX, RD
Draba cuneifolia Nutt. ex. T. & G. var. sonorae (Greene) Parish	T	E			D	MX, RD
Lyrocarpa coulteri Hook. & Harv. ex Harv. var. coulteri	T				D	MX, RD

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
L. linearifolia Roll. in Gentry		E						RD
unidentified winter ephemeral	T							RD
Burseraceae								
Bursera hindsiana (Benth.) Engler	T	E			D		C	MX, RD
B. laxiflora S. Wats. ssp. laxiflora	T							MX, TS
B. microphylla A. Gray	T	E	N		D	A		MX, RD
Buxaceae (see Simmondsiaceae)								
Cactaceae								
Carnegiea gigantea (Engelm.) Britt. & Rose	T					A	C	MX, DS
Echinocereus grandis Britt. & Rose		E						MX
E. websterianus Lindsay			N					MX, CS
E. pectinatus (Scheidw.) Engelm. var. scopulorum (Britt. & Rose) L. Bens.	T							MX
Ferocactus wislizenii (Engelm.) Britt. & Rose var. tiburonensis Lindsay	T							MX
Lemaireocereus thurberi (Engelm.) Britt. & Rose	T	E	N	—[7]	D	A	C	MX, CS, TS
Lophocereus schottii (Engelm.) Britt. & Rose var. schottii	T	E[8]			D	A	C	MX, CS
Machaerocereus gummosus (Engelm.) Britt. & Rose	T	E			D		C	MX, CS, CO
Mammillaria dioeca K. Brandeg. ssp. ?					D		C	MX, CS
M. estebanensis Lindsay		E						MX

M. microcarpa Engelm.	T					A		MX
M. multidigitata W. T. Marshall			N					MX, CS
M. tayloriorum Glass & Foster			N					MX, CS
Opuntia bigelovii Engelm. var. bigelovii	T	E			D	A		MX
O. ciribe Engelm. ex Coult.		E						MX
O. fulgida Engelm. var. fulgida	T			M		A		MX, CS
O. fulgida var. mammillata (Schott ex Engelm.) Coult.	T		N		D	A	C	MX, CS, CO
O. leptocaulis DC.	T				D			MX
O. phaeacantha Engelm. var. discata (Griff.) Bens. & Walk.						A		MX
O. wilcoxii Britt. & Rose			N					MX
O. thurberi Engelm. ssp. versicolor (Engelm. ex Coult.) Felger & Lowe	T				D			MX, CS, TS
Neoevansia striata (Brandeg.) Sanch. Mejor.	T				D			MX, CS
Pachycereus pringlei (S. Wats.) Britt. & Rose	T	E	N	M	D	A	C	MX
Campanulaceae								
Nemacladus glanduliferus Jeps. var. glanduliferus		E			D			RD
Capparaceae								
Atamisquea emarginata Miers	T	E					C	MX, CS
Cleome tenuis S. Wats.	T							MX, RD
Caryophyllaceae								
Achyronychia cooperi A. Gray	T							CO, CR, MX
Drymaria holosteoides Benth.	T							CR, MX

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Celastraceae								
Tricerma phyllanthoides (Benth.) Lundell	T					A		MS, SS, RD
Chenopodiaceae								
Allenrolfea occidentalis (S. Wats.) Kuntze	T					A		SS
Atriplex barclayana (Benth.) Dietr.	T	E			D	A	C	SS, CO, CS, MX
A. linearis S. Wats.	T							CO, MX
A. polycarpa (Torr.) S. Wats.	T	E			D			MX, RD
Chenopodium murale L.	T					A		CO, MX
Salicornia europea L.	T							MS, SS
S. virginica L.	T							SS
Suaeda torreyana S. Wats.	T	E			D	A		SS
Suaeda sp.	T							SS
Combretaceae								
Laguncularia racemosa (L.) Gaertn. f.	T							MS
Convolvulaceae								
Cressa truxillensis HBK.	T					A		SS
Cuscuta leptantha Engelm.	T				D			MX
C. corymbosa Ruiz & Pav. var. grandiflora Engelm.		E	N					MX
Cuscuta sp.	T							MX
Evolvulus alsinoides L. var. acapulcensis (Willd.) Oostrtr.	T							MX, TS, RD

