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THE UNIQUE PLANTS AND ANIMALS OF THE NORTHERN CHANNEL ISLANDS, CALIFORNIA

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by

Michael James Emerson

Committee in charge:

Professor Gary Hugh Brown, Chairman

Doctor Demorest Davenport

Doctor Michael Neushul

March 1982

The thesis of Michael James Emerson

is approved:

_____

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Committee Chairman

March 1982

March 1982

Requests for reprints of all or part of this thesis and the accompanying manuscript should be addressed to:

For the SCI field station, with thanks to Lyndall.

MJE

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ABSTRACT

THE UNIQUE PLANTS AND ANIMALS

OF THE NORTHERN CHANNEL ISLANDS, CALIFORNIA

by

Michael James Emerson

The Northern Channel Islands are the northernmost group of the sixteen California Islands. Despite their close proximity to the southern California mainland, these four islands support a surprising diversity of organisms which are not found on the mainland. Some of these island endemics have been the subject of considerable research, but others are largely unknown both to science and to the general public. It is the purpose of this thesis to list, describe, and illustrate the majority of these organisms and to provide some basic natural history for them, with extensive references for further information.

The first section is an overview of the California Islands, emphasizing the physical and biological features of the Northern Channel Islands. The second section is a catalogue of the endemic and near-endemic biota of these islands, with illustrations and detailed information concerning 106 taxa of plants, invertebrates, and vertebrates. Many of the illustrations are the first which have been done for these organisms.

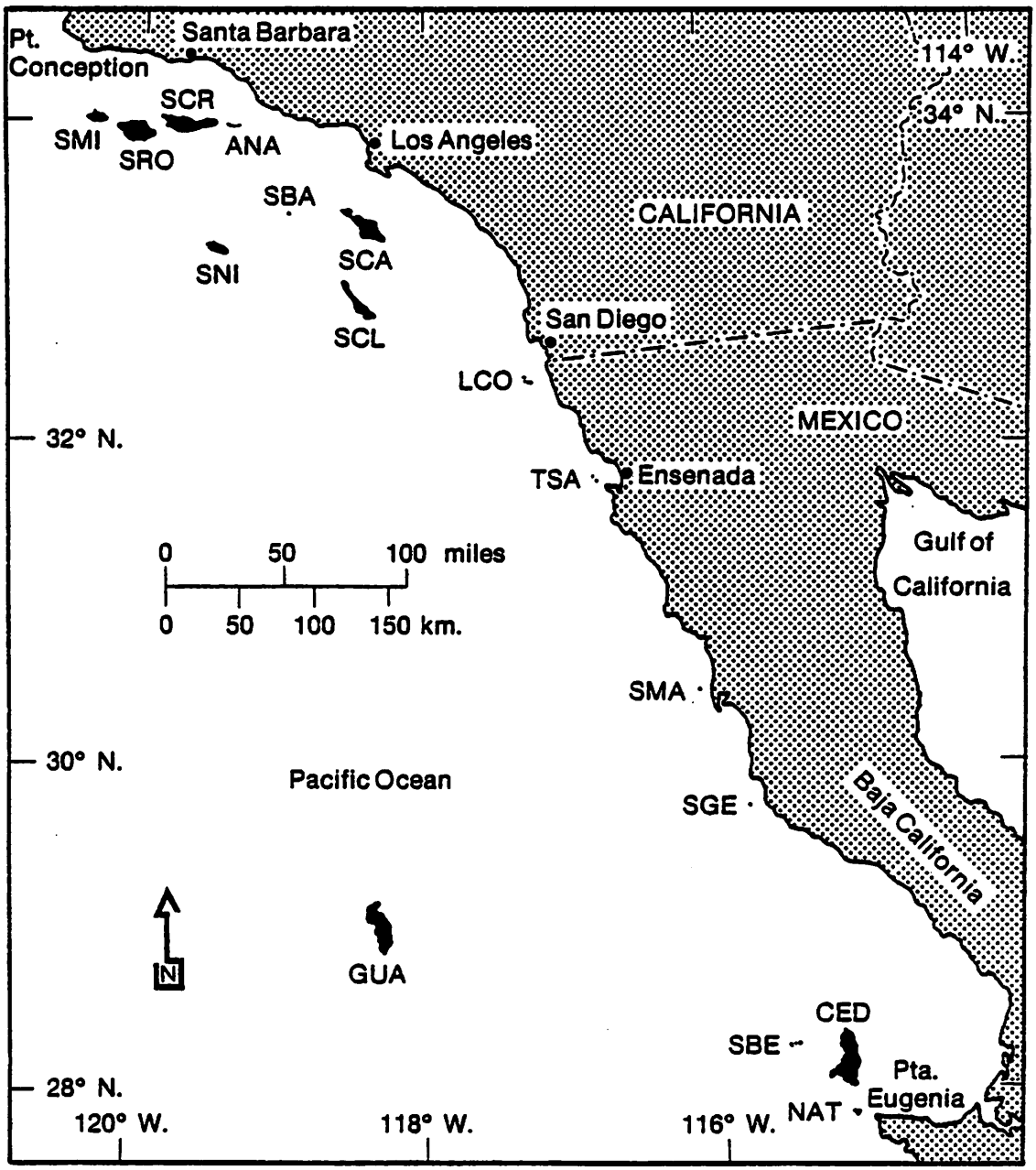
TABLE OF CONTENTS

LIST OF FIGURES

SECTION ONE:

THE CALIFORNIA ISLANDS,

VARIATIONS ON A THEME



ISLANDS

ANA=Anacapa
CED=Cedros
GUA=Guadalupe
LCO=Los Coronados
NAT=Natividad
SBA=Santa Barbara
SBE=San Benito
SCA=Santa Catalina
SCL=San Clemente
SCR=Santa Cruz
SGE=San Geronimo
SMA=San Martin
SMI=San Miguel
SNI=San Nicolas
SRO=Santa Rosa
TSA=Todos Santos

Fig. 1. Map of the California Islands and adjacent mainland.

Sixteen islands line the Pacific coast of North America from Point Conception, California to Punta Eugenia, Baja California del Sur, Mexico (Fig. 1). Although scattered through more than 500 miles, six degrees of latitude, and five degrees of longitude, the California Islands form a cohesive biological unit. They share the majority of their biota with the adjacent mainland, but a significant number of plants and animals are restricted to the islands. Many of these insular endemics are found on islands which are farther apart from each other than they are from the mainland. The conspicuous absence of most mainland animal species from some or all of the islands is interesting and will be discussed elsewhere.

