

# A COMPARISON OF ESTIMATED HISTORIC AND CURRENT VEGETATION COMMUNITY STRUCTURE ON GUADALUPE ISLAND, MEXICO

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**Abstract**—The vegetation of Guadalupe Island has been devastated by a minimum of 150 years and possibly 200 years of heavy grazing by introduced goats. Much of the island is bare soil, and the loss of plant cover has caused severe erosion and soil loss. Where there is plant cover, introduced weeds dominate. For example, *Nicotiana glauca* is a dominant on many of the slopes on the northern part of the island due to its natural adaptation to the island's climatic and soil conditions and because it is apparently undesirable to the goats. Survival of the remaining vegetation is primarily dependent on being less accessible to the goats. Taller and longer lived woody plants whose crowns are above the grazing line survive on portions of the island though they are gradually declining from loss of soil and old age. Patches of the herbaceous natives that are able to tolerate grazing may also be found in grasslands predominantly composed of Mediterranean weeds. Individual native plants also survive in low numbers on cliff faces and rocky ridges, though goats are able to reach seemingly unreachable locations. The only reasonably intact native vegetation is found on the offshore islets where goats have never occurred and where few humans have landed. At the time of visitation of the island by Edward Palmer in the late 1800s, the vegetation was quite different. Using Palmer's notes and early descriptions of the island, it is possible to reconstruct the vegetation that existed on Guadalupe Island. It is known that *Juniperus californica* formed a dominant community in the north, central portion of the island. Furthermore, the cypress and pine forests were much more widespread than they are currently. It is also likely that many of the succulent species that are nearly completely confined to the islets were widespread on the main island during and preceding Palmer's time.

*Keywords: Baja California, cypress, goats, grazing, Guadalupe Island, pines, vegetation*

## INTRODUCTION

Guadalupe Island is located off of the west coast of Baja California (Fig. 1). The first documented observations of Guadalupe Island were made in 1602 by members of an exploratory team lead by Juan Sebastian Vizcaino. This expedition of four small ships was his second attempt to explore and map the west coast of the Californias. Father Antonio De La Ascension on this expedition wrote of an encounter with a large island that was undoubtedly Guadalupe (Wagner 1929, pp. 227–228):

In order not to encounter another gale like the past one [they had frequent problems with weather] by sailing close to land, and in order not to see Cabo del Engano [probably Punta Eugenia] they sailed five

days continuously to the west. At the end of this time they found themselves some eight leagues [4–5 km] away from a large island, which was thought to be the one the sailors from China call "Pajaros" ['birds'].

Although they made every effort to land on it, it was not possible to reach it, as the strong contrary wind prevented it. Two days they spent in these efforts trying to land some men on it, but it was not possible.... In order not to perish there without any hope, they determined to return towards the mainland, so that if the ship did open up and founder, the men might save themselves by being near land.

Two hundred and thirty years passed between Father de la Ascension's observations of the

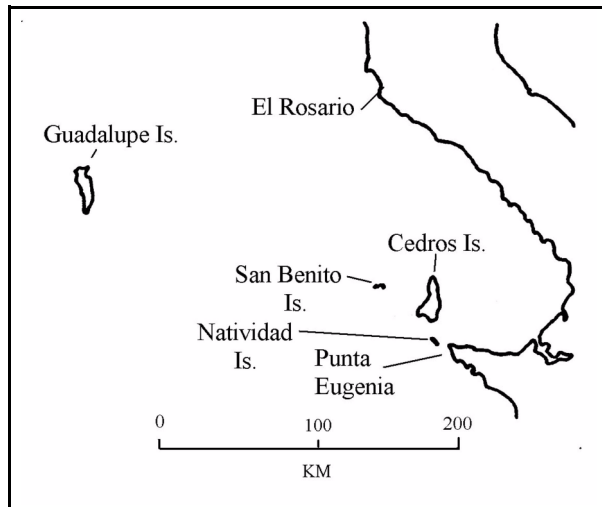


Figure 1. Location map.