Jacquemontia abutiloides Benth. var. eastwoodiana (I. M. Johnst.) Wigg.	T					RD, MX
Ipomoea sp.	T					RD, MX
Cucurbitaceae						
Maximowiczia sonorae S. Wats. var. sonorae	T					RD
Vaseyanthus insularis Rose & vars.	T	E	N	M		MX
Euphorbiaceae						
Acalypha californica Benth.	T	E			D	MX, RD, TS
A. comonduana Millsp.	T					RD, TS
Andrachne ciliato-glandulosa (Millsp.) Croizat	T					MX, RD
Bernardia cinerea Wigg. & Roll.			N			MX
Cnidoscolus palmeri (S. Wats.) Rose	T[5,9]				D	MX, RD
Croton californicus Muell. Arg. var. californicus	T					CO, MX
C. magdalenae Millsp.	T					RD, TS
C. sonorae Torr.	T					MX, RD, TS
Ditaxis lanceolata (Benth.) Pax & Hoffm.	T	E			D	MX, RD
D. serrata (Torr.) Heller	T	E			D	MX, CR, RD
Euphorbia arizonica Engelm.	T					MX, RD
E. eriantha Benth.	T					MX, RD
E. florida Engelm.	T					MX, RD
E. leucophylla Benth.	T					CO
E. magdalenae Benth.	T		N			MX

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
E. misera Benth.	T	E			D			MX
E. pediculifera Engelm.	T	E			D			MX
E. petrina S. Wats.	T	E		M		A		MX, CO
E. polycarpa Benth. var. hirtella Boiss.	T	E			D			MX
E. polycarpa var. polycarpa	T							MX
E. setiloba Engelm.	T	E						MX, RD, CR
E. tomentulosa S. Wats.	T							MX
Jatropha cinerea (Ortega) Muell. Arg.	T							MX
J. cuneata Wigg. & Roll.	T	E	N		D			MX
Pedilanthus macrocarpus Benth.			N					MX
Sapium biloculare (S. Wats.) Pax	T							MX, RD
Tragia amblyodonta (Muell. Arg.) Pax & Hoffm.	T				D			RD
Fabaceae								
Acacia greggii A. Gray	T							RD
A. willardiana Rose	T		N					MX, RD
Calliandra californica Benth.					D			RD, MX
C. eriophylla Benth.	T							MX, RD
C. schottii Torr. ex S. Wats. ssp. rosei (Wigg.) Felger & Lowe	T							RD, TS
Cassia confinis Greene	T							MX

C. covesii A. Gray	T	E	D			MX, CR
Cercidium floridum Benth. ex A. Gray ssp. floridum	T					RD
C. microphyllum (Torr.) Rose & Johnst.	T	E				MX, RD
Coursetia glandulosa A. Gray	T					RD, TS
Dalea emoryi A. Gray	T					MX, CO
D. mollis Benth.	T			A		MX, CR
D. parryi (A. Gray) T. & G	T	E	D			MX
D. vetula Brandeg.	T					MX
Desmanthus covillei (Britt. & Rose) Wigg. ex Turner	T					RD, TS
D. fruticosus Rose	T	E	D			RD, MX
Errazurizia megacarpa (S. Wats.) I.M. Johnst.	T					CO, MX
Hoffmanseggia intricata Brandeg.	T	E	D			MX
Lotus salsuginosus Greene ssp. brevivexillus (Ottley) Munz	T					MX, CR
L. tomentellus Greene	T	E				MX, CR
Lupinus cf. arizonicus S. Wats.	T	E				MX, RD
Lysiloma divaricata (Jacq.) J. F. Macbr.	T					RD, TS
Mimosa laxiflora Benth. in Hook.	T					RD, MX
Olneya tesota A. Gray	T	E	D	A	C	RD, MX
Phaseolus filiformis Benth.	T	E	D			RD, MX
Phaseolus sp.	T[5,9]					RD, MX
Pithecellobium confine Standl.	T		D			MX, RD

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Prosopis glandulosa Torr. var. torreyana (Benson) M. C. Johnst.	T	E			D	A		RD, MX
Tephrosia palmeri S. Wats.	T							MX
Fouquieriaceae								
Fouquieria diguetii (Van Tiegh.) I. M. Johnst.		—[10]	N					MX
F. splendens Engelm. ssp. splendens	T				D			MX, CO
Frankeniaceae								
Frankenia palmeri S. Wats.	T							CO
Hydrophyllaceae								
Eucrypta micrantha (Torr.) Heller	T							RD, MX
Nama hispidum A. Gray	T							MX, CR, RD
Phacelia minutiflora J. W. Voss ex Munz	T							MX
P. crenulata A. Gray	T	E						MX, RD
P. pedicellata A. Gray	T	E			D			MX, RD
Koeberliniaceae								
Koeberlinia spinosa Zucc.	T							MX, RD
Krameriaceae								
Krameria grayi Rose & Painter	T							MX, CR
K. parvifolia Benth.	T							MX
Lamiaceae (Labiatae)								
Hyptis emoryi Torr.	T	E			D			RD, MX
Salvia similis Brandeg.			N					MX