Compared to an archipelago such as the Hawaiian Islands, the California Islands are relatively small, dry, close to shore, and close to each other. Within this limited range, however, the islands show considerable physical and biological diversity. Some are little more than offshore rocks supporting few plants or animals, while others are fairly large, mountainous islands far beyond sight of land, harboring forests of palm, cypress, and pine, as well as a variety of unique species. Every intermediate condition between these two extremes is also to be found among the lot, providing researchers with a variety of discrete ecosystems. Unfortunately, the eight Mexican islands have not been studied with sufficient thoroughness to allow their inclusion in comparative studies with any reliability. The few studies which

attempt to deal with the biology of the California Islands as a whole focus on species diversity: Johnson et al. (1968, plants), Savage (1967, amphibians and reptiles), Wilcox (1980, reptiles), and Power (1972, birds). Some comparative physical and biological data on the islands are summarized in Tables 1 and 2.

A major difficulty encountered in each of the papers listed above is the pronounced decrease of rainfall from north to south along the coast, which makes any comparison of the northern and southern islands unbalanced. There is also a slight increase in temperature to the south, though all of the islands share an exceptionally mild climate. This climatic range affects various taxa differently, due to their specific ecological requirements. To lessen the effect of variable climatic and research considerations, it is convenient to divide the sixteen California Islands into two equal geographic sets (the Channel Islands and Baja California Islands), each comprised of two groups of four islands. These groupings will be considered from north to south, with the emphasis on the four northernmost islands.

Not considered in this paper are those islands lying to the north (Año Nuevo, Farallons) and south (Asención, Magdalena) of the California Islands proper. These islands share few non-endemic species with the sixteen islands described here, and probably none of the same endemics are found there. They seem to be in an altogether different biological realm, though the reasons for their exclusion might throw considerable light on those

factors which unify the California Islands. To illustrate the simultaneous unity and diversity of the California Islands one need only consider the distribution of such endemics as the island poppy (Eschscholzia ramosa*), which has been reported from all but one of the islands, and the deer mouse (Peromyscus maniculatus*), which occurs as a different subspecies on each of thirteen California Islands. A variety of factors are responsible for "the surprising number of . . . species endemic to more than one of the California Islands . . . . The distances between some of the islands occupied by some of these species are greater than distances to the mainland" (Carlquist 1974:25-26). The origin of endemics is a complex and controversial issue which will be discussed in a separate manuscript.

Throughout this thesis, an asterisk (*) indicates a taxon which is illustrated in the catalogue of endemics. Species which have not been illustrated are mostly with near-endemics with fairly extensive mainland distributions, extinct species, and forms which are very weakly differentiated on the islands. Such species are mentioned briefly at the beginnings of the sections of the catalogue dealing with plants, invertebrates, and vertebrates, respectively. The few nonendemics are mentioned largely in connection with the islands' plant and animal communities, or because they demonstrate certain phenomena common to endemics.

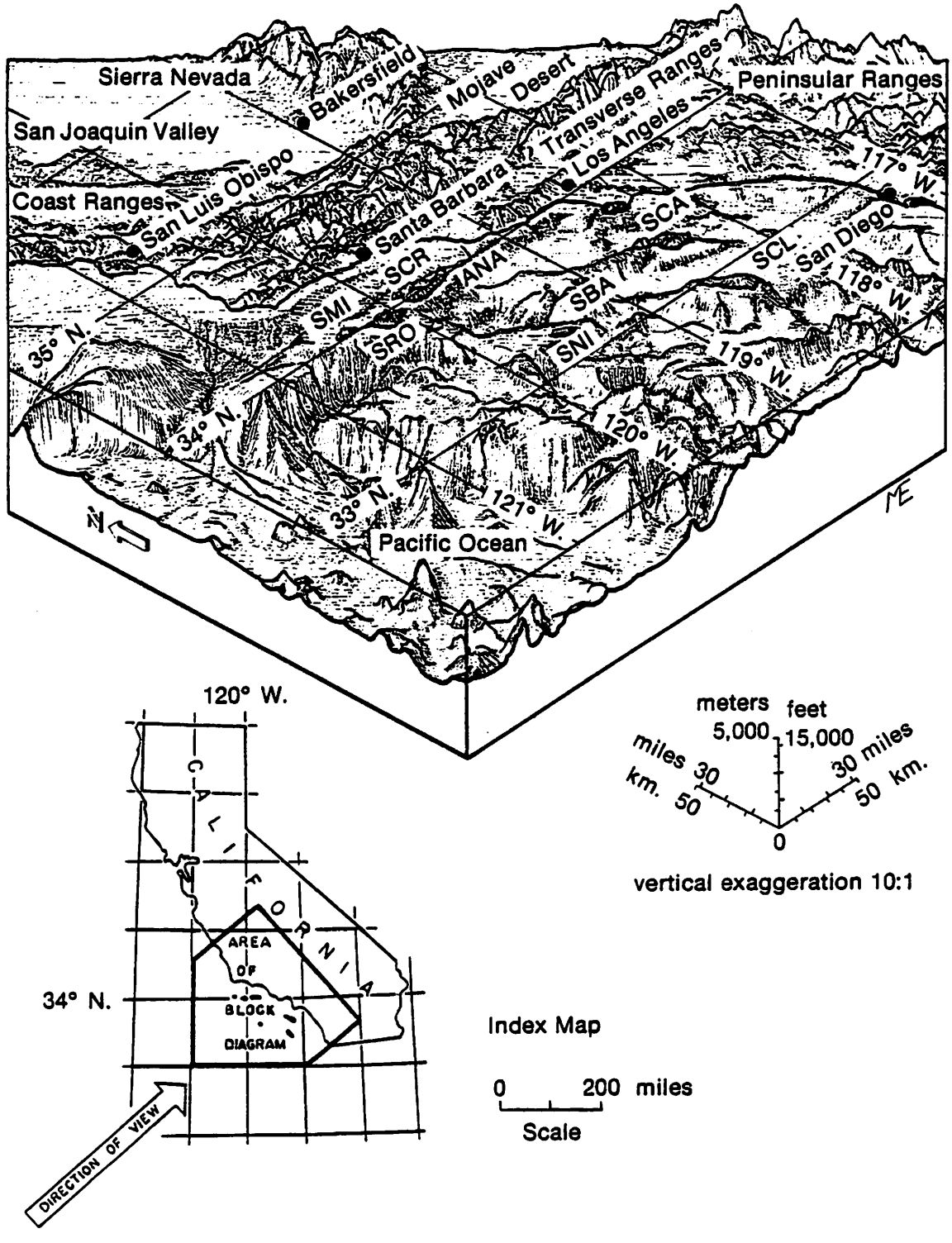


Fig. 2. Projection of the Southern California Continental Borderland.