attempted landing by Vizcaino's men and the next written account of the island. But the island nevertheless became more known partially as a result of Vizcaino's maps. In the mean time, beginning in the late 1700s and through the mid 1800's, Guadalupe was continuously visited by fur seal, otter and elephant seal hunters (Scammon 1874, Townsend 1931, Ogden 1941). The first detailed description of Guadalupe Island was by A. Du Petit-Thouars (1956, p. 90) in his diary of the voyages of the frigate *Venus* in 1836. In November, they left the coast of California and set a course to Guadalupe Island. They wished to verify the position and study hydrography. On November 17, the island was sighted and observed from the ship. He wrote:

The island of Guadalupe is very high. On all sides it shows steep sides which seem impossible as disembarkment points except on the N. E. and S. S. E.... This island, evidently of volcanic origin, is not inhabited and we saw no signs that it ever had been. Furthermore, it seemed from its sterile nature hardly susceptible to receive any population other than those who establish themselves there temporarily for seal hunting. The vegetation that we saw on Guadalupe Island did not appear very vigorous. The island is wooded only on that part of its northern slope which faces to the N. N. E., but in several ravines on

the east coast and some hollows in the surface we saw some bushes and stunted trees. Elsewhere it is covered by sparse vegetation which often leaves the rocks uncovered. We observed water nowhere but the eastern slopes seem to us to be cut by several beds of torrents, then dry, which led us to presume that during the winter and part of the spring water may be found on this island.

While Du Petit-Thouars only observed the island from the water, he did not indicate whether or not goats were already present on the island. Judging by the numbers that were present at the time of Palmer's visit, 39 years later and the adverse grazing effects that already existed at the time of his visit, they were likely already present at the time of Du Petit-Thouars' visit.

On 17 March 1859, Janos Xantus, a Hungarian who was a member of the United States Army but who also worked for the Smithsonian Institution, visited Guadalupe Island for several hours (Madden 1949). Mr. Xantus was an avid avian collector and discoverer of a number of species new to science, but he was also known to be a fabricator of information. While he made no collections on this visit, he described the island as being entirely covered with gigantic cacti, groves of heavy timber, tall palms, an exotic list of birds, and dark colored jackrabbits. The description would fit a combination of islands in the Sea of Cortez and western Mexico. He did, however, mention that there were 10,000 goats on the island.

In 1874, someone under the apparent pseudonym of "Buena Esperanza" which translated means "good hope" wrote an account of Guadalupe Island in *Forest and Stream* (Esperanza 1874). The article, titled "La Isla de la Piel de Oro, Sin Duda Alguna" was clearly biased because it was intended to extol the virtues of the island in order to attract investors into a goat-rearing scheme to produce Angora wool. However, it does provide a glimpse of the habitat. The article mentions forests on Guadalupe Island consisting of 4,500 acres of "white cedar and pine", likely referring to the cypress (*Cupressus guadalupensis*) and Monterey pines (*Pinus radiata* var. *binata*). The article also refers to "spruce timber," possibly California juniper (*Juniperus californica*), over the central part

of the island and makes reference to the presence of sycamores, *Platanus*, that apparently never did exist there. Edward Palmer became intrigued after reading this article and became the first scientific explorer to visit the island (Watson 1876). Much of the early documentation on the flora and fauna of the island was the result of his visits.

Following the mapping of Guadalupe by Vizcaino, the opportunity existed for any mariner to release goats onto the island. Captain Cooke was famous for releasing goats onto islands during his voyages in 1775–1778. Seal and otter hunters rose to prominence in the area shortly after the turn of the nineteenth century (Pourade 1961, pp. 93–94). Janus Xantus, as unreliable as he was, mentioned 10,000 goats in 1859 and the Esparanza article, another exaggeration, mentioned that in 1870 it was estimated that there were 100,000 goats on the island. When considering the length of time necessary for a few goats to become established and propagate, and the time that it takes for them to cause damage, a likely period of goat introduction would have been between 1800 and 1825. One would expect that a period of roughly 50 or more years would be necessary to generate the number of goats and the vegetation damage that already existed at the time of Palmer's arrival.