Loasaceae						
Eucnide cordata Kell. ex Curran		E				MX
E. rupestris (Baill.) Thomps. & Ernst	T	E	N		D	MX, CS
Mentzelia adhaerans Benth.	T	E	N	M	D	MX, CS, CR, RD
M. hirsutissima S. Wats.	T					MX
Petalonyx linearis Greene	T	E		M		MX
Malphigiaceae						
Janusia californica Benth.	T				D	RD, TS, MX
J. gracilis A. Gray	T	E			D	MX, RD
Mascagnia macroptera (Sessé & Moc.) Nieden.	T					RD, TS
Thryallis angustifolia (Benth.) Kuntze	T	N				MX
Malvaceae						
Abutilon californicum Benth.	T					RD, MX
A. crispum Sweet	T				D	MX, RD
A. incanum (Link) Sweet ssp. incanum	T				D	MX, RD
A. palmeri A. Gray	T			M		RD
Gossypium klotzschianum Anders. var. davidsonii (Kell.) J. B. Hutch.			N			MX
Hibiscus biseptus S. Wats.	T					MX
H. denudatus Benth.	T	E			D	MX
Horsfordia alata (S. Wats.) A. Gray	T					RD
H. newberryi (S. Wats.) A. Gray	T	E				RD, MX
Sphaeralcea ambigua A. Gray var. ambigua	T				D	MX

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
S. ambigua var. versicolor (Kearney) Kearney		E						MX
S. hainesii Brandegee				M				MX
S. orcuttii Rose	?					A		MX
Martyniaceae								
Proboscidea altheaefolia (Benth.) Dcne.	T							MX, RD
Moraceae								
Ficus petiolaris HKB. ssp. palmeri (S. Wats.) Felger & Lowe	T	E	N	M	D	A	C	RD, MX, CS, TS
Nyctaginaceae								
Abronia maritima Nutt. ex S. Wats.	T					A		SS
Allionia incarnata L.	T				D			MX, CR
Boerhaavia coulteri (Hook f.) S. Wats.	T	E						MX, RD
B. erecta L.	T				D			MX, RD
Boerhaavia sp.			N					MX
Commicarpus scandens (L.) Standl.	T							RD, MX
Mirabilis tenuiloba S. Wats.		E						MX
Onagraceae								
Camissonia californica (Nutt. ex T. & G.) Raven	T							MX, RD
C. cardiophylla (Torr.) Raven ssp. cardiophylla	T	E		M				MX
C. chamaenerioides (A. Gray) Raven	T							MX, RD

Oenothera californica S. Wats. ssp. arizonica (Munz) Klein	T							CO, MX
Papaveraceae								
Argemone subintegrifolia Ownby		E						MX
Eschscholzia minutiflora S. Wats.	T							MX
Passifloraceae								
Passiflora arida (Mast. & Rose) Killip var. arida	T	E						MX, RD
P. palmeri Rose	T	E			D			MX, RD
Phytolaccaceae								
Phaulothamnus spinescens A. Gray	T		N		D	A	C	MX, RD, CS
Stegnosperma halimifolium Benth.	T	E		M	D		C	MX, RD, CS
Plumbaginaceae								
Plumbago scandens L.	T							RD, TS
Poylgonaceae								
Eriogonum inflatum Torr. & Frem.	T	E						MX
Portulacaceae								
Portulaca lanceolata Engelm. & Gray	T							MX
P. parvula A. Gray	T							MX
Portulaca sp.	T							MX
Resedaceae								
Oligomeris linifolia (Vahl) Macbr.	T	E			D			MX, CR
Rhamnaceae								
Colubrina viridis (Jones) M. C. Johnst.	T	E	N		D		C	MX, RD, CS
Condalia globosa I. M. Johnst. var. pubescens I. M. Johnst.	T	E			D			MX, RD
Zizyphus obtusitolius (T. & G.) A. Gray var. canescens (Gray) M. C. Johnst.	T	E			D			RD, MX