THE CHANNEL ISLANDS

Among the California Islands as a whole, the Channel Islands are in the broad middle of the spectrum of size, elevation, and distance from the mainland. Even so, the largest of them is almost 100 times the size of the smallest island. They form a cohesive group united by similarities in geography, topography, history, and biology; including many endemics shared by most or all of the islands.

The Channel Islands lie entirely within the Southern California Bight, the great indentation of the Pacific Coast from Point Conception to Cabo Colnett, Baja California. The region is known to geologists as the Southern California Continental Borderland, which differs from the usual continental shelf and slope pattern in its extreme geological and topographical complexity, characterized by alternating basins and ridges (Fig. 2). This complexity reveals the recency and ongoing nature of the geological forces molding the region. The Channel Islands are the exposed tops of mountains which are separated from the adjacent mainland by fairly deep waters. Due to the presence of large petroleum reserves in the region, the geology of the Borderland has been the focus of considerable study in recent years (Howell 1976), though the the subject has defied easy synthesis and interpretation (Vedder and Howell 1980).

When Juan Rodriguez Cabrillo sailed up the Pacific coast of

North America in 1542, fifty years after Columbus' famous voyage, he found the Channel Islands well populated by friendly aborigines. He was followed during the next one hundred and fifty years by a series of explorers whose main impact on the islands was to name, rename, and map them, undoubtedly introducing some diseases and pests in the process. During the first half of the nineteenth century the islands were frequented by sailors of many nations who hunted whales and elephant seals for their oil, and fur seals and sea otters for their rich pelts. Most destructive were Aleut hunters brought by the Russians, who decimated the local Indians as well as sea mammals (Holland 1962).

Shortly before California was ceeded to the United States in the Treaty of Guadalupe Hidalgo of 1848, the Mexican governor granted the three largest islands to private citizens. The other five islands were assumed by the federal government, though Mexico still occasionally claims the islands since they were not specifically mentioned in the treaty (Hillinger 1958, Weaver 1969). Domesticates, pests, and game, including horses, burros, bison, goats, sheep, deer, elk, pigs, dogs, cats, mice, rats, and rabbits were brought in part to all of the islands by private owners and leasees during the first half of the century and especially around the time California attained statehood in 1850. The feral sheep, goats, and pigs proliferated and largely denuded the islands by the end of the century, exterminating certain native species in the process. Various abortive attempts at

cultivation caused further erosion and encouraged the establishment of weeds and pests (Hochberg et al. 1979, Power 1980a:103-170).

More recently, the armed forces (especially the Navy) have established installations on several of the islands and have used others as bombing ranges (Hillinger 1958). The three largest islands continue to be run as cattle ranches of impressive size (Warren 1958). During the first half of this century, several species disappeared from the islands, including a few endemics and most of the large raptors such as Bald Eagles, Ospreys, and Peregrine Falcons (Kiff 1980). The Channel Islands National Monument was established in 1938 to protect the two smallest Channel Islands (Santa Barbara and Anacapa). San Miguel Island was eventually administered jointly by the National Park Service and the U.S. Navy (the latter still has preemptory control and may resume bombing). The Channel Islands National Park was finally approved in 1979 to protect the unique natural resources of the Northern Channel Islands and Santa Barbara Island to the south, except for the major part of Santa Cruz Island (which was acquired by a private conservation organization in 1978). The appropriation of funds for the purchase of Santa Rosa and the eastern end of Santa Cruz Island has not been made, however, and the present political climate is not likely to expediate the transactions which will complete the park.

Being readily accessible to various population centers and

research institutes (Loefer 1967), most of the Channel Islands are thoroughly studied and their biota well known, except for the invertebrates and algae. The proceedings of the two symposia on the California Islands (Philbrick 1967, Power 1980a) deal primarily with various aspects of the Channel Islands' geology, marine ecology, and terrestrial biology. Some other publications of general interest include Dailey et al. (1974), Feldmeth and Emerson (in prep., natural history), Doran (1980, bibliographical), Hillinger (1958, historical and anecdotal), Philbrick and Haller (1977, plant communities), Dunkle (1950, plant ecology), Thorne (1969a, botany and general ecology), Miller and Menke (1981, terrestrial arthropods), and Johnson (1972, endemic birds). The National Park Service, with headquarters in Ventura, has generated considerable unpublished research concerning the three islands under its jurisdiction (e.g., Glassow 1977, Power 1979).

The marine life of the Channel Islands has recently become the focus intense scientific research (Power 1980a), partly because the islands support near-shore habitats which have not been greatly disturbed by man. Among the most interesting and widely shared conclusions from diverse studies of algae and macroinvertebrates is that the distributions of many organisms among these islands closely reflect that expected from an analysis of the ocean currents currents which bathe the Southern California Bight. Northern species predominate in areas exposed to the

California Current, principly San Miguel, Santa Rosa, and San Nicolas islands. Southern species are prevalent on San Clemente and Santa Catalina islands, where the Southern California Countercurrent brings warm water up from the south. The remaining islands are transitional in their marine species composition. Similar patterns may be discerned among the terrestrial biota, including several endemics. This is probably due mainly to the influence of currents on local weather patterns.