The objectives of this paper are to compile historical records documenting the extent and coverage vegetation communities on the island and attempt to assess what combinations of species would have likely formed these vegetation communities and then create a map of their potential distribution. This information may be used not only to evaluate the historical vegetation but may also be of interest for any efforts to restore the island's native vegetation.

## METHODS

Beginning with Palmer in 1875, collectors have documented species of plants and animals that occurred on Guadalupe Island. Individual notes and discussions in early published accounts have also included some anecdotal references to the distribution and abundance of the species of plants and birds that were collected. These collections, and the publications describing them, comprise a list of species that can be used as a basis for a

discussion of what may have comprised vegetation communities prior to the arrival of goats.

Personal observations of the vegetation and species composition that remains on Guadalupe Island were made during a series of visits I made to the island from April 1979 through the spring of 2000. During these visits, the pine, palm and cypress forests were hiked extensively. The lowlands and south mesa were visited by means of forays from boats. In the spring of 2000, the entire island was circumnavigated by helicopter and explorations were made to the offshore islets where the vegetation was observed in its apparent pristine form.

Proposals for vegetation communities were made through observation of the remnant distribution of species on Guadalupe Island in comparison with the form and morphology of modern vegetation communities on the California Channel Islands and mainland of California and Baja California. For example, the Guadalupe sage scrub community is proposed to be made up of a series of species or species relatives that occur in sage scrub habitats in other locations in California and Baja California, both on the mainland and on adjacent islands, though little or none of such a community with these assembled species still remains on the island. The proposed distribution of these communities is based on the original locations of specimens collected from historical data as well as a number of other factors as follows:

- 1) Assessment of likely precipitation patterns when considering adiabatic increases in precipitation and topographic features; precipitation levels as indicated from data from locations on the California Channel Islands and Point Loma in San Diego County provide guidance for estimates of precipitation levels and patterns on Guadalupe Island when extrapolated from the data that has been collected on the south end of the island.

- 2) Slope aspect and exposure; these factors also affect vegetation when considering the augmentation of moisture from persistent spring and summer cloud patterns and fog condensation (Oberbauer 1993).

- 3) Color satellite imagery of the island with a resolution of 20 m and high resolution digital image data (USDA Forest Service 2004) were utilized when interpreting and delineating the map of pristine vege-

tation on the island. The maps are intended to depict vegetation as it currently appears (Fig. 2) and as depiction of the vegetation prior to the introduction of goats in the early part of the nineteenth century (Fig. 3).

4) Information on the spatial relationship of plant species and vegetation communities in comparable environments on the mainland of California and Baja California and the adjacent islands.

#### *Vegetation Communities*

The vegetation on modern day Guadalupe Island has been suffering from approximately 200 years of heavy grazing and browsing by goats. The vegetation is now so sparse that it is difficult to do

more than map the scattered remnants (Fig. 2). Much of what originally occurred on the island has been replaced by non-indigenous species or nearly barren land. The cypress forest also declined precipitously. The major areas where the vegetation may resemble a relatively intact community are on the south-east side of the island, where *Lycium*, *Atriplex* and *Ambrosia* occur together, and the southern mesa where *Deinandra greeneana* and *D. palmeri*, *Sphaeralcea palmeri*, and *Lupinus niveus* form a vegetative cover.

Notes by Palmer and others (Gray 1876, Watson 1876, Greene 1885, Anthony 1925, Moran 1996) provide some insight regarding the occurrence of vegetation assemblages and their dominant species. Meling-Lopez (1985) examined the species composition of vegetation that exists on Guadalupe Island in modern times, along with discussion of the weedy communities that remain. Here, based on the vestiges of native plant populations that exist on the island, some in loose associations that provide a hint into their former assemblages, I make an attempt to reconstruct the vegetation communities that existed in the past.

Finally, vegetation communities were also mapped with assumptions for their distribution prior to impact from goats (Fig. 3). The original vegetation that occurred on Guadalupe Island is vastly different than the vegetation currently found on the island. Estimates of cover for the various vegetation communities prior to the introduction of goats, as well as modern times, depict a total loss of sage scrub and other communities (Table 1). A listing of species within each community is found in the Appendix.