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Rhizophoraceae								
Rhizophera mangle L.	T							MS
Rubiaceae								
Randia thurberi S. Wats.	T							MX, RD, TS
Salicaceae								
Salix gooddingii Ball. var. gooddingii	T							RA
Sapindaceae								
Cardiospermum corindum L.	T				D			MX, RD
Dodonaea viscosa Jacq.	T							RD, MX
Sapotaceae								
Bumelia occidentalis Hemsl.	T							RD
Sideroxylon leucophyllum S. Wats		E						MX, RD
Scrophulariaceae								
Antirrhinum cyathiferum Benth.	T	E	N		D		C	MX, RD CS, CR
A. kingii S. Wats. var. watsonii (Vasey & Rose) Munz	T				D			MX, RD
Galvezia juncea (Benth.) Ball var. pubescens (Brandeg.) I. M. Johnst.		E	N					RD, MX
Linaria canadensis (L.) Dum-Cours. var. texana (Scheele) Penn.	T							RA
Stemodia durantifolia (L.) Sw.	T							RA
Simaroubaceae								
Castela polyandra Moran & Felger	T							MX

Simmondsiaceae								
Simmondsia chinensis (Link) Schneid.	T	E	N		D			MX, RD
Solanaceae								
Datura discolor Benth.	T				D	A		MX, RD
Lycium andersonii A. Gray var. andersonii	T	E						RD, MX
L. andersonii var. deserticola (Hitchc.) Jeps.	T							RD, MX
L. brevipes Benth. var. brevipes	T	E		M	D	A	C	CS, MX, RD
L. californicum Nutt. ex Gray ssp. californicum	T							CO, MX
L. fremontii A. Gray var. fremontii	T							MX, RD
L. megacarpum Wigg.		E						MX
Nicotiana clevelandii A. Gray	T							MX, RD
N. trigonophylla Dunal	T	E		M	D	A	C	MX, RD, CS
Physalis crassifolia Benth. var. versicolor (Rybd.) Waterfall	T							MX
P. crassifolia var. infundibularis I. M. Johnst.		E						MX
P. pubescens L.	T							RA
Solanum hindsianum Benth.	T	E			D			MX, RD
Sterculiaceae								
Ayenia compacta Rose	T	E						MX
A. glabra S. Wats.	T							RD, TS
Melochia tomentosa L. var. tomentosa	T		N		D			MX, RD
Tamaricaceae								
Tamarix ramosissima Ladeb	T							RA

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Theophrastaceae								
Jacquinia pungens A. Gray	T							MX, RD
Ulmaceae								
Celtis pallida Torr.	T							RD, MX
Urticaceae								
Parietaria floridana Nutt.	T	E	N		D			RD, MX
Verbenaceae								
Avicennia germinans (L.) Stearn	T							MS
Lippia palmeri S. Wats.	T				D			MX, RD
Violaceae								
Hybanthus fruticulosus (Benth.) I. M. Johnst. var. flavescens (Dow.) I. M. Johnst.	T							RD, MX
Viscaceae								
Phoradendron californicum Nutt.	T							MX, RD
P. diguetianum Van Tiegh.	T							MX, CR, MS
Zygophyllaceae								
Fagonia californica Benth.	T				D			MX
F. pachyacantha Rydb. in Vail & Rydb.	T							MX, CR
F. palmeri Vasey & Rose	T							MX
Guaiacum coulteri A. Gray	T							RD, TS
Kallstroemia californica (S. Wats.) Vail var. brachystylis (Vail) Kearn. & Peebl.	T				D			MX, CR, RD
K. grandiflora Torr. ex A. Gray	T							MX, CR, RD

Larrea divaricata Cav. ssp. tridentata (Sessé & Moc. ex DC.) Felger & Lowe	T							CR, MX
Viscainoa geniculata (Kell.) Greene var. geniculata	T	E		M	D	A	C	MX, CS
Monocotyledoneae								
Cyperaceae								
Cyperus aristatus Rottb.				M				MX
C. elegans L.	T							RA
Eleocharis geniculata (L.) R. & S.	T							RA
Liliaceae								
Agave chrysoglossa I. M. Johnst.	T		N					MX
A. dentiens Trel.		E						MX
A. subsimplex Trel.	T				D	C		MX
Poaceae								
Aristida adscensionis L.	T	E	N	M	D			MX, CR, RD
A. californica Thurb. ex S. Wats.	T							CO, MX
A. ternipes Cav.	T		N					MX
A. wrightii Nash	T							MX
Bothriochloa barbinodis (Lag.) Herter			N					MX
Bouteloua aristidoides (HBK.) Griseb.	T	E	N		D	A	C	MX, CR, CS
B. barbata Lag.	T	E				A		MX, CR
Cathestecum erectum Vasey & Hack.	T							MX, RD, TS
Cenchrus palmeri Vasey	T	E	N			A		CO, MX
Chloris brandegeei (Vasey) Swallen		E						MX, RD
Distichlis spicata (L.) Greene var. stricta (Gray) Beetle	T							RA