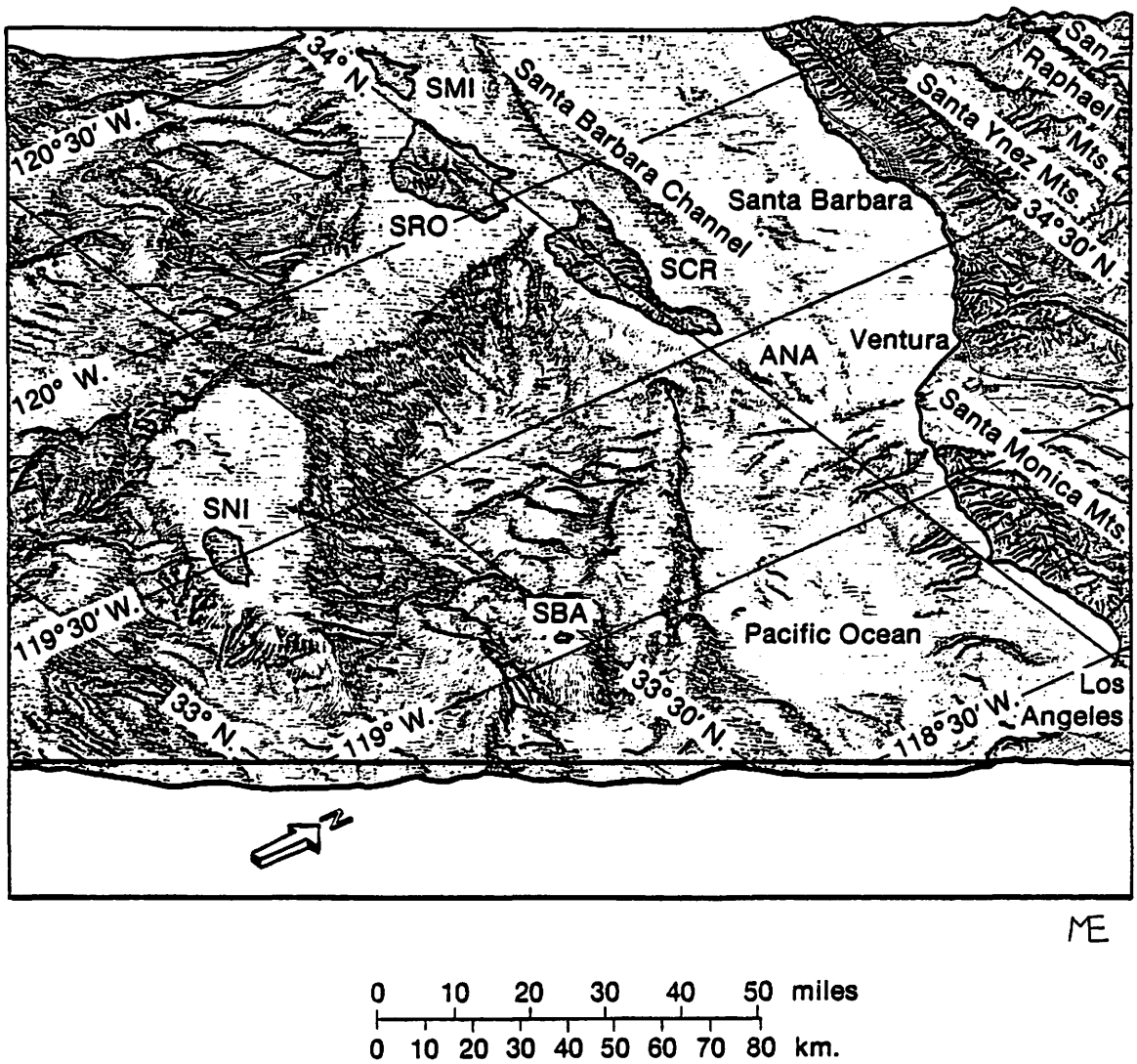


Fig. 3. Projection of the Northern Channel Islands and surroundings.

The Northern Channel Islands

The Northern Channel Islands are among the most conspicuous landmarks of southern California. They are familiar to millions of residents and travelers along the coast of southern Santa Barbara and Ventura counties as a broken silhouette stretching across most of the Pacific horizon. From the campus of the University of California at Santa Barbara, all four islands are visible on a clear day, though they may disappear for months at a time during hazy and foggy weather in the summer. The islands are a mystery to the general public and a lure to researchers, who are amassing a tremendous store of information concerning the insular ecosystem (Woodhouse 1981).

The most geographically coherent subgroup among the California Islands, the Northern Channel Islands are separated from each other by rather narrow, shallow straits (Fig. 3). They were undoubtedly united as one large island during glacial periods, when sea level fell several hundred feet (Vedder and Howell 1980). Although many researchers have long assumed that the islands were also connected to the mainland as an extension of the Santa Monica Mountains (Junger and Johnson 1980), there is no geological or biological evidence to support this theory (Wenner and Johnson 1980). Despite their close proximity, each island is ecologically distinctive. When considered from west to east, however, as they will be presented here, the adjacent ends of any

two islands bear a definite resemblance to each other in terms of topography and vegetation. This provides the researcher with analogous habitats set in differing ecosystems (e.g., Miller 1951).

Exploitation of petroleum reserves in the Santa Barbara Channel is already intensive and promises to become greater in the near future. One positive result of this geological interest in the area is the thoroughness with which the islands have been studied (Weaver 1969). Weaver and Doerner (1967) provide a slightly dated interpretation of the geological history of the islands, and Yanev (1980) incorporates recent theories regarding the formation of the Northern Channel Islands and related structures.

> "The island chain appears to be a faulted east-west trending anticline with both flanks represented in outcrop on Santa Cruz and Santa Rosa islands, but with only the northern flank exposed on San Miguel and Anacapa islands. This structural appearance may be oversimplified and misleading since it is doubtful that the central island fault on Santa Rosa is the same as that on Santa Cruz and that it was ever a continuous structure" (Weaver 1969:9).

Glassow (1977) details the archaeology of the four islands plus Santa Barbara Island. The Northern Channel Islands were inhabited for thousands of years by the Canaliños, or island Chumash, a culture of the Hokan group native to the Pacific coast. The Santa Barbara Museum of Natural History and Santa Barbara Botanic Garden have long been active in research on the Northern Channel Islands and provide exhibits and information concerning

them.

A number of organisms are endemic only to the Northern Channel Islands, being found on more than one of the islands in appropriate habitats. These include:

(Plants)

Arabis hoffmannii*
Arctostaphylos tomentosa insulicola*
Castilleja hololeuca*
Dudleya candelabrum*
Eriogonum arborescens*
E. grande* rubescens
Galium angustifolium foliosum*
G. buxifolium*
G. californicum miguelense*
Haplopappus detonsus*
Lavatera a. assurgentiflora*
Malacothrix indecora*
M. squalida*
Phacelia divaricata insularis*
Solanum wallacei clockeyi*
Thysanocarpus laciniatus* ramosus?