## RESULTS

### *Pine Forest*

Within the pine forest, *Pinus radiata* var. *binata* is not only the defining species, but virtually the only woody species present. Prior to the introduction of goats, the pines would have formed nearly pure stands. However, other species that would have historically occurred with the pines are species of *Ceanothus*, *Arctostaphylos* and *Heteromeles*. The pine forest appears to be confined to areas where fog is prevalent during spring, summer and fall. Guadalupe Island is noteworthy for its location in the midst of the

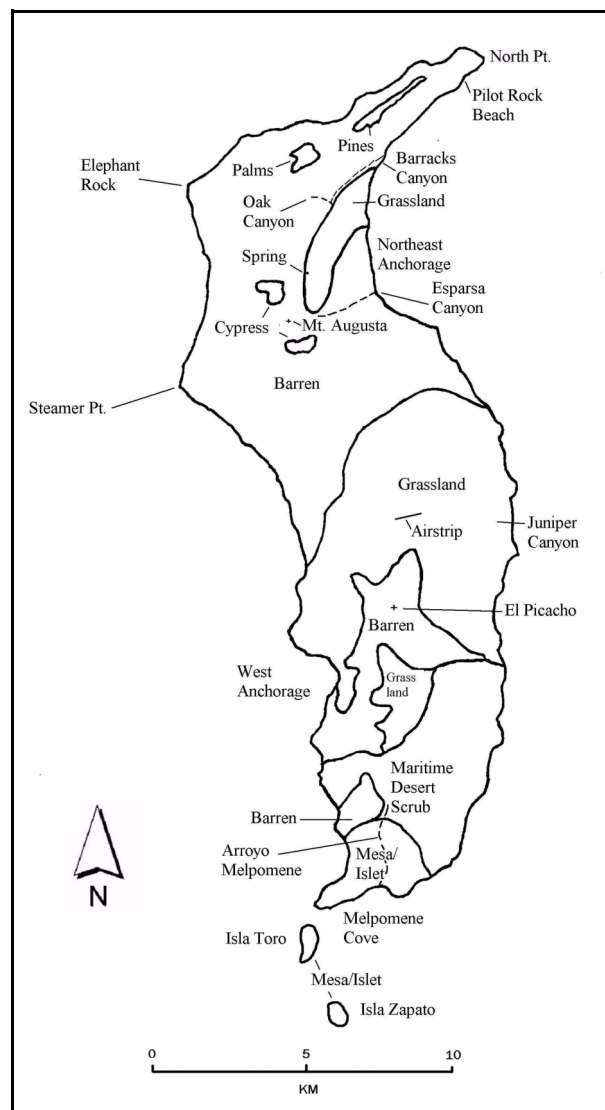


Figure 2. Modern Guadalupe Island vegetation and landmarks.

California current, where coastal stratus clouds form as a result of cool ocean temperatures. For days at a time, the northern end of the island is subjected to clouds banking up and pouring over the high ridges. Over a comparable time period 62% of the summer days are cloudy or partly cloudy on Guadalupe Island, in contrast to 19% of the days at San Diego (Oberbauer 1993).

*Pinus torreyana* in San Diego County grows in locations that receive an average seasonal precipitation of 270 mm. *Pinus radiata* and *P. muricata* grow in locations in California that receive between 330 mm and 510 mm of rain per season (State of California 1981), however, condensation from wind driven fog may substantially increase that amount (Zinke 1964, McDonald and Laacke 1990). Near Erendira on the Baja California mainland, *P. muricata* grows on a low mountain range and in low elevation canyons that receive as little as 203 mm of rainfall (Hastings and Humphrey 1969). On Guadalupe Island, pines grow under rainfall conditions that are likely to be similar to those of the pines in California and Baja California, and the fog condensation is likely to supplement this precipitation, especially during years of low rainfall.