TABLE 1 (cont'd)

	Tiburón	San Esteban	San Pedro Nolasco	San Pedro Mártir	Dátil (=Turner's)	Alcatraz	Cholludo	Community[4] (commonest occurrence)
Eragrostis diffusa Buck.			N					MX
Erioneuron pulchellum (HBK.) Tateoka	T	E			D			MX
Heteropogon contortus (L.) Beauv. ex R. & S.	T	E						MX, RD
Lasiacis sorghoides (Desv.) Hitch. & Chase	T							RA
Leptochloa filiformis Beauv. var. filiformis	T		N					MX, RD, TS
Monanthochloe littoralis Engelm.	T					A		SS
Muhlenbergia microsperma (DC.) Kunth	T	E	N	M			C	MX, RD, TS
Panicum cf. arizonicum Scribn. & Merr.	T	E			D		C	MX, RD
P. capillare L. var. hirticaule (Presl.) Gould	T							RD, TS
Phragmites australis (Cav.) Trin. ex Steud.	T							RA
Setaria liebmannii Fourn.	T							MX, RD
S. macrostachya HBK.	T	E	N		D			MX, RD
Sporobolus cryptandrus (Torr.) A. Gray	T							CO, MX
S. patens Swall.	T							MX, RD
S. virginicus (L.) Kunth	?					A		SS
Trichachne californica (Benth.) Chase	T		N		D		C	MX
Trichloris crinata (Lag.) Parodi			N					MX
Potamogetonaceae								
Ruppia maritima L.	T							SG

Typhaceae				
Typha domingensis Pers.	T			RA
Zosteraceae				
Zostera marina L.	T		A[11]	SG

4. SG = seagrass meadow, MS = mangrove scrub, SS = saltscrub, CO = coast scrub, CR = creosotebush scrub, MX = mixed desertscrub, CS = cactus scrub, RD = riparian desertscrub, RA = riparian *aguaje,* TS = thornscrub and desertscrub-thornscrub ecotone.
5. Presence verified by Seri Indian informants (see Felger and Moser 1970, etc., and unpublished data). We consider these reports to be highly reliable.
6. Family designations follow Thorne (1968).
7. *Lemaireocereus* is reported on San Pedro Mártir by Gentry (1949) and Hastings et al. (1972). This seems to be an error. Neither Reid Moran nor I have found it there.
8. We have not found *Lophocereus* on San Esteban. The report of its occurrence on that island by Hastings et al. (1972) is based on a specimen from that island collected by D. Bostic (SD).
9. Felger and Moser (1976).
10. *Fouquieria diguetii* does not seem to occur on San Esteban, although Gentry (1949) and Hastings et al. (1972) report it is (was) there, and Johnston (1924) infers it was present. Concerning San Esteban and this species, Reid Moran *(personal communication)* says "I have not collected it, do not recollect seeing it, and do not find it listed in my field notes."
11. In beach drift, and probably not growing close offshore from this island.

TABLE 2

Statistical Summary of the Vascular Plants on the Sonoran Islands of the Gulf of California

	The 8 Islands			Tiburón			San Esteban		
	Families	Genera	Species	Families	Genera	Species	Families	Genera	Species
Pteridophytes	2	3	4	2	3	3	—	—	—
Gymnosperms	1	1	1	—	—	—	1	1	1
Dicotyledons	61	187	285	59	176	251	36	79	95
Monocotyledons	6	26	37	6	22	30	2	10	11
Totals:	70	217	327	67	201	286	39	90	107
Ratio of taxonomic diversity	1.0:	3.1:	4.7	1.0:	3.0:	4.3	1.0:	2.3:	2.7