(Invertebrates)

Helminthoglypta ayresiana*
Arachnis picta insularis*
Bembix americana hamata*
Cnomotettix caudulus*
Eustattus vanduzeei*
Okanagona hirsuta*
O. vanduzeei ssp.
Lutica maculata*
Vejovis minimus thompsoni*

(Vertebrates)

Batrachoceps p. pacificus*
Sceloporus occidentalis becki*
Pituophis melanoleucus pumilis*
Aimophila ruficeps obscura*
Thryomanes biwickii nesophilus*
Spilogale gracilis amphialus*
Peromyscus* nesodytes (extinct)
Mammuthus exilis (extinct)

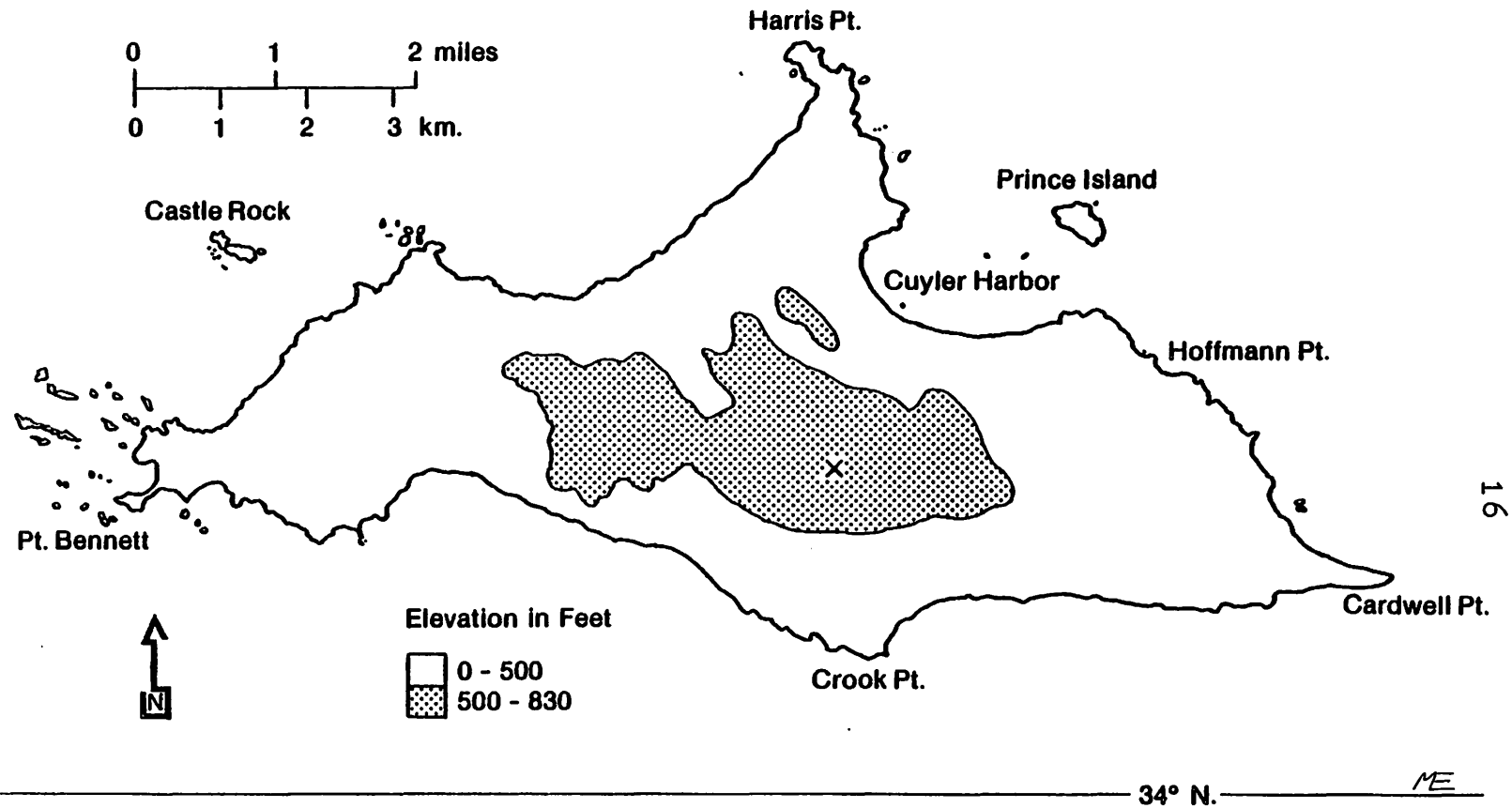


Fig. 4. Map of San Miguel Island.

San Miguel Island (SMI)

The visitor to San Miguel Island is invariably struck by a sense of desolation and mystery. Stripped bare in many places by constant winds, the land reveals the skeletons of its past: ancient shells, trees, bones, and remains of Indian and more recent inhabitation; and the offshore reefs grip the wrecks of an untold number of ships. Wind, fog, and the largely barren landscape seem to repel human intrusion and add to "the feeling of depression one has about the island" (Holland 1963:153). Nonetheless, San Miguel Island is a fascinating place to visit.

The first Europeans to visit San Miguel Island found two Canaliño villages with about one hundred inhabitants (Glassow 1980). Juan Rodriguez Cabrillo, the 'discoverer' of California, was injured in a fall on this island in October of 1542 during his journey northward. His injury worsened during the voyage and he died on San Miguel Island in Janaury, 1543, on the return trip. He is reportedly buried on the island (Hillinger 1958, Doran 1980). Ralph Hoffmann, director of the Santa Barbara Museum of Natural History and an important botanist of the early period of island study, fell to his death from Hoffmann Point while collecting plants in 1932 (Cockerell 1937, Smith 1976:44). Beginning with George Nidever, a series of interesting characters have inhabited San Miguel Island since 1850, some of them proclaiming themselves sovereign rulers of an autonomous kingdom

(Holland 1963). Herbert Lester (who, along with his family, was the only long-time resident of the island during this century), committed suicide on San Miguel in 1942 (Lester 1979). The island has been uninhabited ever since, though Park Service personnel are usually present today to protect San Miguel's fragile ecosystem.