The largest pine on Guadalupe Island, with a trunk approximately 2.1 m in diameter, grows at the upper limit of the existing distribution. These pines grow to large size, with the tallest being 30 m and a number of them over 25 m tall. As an indication of their continued decline, the pine forest currently consists of approximately 202 widely scattered trees (D. Rogers pers. comm. 2002), dropping from 383 in 1960s (Libby et al. 1968).

#### Cypress Forest

Cypress forest composed of *Cupressus guadalupensis* form what still appears to be relatively dense stands in two large patches on the upper portion of the island, near the highest peak. At an elevation of 1200 m, the presence of the cypress is probably due to the higher precipitation that increases with elevation. While this area is occasionally exposed to wind driven fog, because of its higher elevation it is frequently above the cloud layer and does not receive the same high level of fog condensation that occurs at somewhat lower elevations in the pine forest on the north end of the island. Tecate cypress in San Diego County

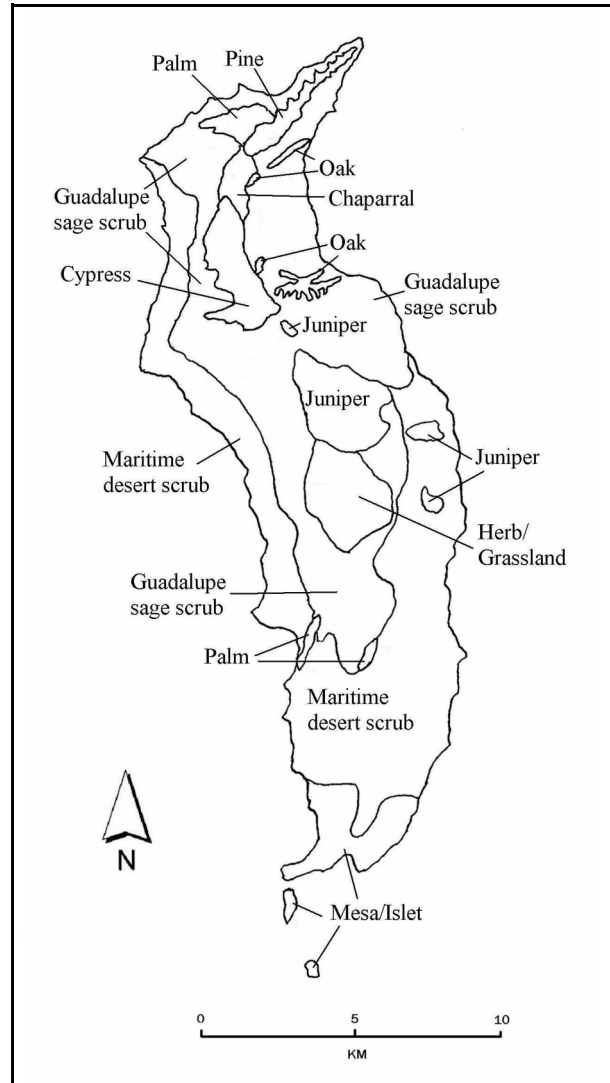


Figure 3. Estimate of vegetative cover on Guadalupe Island before human contact.

grows in canyons that receive approximately 300 mm of rain per season (State of California 1981), but the broader distribution of the trees probably receives between 380–450 mm of rain per season. The rainfall in the area of the cypress on Guadalupe Island may fall within a similar range. On Guadalupe Island the cypress commonly grow between 12 and 18 m tall, somewhat larger than the mainland populations of related cypress. While few native plants currently grow within the cypress stands, Franceschi (1893) found the remnants of what must have been an extensive understory of *Ceanothus crassifolius*, and it is likely *Heteromeles* would have grown with them in pristine times as they do in mainland stands.

Table 1. Vegetation coverage on Guadalupe Island estimated for 1800 (prior to goat introduction) and 2000.