	San Pedro Nolasco			San Pedro Mártir			Dátil		
	Families	Genera	Species	Families	Genera	Species	Families	Genera	Species
Pteridophytes	1	1	1	—	—	—	—	—	—
Dicotyledons	23	40	42	11	20	20	33	79	92
Monocotyledons	2	11	12	2	3	3	2	7	7
Totals:	26	52	55	13	23	23	35	86	99
Ratio of taxonomic diversity	1.0:	2.0:	2.1	1.0:	1.8:	1.8	1.0:	2.5:	2.8

	Alcatraz			Patos			Cholludo		
	Families	Genera	Species	Families	Genera	Species	Families	Genera	Species
Dicotyledons	18	32	36	4	9	9	13	23	23
Monocotyledons	2	5	6	1	1	1	2	5	5
Totals:	19	36	41	5	10	10	15	28	28
Ratio of taxonomic diversity	1.0:	2.0:	2.3	1.0:	2.0:	2.0	1.0:	1.9:	1.9

Largest Genera (number of species):

Euphorbia	11
Opuntia	7
Lycium	6
Mammillaria	5

Abutilon	4
Aristida	4
Cryptantha	4
Dalea	4

The 8 Islands:	*Number*	*Percent*		*Number*	*Percent*
Asteraceae	22 (33)	10.1 (10.1)	Solanaceae	5 (10)	2.3 (3.1)
Fabaceae	18 (29)	8.3 (8.9)	Acanthaceae	8 (8)	3.7 (2.4)
Poaceae	20 (28)	9.2 (8.6)	Boraginaceae	5 (9)	2.3 (2.8)
Euphorbiaceae	11 (26)	5.1 (8.0)	Chenopodiaceae	5 (9)	2.3 (2.8)
Cactaceae	10 (22)	4.6 (6.7)	Apocynaceae	6 (8)	2.8 (2.4)
Malvaceae	5 (12)	2.3 (3.7)			
Tiburón:					
Asteraceae	21 (28)	10.4 (9.8)	Malvaceae	4 (10)	2.0 (3.5)
Fabaceae	18 (28)	9.0 (9.8)	Chenopodiaceae	5 (9)	2.5 (3.2)
Poaceae	16 (24)	8.0 (8.4)	Acanthaceae	8 (8)	4.0 (2.8)
Euphorbiaceae	9 (24)	4.5 (8.4)	Boraginaceae	5 (8)	2.5 (2.8)
Cactaceae	10 (13)	5.0 (4.6)	Apocynaceae	5 (7)	2.5 (2.5)
Solanaceae	5 (10)	2.5 (3.5)			
San Esteban:					
Asteraceae	12 (14)	13.3 (13.2)	Solanaceae	4 (5)	4.4 (4.7)
Fabaceae	10 (10)	11.1 (9.4)	Malvaceae	3 (3)	3.3 (2.8)
Poaceae	9 (10)	10.0 (9.4)			
Euphorbiaceae	4 (9)	4.4 (8.5)			
Cactaceae	6 (7)	6.7 (6.6)			
San Pedro Nolasco:					
Poaceae	10 (11)	19.6 (20.0)			
Asteraceae	8 (9)	15.7 (16.4)			
Cactaceae	5 (7)	9.8 (12.7)			
Euphorbiaceae	4 (4)	7.8 (7.3)			

TABLE 2 (cont'd)
Largest Families (General & Species)

Dátil:	*Number*	*Percent*
Asteraceae	10 (11)	11.6 (11.3)
Cactaceae	7 (10)	8.1 (10.3)
Fabaceae	9 (9)	10.5 (9.3)
Euphorbiaceae	6 (9)	7.0 (9.3)
Poaceae	6 (6)	7.0 (6.2)

TABLE 3

Geographic Data for the Sonoran Islands

Island	Area (km^2)	Nearest larger land Mass and distance	Highest Elevation	Number of Species
Tiburón	ca 1210	Punta Santa Rosa, Sonora 1.4 km	875	286
San Esteban	43	South shore Tiburón 11.6 km	550	107
San Pedro Nolasco	3.5	Punta San Pedro, Sonora 10.0 km	318	55
San Pedro Mártir	1.5+	Punta Monumento, south shore Tiburón 40.7 km	320	23
Dátil	1.5	Punta Monumento, south shore Tiburón 1.9 km	183	99
Alcatraz	0.5	Bahía Kino, Sonora 1.4 km	130	43
Patos	0.3	Northwest shore Tiburón 7.3 km	69	10
Cholludo	ca 0.1	North shore Dátil ca 0.5 km	ca 75+	28

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