The most northern and westerly of the California Islands, San Miguel lies 26 miles south of Point Conception and 3 miles west of Santa Rosa Island. It is fairly small, only 14 miles square. The island is dominated by two rather gentle hills over 800 feet in elevation (Fig. 4). The generally even topography is dissected by many ravines which are partly the result of recent erosion caused by overgrazing, agriculture, bombing, and construction, all of have been discontinued at this time (Johnson 1980).

Vegetation stripping has also resulted in the periodic activation of great sand dunes which cover most of the island. Such episodes have a long history on San Miguel Island extending back at least to the late Pleistocene, when mammoths probably decimated the island's vegetation, which included various trees and shrubs (loc. cit.). The arrival of man may ave eliminated the elephants as landscape modifiers, but probably increased the incidence of fires, resulting in further vegetation stripping and sand encroachment. It must be assumed that the present biota of San Miguel Island has been greatly influenced by thousands of

years of extreme disturbance.

The geology of San Miguel Island yields a number of features of considerable interest (Johnson 1979). Most of the island is dominated by Pleistocene and Recent dunes and marine terrace formations. These have erroded in many places to reveal calcified casts of ancient forests and other vegetation. Although the trunks of many of these fossils are rather large, the original plants (e.g., Rhus integrifolia) may have been much smaller, the present size being the result of accumulated deposits of calcium carbonate and sand (Hochberg et al. 1979). Most of the caliche forests appear to date from the late Pleistocene, though both their age and ancestry may vary from one site to the next. The large, straight trunk casts may be of pines. Cypress wood has also been identified from ancient deposits on the island. Fossil plants and mammoth bones are preserved in abundance at Running Springs, where highly mineralized water has coated various objects. Older sediments and volcaniclastics are exposed on north-facing cliffs (Weaver 1969). The island is surrounded by reefs and rocks, the largest of which is Prince Island, at the entrance of picturesque Cuyler Harbor.

San Miguel Island lies in the full force of the California Current as it sweeps around Point Conception, "making San Miguel Island one of the windiest, foggiest, most maritime, and wave-pounded areas on the west coast of North America" (Johnson 1980: 103). Strong northwesterly winds blow almost incessantly, driv-

ing san dunes before them and pruning the vegetation to a low, scrubby form. Dense fog is frequent and helps keep temperatures cool and even, averaging 58.7 F with a mean annual range of only 5.4 F (Dunkle 1950). The overall pattern is very similar to that of the adjacent mainland, such as Point Arguello (Elford et al. 1965). Frost occurs with extreme rarity on the island, if at all. Annual precipitation averages about 14 inches (Weissman and Rentz 1977), though great fluctuations are characteristic (Johnson 1980).

The only permanent surface water on San Miguel Island consists of a number of brackish springs. The island's vegetation reflects this aridity and the immediate influence of the surrounding ocean. Coastal sage scrubs less than five feet tall predominates over much of the island, interspersed with grassland on the marine terraces (which may reach the top of the island). Coastal bluff vegetation attains perhaps its richest expression anywhere on San Miguel's north-facing cliffs (especially Hoffmann Point), where multicolored hanging gardens bloom in spring. Coastal dune vegetation follows the rivers of sand which streak across the island, occurring farther inland than in other locales. These interior dunes are undergoing stabilization at the present time, and dune vegetation will presumably become restricted to beach areas in the future (Pilbrick, pers. comm. 1979).

A newly described buckwheat (Eriogonum grande* dunklei) is

apparently restricted to sea cliffs on San Miguel Island (Reveal 1980). An undescribed Castilleja* species has also been reported from the island (Smith 1976:313). Philbrick (1980) reports an unusual form of giant rye grass (Elymus condensatus) which is most distinctive on Prince Island, where it is one of the very few existing plants. Similar specimens are found on adjacent parts of San Miguel Island and on the mainland coast. Some of the more conspicuous endemic and near-endemic plants found on the island include:

Astragalus miguelensis*
Calystegia m. macrostegia*
Coreopsis gigantea
Eriogonum grande* rubescens
Erysimum insulare*
Eschscholzia* californica maritima
Lotus scoparius* veatchii
Malacothrix* incana/succulenta
Platystemon californicus ornithopus*

The native, terrestrial vertebrates consist of a salamander (Batrachoceps p. pacificus*), two lizards (Gerrhonotus m. multicarinatus and Sceloporus occidentalis becki*), a unique deer mouse (Peromyscus maniculatus* streatori), and a similarly restricted subspecies of the island fox (Urocyon l.* littoralis). The black rat (Rattus rattus) is established on the island and may pose a threat to the endemic deer mouse (Collins et al. 1979). None of these species is especially abundant on San Miguel Island. Feral sheep and burros were eliminated from the island in recent decades.

A unique Song Sparrow (Melospiza melodia micronyx*) and the

Horned Lark (Eremophila alpestris insularis*) are farily common. Other resident, endemic birds are the Allen's Hummingbird (Selasphorus sasin sedentarius*) and Orange-crowned Warbler (Vermivora celata sordida*). The Loggerhead Shrike (Lanius ludovicianus anthonyi*) formerly bred on the island. Bird and mammal remains from Canaliño middens are analyzed by Guthrie (1980) and Walker (1980).

As might be expected, the biogeographic affinities of San Miguel Island are strongest with Santa Rosa and the other northern islands, and with mainland coast north from Point Conception. Several endemics are found only on San Miguel and Santa Rosa Islands. A few species of plants (Amsinckia spectabilis nicolai, Malacothrix indecora* aff., M. saxatilis implicata*) suggest a weak affinity with San Nicolas Island to the south. An unusual link with Santa Cruz Island will be discussed later.

The most conspicuous animals on San Miguel Island are not usually considered endemics, though many of them breed only on islands. Prince Island supports the most important sea bird rookeries in southern California in terms of both abundance and species diversity (Hunt et al. 1980). Even more spectacular are the more than forty thousand seals and sea lions of six species which haul out and breed on the beaches of San Miguel Island itself (Howorth 1976, Le Boeuf and Bonnel 1980). The latter are among the largest and most diverse pinniped colonies in the world (Bartholomew 1967). Both the sea bird and pinniped rookeries are

highly sensitive to disturbance by humans, except for the immense northern elephant seals (Mirounga angustirostris), which allow close approach. The population dynamics of pinnipeds on San Miguel Island are interesting (LeBoeuf and Bonnel 1980). There has been a great increase in the total number of individuals following the exploitation of the last century. Most populations have increased locally, while others appear to be declining.