Community	1800 - area km <sup>2</sup>	Percent of island	2000 - area km <sup>2</sup>	Percent of island
Pine forest	6.5	2.5%	<0.1	<0.1%
Cypress forest	9.5	3.7%	1.4	0.5%
Juniper woodland	12.0	4.7%	0.0	0.0%
Palm forest	7.5	2.9%	0.8	0.3%
Oak/canyon woodland	3.0	1.2%	0.0	0.0%
Chaparral	6.0	2.3%	0.0	0.0%
Herb/grassland	12.5	4.9%	128.2	50.2%
Mesa/islet	12.0	4.7%	12.0	4.7%
Guadalupe sage scrub	76.0	29.7%	0.0	0.0%
Maritime desert scrub	105.5	41.3%	8.0	3.1%
Bare earth	5.0	2.0%	105.0	41.0%

### *Chaparral*

The chaparral vegetation community that would be expected on Guadalupe Island is now absent. Components of chaparral communities, including several species of *Ceanothus*, *Arctostaphylos*, and *Heteromeles*, were formerly collected on the island and even formed chaparral stands as indicated by Franceschi (1893). On the mainland near where cypress and Monterey pines grow, chaparral grows in the openings between the trees and forms a vegetative mosaic around and between groves and forests of trees. Chaparral also typically grows lower on the slopes in conditions that are less favorable for the trees. On the prehistoric island, chaparral would have grown along the entire ridge connecting the cypress and pine forests (Fig. 3). Recently, *Ceanothus* has been rediscovered on Guadalupe Island within exclosures constructed around portions of the forested areas of the island (S. Junak pers. comm.).

### *Guadalupe Sage Scrub*

A form of sage scrub vegetation was described in the writings of the early explorers to the island. This sage scrub community would have been one of the most widespread on the island, extending down to the water line on the northeast side and up to the forests and chaparral on the upper portions of the island. This community no longer exists. Remnant individual plants may be found on some of the steepest cliffs but it has been eliminated on the lowlands.

*Satureja palmeri* was mentioned as a dominant on the slopes approaching the lower elevations on the island, and Watson (1876) attributed its

abundance to the fact that it was less palatable to goats. However, the goats likely eliminated it as a member of this plant community at an early time. Other species that would have occurred with it are a unique mix of low shrubs, some with showy flowers such as *Senecio palmeri* and *Crossosoma californica*. Palmer described vast areas where *Senecio* was present. *Galvesia speciosa* would have grown in rocky areas. *Artemisia californica*, the common California sage brush, was collected from a number of places on the island and would have also occurred in this community. The *Crossosoma* is listed here as a sage scrub component in spite of typically being associated with steep cliffs. However, I found it on San Clemente Island in 1979, prior to the removal of goats, on flat ground in an area where goat grazing was less common.

### *Maritime Desert Scrub*

The southeastern portion of the island also supports what appears to be natural combinations of *Atriplex barclayana*, *Ambrosia camphorata* and *Lycium californicum*, forming a low shrub vegetation. Goats are apparently less numerous in this location due to the aridity and lower level of condensation and moisture. This community is widespread on the lower slopes of a number of the California and Baja California Islands and on the adjacent mainland.

### *Oak/Canyon Woodland*

A form of woodland dominated by *Quercus tomentella* grows in the deep canyons on the northern end of the island. It would have extended

from the lower elevations up into the pine and palm forests. Associated species would likely have been *Rhamnus pirifolia*, *Heteromeles arbutifolia*, and the now extinct *Hesperalea palmeri*. Oaks are currently very limited on Guadalupe Island as they are not reproducing and are gradually succumbing to the effects of erosion.

#### *Palm Forest*

*Brahea edulis* forms an extensive stand on the northwestern side of Guadalupe Island. Palms are also found in numbers along the bottoms of drainage channels throughout the island, including the dry southeastern and southwestern sides of the island and the southwest coast and upper Melpomene arroyo. Other species that likely would have occurred include *Lonicera hispidula* var. *vacillans*, *Marah macrocarpa* and *Senecio palmeri*. In some of the canyons on the northwestern side of the island the palms grew into the pine forest. Based on comparison of photographs from the 1950s in Moran (1996) with more recent observations, it appears that the density of palms has declined significantly in the last 50 years.