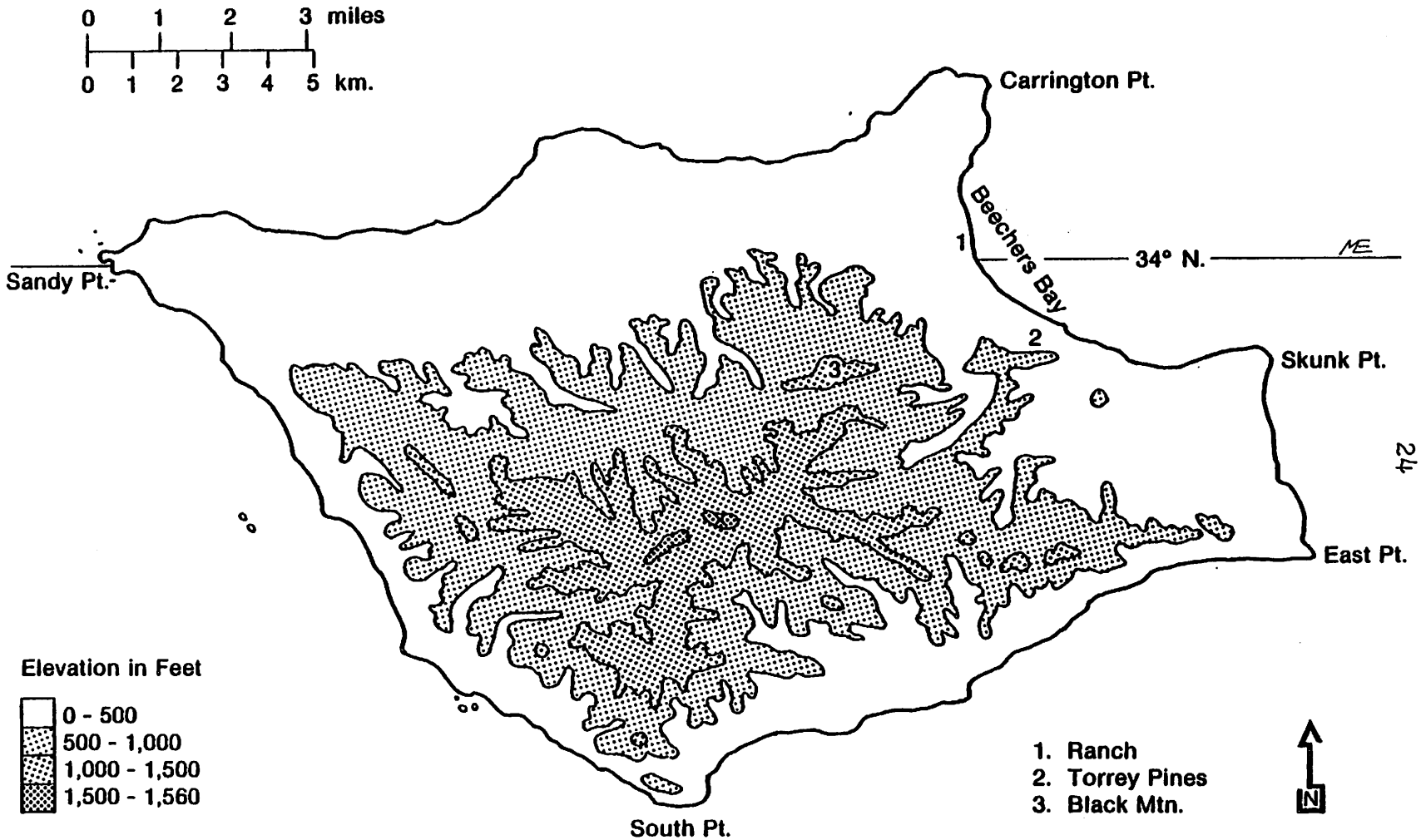


Fig. 5. Map of Santa Rosa Island.

Santa Rosa Island (SRO)

Santa Rosa Island is a rancher's paradise. No predators, rattlesnakes, or even rodent burrows lie in wait for the fat cattle. Gently rolling hills densely cloaked in grass cover much of the island, providing expansive vistas which reveal Santa Rosa's large size. Headquarters of the Vail and Vickers ranch are located on Beechers Bay in the northeastern part of the island (Fig. 5) and includes a number of fine, old buildings. Despite some protection from nearby hills, the introduced eucalyptus trees at the ranch grow more horizontally than vertically, providing mute testimony to the strong northwesterly winds which persist through most of the year on this open, exposed island.

When Europeans first arrived on Santa Rosa Island, they found eight Indian villages supporting more than six hundred inhabitants (Glassow 1980). The archaeology of this island has been the subject of intense study for many years (Orr 1967, 1968). Recent investigations suggest that human occupation on Santa Rosa Island may have occurred more than 40,000 years ago (Berger 1980), one of the earliest dates proposed for North America. Glassow (1980) disputes the validity of these findings and gives approximately 7,000 years ago as the earliest reliable date for man on Santa Rosa Island. The former dates are reportedly associated with remains of the endemic dwarf mammoth.

Early in the ninteenth century the Canaliño population on Santa Rosa Island disappeared, the victim of foreign interference (Holland 1962) and a severe earthquake (Orr 1967). Beginning with a Mexican land grant to the Carrillos, the island's ownership underwent a period of conflicting claims and counterclaims during the latter half of the century until it was bought by the present owners in 1902 (Holland 1962). The subsequent elimination of sheep helped prevent much of the erosion which has ruined many of the California Islands. The U.S. Navy and Air Force operated installations on Santa Rosa (now abandoned) during the middle of this century (Hillinger 1958). The island is currently included in the Channel Island National Park, though it will remain in private hands until funds are appropriated for the purchase of the land.

Slightly more removed from the mainland than San Miguel Island, Santa Rosa lies 27 miles southwest of Coal Oil Point on the University of California at Santa Barbara campus. Three miles separate the island from San Miguel to the west, and Santa Cruz Island lies six miles east. Second-largest of the Channel Islands, Santa Rosa measures about fifteen miles long and ten miles wide, covering eighty-four miles square. The western part of the island is low and sandy, closely resembling San Miguel both physically and biologically (S.E. Miller, pers. comm. 1979). The eastern half is topographically more diverse, with gently rolling, grassy hills cut by deep, wooded canyons, and rising in

the central part of the island to a group of rounded peaks over 1,500 feet in elevation and supporting some trees.