#### *Herb/Grassland*

Where the soils are deeper and finer, grassland vegetation naturally occurred on the island. Prior to the introduction of goats, the main location of this community would have been the region surrounding the present airstrip in the central portion of the island. *Nasella lepida* would have been a dominant plant and *Dissanthelium californicum* would have occurred in a lower abundance. Several forbs which still occur in the grasslands but likely would have been more abundant, include *Lasthenia californica*, *Layia platyglossa*, *Gilia nevini*, and *Guillenia lasiophylla*. *Pogogyne tenuiflora* was found in the area near the spring and among openings in the shrubs, though it was probably quite limited in area even prior to the introduction of goats. Modern areas of grassland in the northern parts of the island have been the result of the removal of the shrub vegetation by the goats.

#### *Guadalupe Mesa/Islet Scrub*

One of the most interesting communities on Guadalupe Island is found on the southern-mesa and may have extended up into Arroyo

Melpomene. It also occurs on the islets off the southern end of the main island (Rebman et al. 2002). It is composed of a mix of succulents and non-succulent species, the most notable being *Cistanthe guadalupensis*, a sausage stemmed shrub in the Portulacaceae with succulent leaves and wands of pink flowers which appear during a short period in spring. Other species that have significant cover are *Deinandra greeneana*, *Deinandra palmeri*, and *Lavatera lindsayi*. *Lavatera* forms patches of leafy growth in the midst of the *Cistanthe*. *Stephanomeria guadalupensis* is another species that has been found in a few locations on the main island, but is dominant on the islets. Fruticose and foliose lichens are also a major component of this community providing a leafy and crusty cover for the exposed rocks.

The succulent leaves and stems of several of the species in this community have made them prime targets for goat grazing. On the main island, many elements of the vegetation survive but others, including the *Stephanomeria*, *Cistanthe* and *Lavatera*, were either grazed to extinction or are now very rare. Due to their inaccessibility, vegetation on the two main islets off the southern end of Guadalupe survive in a pristine condition with no grazing and very few weeds.

#### *Juniper Woodland*

A number of early researchers including Palmer and Anthony (Watson 1876, Anthony 1925), described extensive stands of California juniper in the area north of what is now the valley with the airstrip and extending down the east side of the island. From their descriptions this was nearly a pure stand of juniper, but was likely mixed with some sage scrub components similar to juniper woodlands occurring on Cedros Island, approximately 220 km to the southeast. The trees were dead and dying at the time Palmer visited the island and had virtually disappeared by the early 20<sup>th</sup> century. Moran (1996) found a few 5-m tall trees in east side canyons in the 1950s.

#### *Bare Surface*

I found bare rock and exposed soil widespread across the island. The soil has been eroded away exposing rounded, loose football-sized volcanic rocks. Several cinder cones also appear to have been naturally bare. Prior to introduction of goats,

exposed rock and soil would likely have been distributed in patches in a variety of locations on the island. On parts of the island that are currently nearly bare, *Nicotiana glauca* is common, especially on the steep northeast slopes of the island.

## DISCUSSION

### *Can the Vegetation be Restored?*

Providing a construct of what the original plant communities on Guadalupe Island might have been gives a starting point for future efforts to restore the island's vegetation. Removal of the feral goats will not bring back all of the original vegetation communities because some are certainly gone forever. However, positive responses should be quick following goat removal. Considering the responses that have occurred on other islands, the first effect of removing the goats is a likely increase in ground cover by non-native species, especially in the grassy areas (Klinger et al. 1994, Laughrin et al. 1994). It is also likely that species long thought lost or possibly never previously documented on the island will be found after the goats are removed. Removal of sheep from Santa Cruz Island and goats from San Clemente Island has also allowed for extensive natural reforestation and re-establishment of a variety of vegetation in the canyons (Wehtje 1994, pers. observ. on San Clemente Island in 1991 and Santa Cruz Island 1992).

Within the past three years exclosures have been placed in several locations on Guadalupe Island to fence goats out of several of forested areas. Within these exclosures, species thought to be extinct such as *Ceanothus* and *Satureja* have been rediscovered (S. Junak pers. comm.). In addition, there has been vigorous growth of pine and cypress seedlings (A. Aguirre pers. comm.). Specific efforts of the Island Conservation Ecology Group and efforts coordinated by Exequiel Ezcurra are in the process of evaluating the appropriate steps toward recovery of the ecosystems on Guadalupe Island.

Some basic steps for restoration of the island may involve initially letting the island rest after goat removal. This would allow native seeds that might have laid dormant for decades to appear, as in the case of the *Satureja* and *Ceanothus* in the exclosures. Propagation of island stock using on-

island nursery facilities for key species may be an appropriate second phase to vegetation recovery. Ultimately, decisions will need to be made regarding whether or not a species that originally occurred on the island should be reintroduced. It may be necessary to consider that the island is like a rare and old sculpture; it may be better to clean the island by removing the goats and provide basic revegetation rather than to attempt full restoration that may result in damage to what is left.

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Appendix. Vegetation communities and predicted dominant species.

Species	Vegetation Community								
	Guadalupe sage scrub	Guadalupe mesa scrub	Maritime desert scrub	Herb/grassland	Chaparral	Oak/canyon woodland	Pine forest	Cypress forest	Palm forest
<i>Ambrosia camphorata</i>	X		X						
<i>Arctostaphylos sp.</i>					X		X	X	
<i>Artemisia californica</i>	X		X						
<i>Atriplex barclayana</i>			X						
<i>Baeriopsis guadalupensis</i>		X							
<i>Brahea edulis</i>									X
<i>Castilleja fruticosa</i>		X							
<i>Ceanothus arboreus</i>					X	X	X	X	
<i>Ceanothus crassifolius</i>					X	X	X	X	
<i>Ceanothus cuneatus</i>					X	X	X	X	
<i>Cistanthe guadalupensis</i>		X							
<i>Crossosoma californica</i>	X					X			
<i>Cupressus guadalupensis</i>								X	
<i>Deinandra greeneana ssp. greeneana</i>		X							
<i>Deinandra palmeri</i>		X							
<i>Dichelostemma pulchella</i>	X	X	X	X					
<i>Dissanthelium californicum</i>				X					
<i>Dudleya guadalupensis</i>	X	X							
<i>Erysimum moranii</i>		X							
<i>Eschscholzia palmeri</i>		X							
<i>Galvesia speciosa</i>	X					X			
<i>Gilia nevinii</i>				X					
<i>Guillenia lasiophylla</i>				X					
<i>Hazardia cana</i>	X					X			
<i>Hesperelaea palmeri</i>						X			
<i>Heteromeles arbutifolia</i>						X	X	X	
<i>Lasthenia californica</i>				X					
<i>Lavatera lindsayi</i>		X							
<i>Lavatera occidentalis</i>		X							
<i>Layia platyglossa</i>				X					
<i>Lomatium insulare</i>		X							
<i>Lonicera hispidula var. vacillans</i>						X			
<i>Lupinus niveus</i>				X					
<i>Lycium californicum</i>			X						
<i>Malosma laurina</i>	X					X			

Appendix (continued). Vegetation communities and predicted dominant species.

Species	Vegetation Community								
	Guadalupe sage scrub	Guadalupe mesa scrub	Maritime desert scrub	Herb/grassland	Chaparral	Oak/canyon woodland	Pine forest	Cypress forest	Palm forest
<i>Mammillaria blossfeldiana</i> var. <i>shurliana</i>		X							
<i>Mirabilis laevis</i> var. <i>crassifolia</i>	X								
<i>Nasella lepida</i>				X					
<i>Perityle incana</i>	X								
<i>Pinus radiata</i> var. <i>binata</i>							X		
<i>Polypodium scouleri</i>							X	X	
<i>Polystichum munitum</i>							X		
<i>Quercus tomentella</i>								X	
<i>Rhamnus pirifolia</i>					X			X	
<i>Ribes sanguineum</i>	X				X				
<i>Satureja palmeri</i>	X								
<i>Senecio palmeri</i>	X								
<i>Sphaeralcea palmeri</i>		X							
<i>Stephanomeria guadalupensis</i>		X							
<i>Vulpia microstachys</i> var. <i>pauciflora</i>				X					