Santa Rosa Island is mainly comprised of sedimentary rocks overlain by Pleistocene marine terrace deposits which largely cover the island except where they have been eroded (Weaver 1969). Lobo Canyon in the northern part of the island contains some beautifully sculptured sandstone formations shaped by wind and water. Extensive deposits containing fossils of the dwarf mammoth occur in the northwestern section and elsewhere (Orr 1968).

The climate of Santa Rosa Island has not been well documented (Dunkle 1950, Orr 1968). It appears to be slightly drier than San Miguel (Weissman and Rentz 1977), though the highlands undoubtedly receive greater precipitation. The winds on Santa Rosa tend to be somewhat more westerly than on San Miguel Island, and the greater local relief provides more extensive areas of shelter. Dense fog is also characteristic and seems to be instrumental in maintaining certain plant communities, such as pine groves.

Despite the dominance of rather dry grassland over almost all of Santa Rosa, the island supports the most diverse assemblage of plant communities on the Channel Islands (Philbrick and Haller 1977). Most of these communities exist in small, scattered patches, however, and the overall impression of the island is one of low ecological diversity. Coastal dune vegeta-

tion occurs in sandy areas mainly at the western and eastern extremes of the island. Although the dominant, widespread species are probably the same in both areas, the endemics which characterize each end are mostly different. The western dunes support many of the same forms listed for San Miguel Island, and the slightly more sheltered, eastern dunes harbor many of the forms peculiar to Santa Rosa Island. The concentration of endemics at the eastern (downwind) end of the island is an interesting biogeographic feature. Coastal bluff communities occupy appropriate habitats, including certain interior cliffs. Coastal sage scrub and chaparral occur on the steep slopes of many of the canyons and mountains, growing horizontally in areas exposed to the wind and achieving greater stature in sheltered areas. Oak woodland, island woodland, and riparian woodland are restricted to well-watered canyons and highlands. Bishop pine forests are poorly represented on the leeward side of Black Mountain (Linhart et al. 1967); and an extensive Torrey pine forest occurs on the hills above Beecher's Bay at the northeastern corner of the island and elswhere nearby (Amme 1975, Haller 1967, Smith 1976: 312). The only other native stands of Torrey pine are at Del Mar near San Diego.

Four plants are completely restricted to Santa Rosa Island: Arctostaphylos confertiflora*, Dudleya blochmaniae insularis*, D. greenei* nana, and Gilia tenuiflora hoffmannii*. As mentioned previously, the endemics of the western half of the island are

largely those of San Miguel Island. Some endemics and near-endemics which are widespread or conspicuous on the more easily accessible eastern half include:

Arctostaphylos* spp.
Ceanothus megacarpus insularis*
Cercocarpus betuloides blanchae*
Coreopsis gigantea
Dudleya greenei*
Isomeris aborea insularis*
Lyonothamnus floribundus asplenifolius*
Mimulus flemingii*
Pinus muricata remorata
P. torreyana
Prunus ilicifolia lyonii*
Quercus tomentella*
Salvia brandegei*

A frog (Hyla regilla), a salamander (Batrachoceps p. pacificus*), two lizards (Gerrhonotus m. multicarinatus and Sceloporus occidentalis beckii*), one snake (Pituophis melanoleucus pumilis*), a deer mouse (Peromyscus maniculatus* sanctarosae), a skunk (Spilogale gracilis amphialus*), and the island fox (Urocyon littoralis* santarosae) are all native to Santa Rosa Island. The skunk and fox are fairly common, though the former is not frequently seen (Laughrin, pers. comm. 1978). Besides livestock such as cattle and horses, feral pigs are common, as well as black-tailed deer and elk, which were introduced as game animals early in this century. Horned Larks (Eremophila alpestris insularis*), Loggerhead Shrikes (Lanius ludovicianus anthonyi*), and Song Sparrows (Melospiza melodia* clementae) are conspicuous members of the resident avifauna, which also includes Rufous-sided Towhees (Pipilio erythrophthal-

mus clementae*), Allen's Hummingbirds (Selasphorus sasin sedentarius*), Bewick's Wrens (Thryomanes bewickii nesophilus*), Western Flycatchers (Empidonax difficilis insulicola), and the Orange-crowned Warbler (Vermivora celata sordida*). Miller (1951) has analyzed the avifauna of Santa Rosa Island in comparison with Santa Cruz Island. He found a number of interesting differences between ecologically similar areas on the two islands, especially in the abundance and distribution of endemics.

The biogeographic patterns of Santa Rosa Island's biota are interesting in other respects as well. As might be expected, the major affinities lie with San Miguel Island on one hand, Santa Cruz Island on the other, and the Northern Channel Islands in general. A few endemics and near-endemics, however, show a unique affinity with organisms on with the islands and mainland to the south. These include at least three plants (Isomeris arborea insularis*, Pinus torreyana, and Salvia brandegei*) and two birds (Melospiza melodia* clementae and Pipilio erythrophthalmus clementae*). A few nonendemic and near-endemic plants (e.g., Castilleja* mollis and Erysimum ammophilum*) with more northerly distributions are also found only on Santa Rosa among the California Islands. Although disjunctions of this sort are common on the islands and in the mainland biota, Santa Rosa Island seems unusual in that it is surrounded by islands with strong northern affinities and habitats which seem equally suitable for the disjunct species. Miller (1951) has pointed out the

submarine ridge extending toward San Nicolas Island (Fig. 3) as a probable immigration route for such species during glacial periods, but this does not explain their absence from the other Northern Channel Islands, which were interconnected at the same time.

Santa Rosa Island holds great potential for scientific research. Although the island's archaeology and ornithology have been investigated fairly thoroughly, the distribution of other major groups of organisms on Santa Rosa Island is largely unknown. A more thorough catalogue of the island's biota may reveal new endemics and confirm the apparent absence of several organisms there which are found on adjacent islands (e.g., Galium buxifolium*, Malacothrix indecora*, three endemic snails, etc.). Such studies would further emphasize the unique nature of Santa Rosa Island's biota.

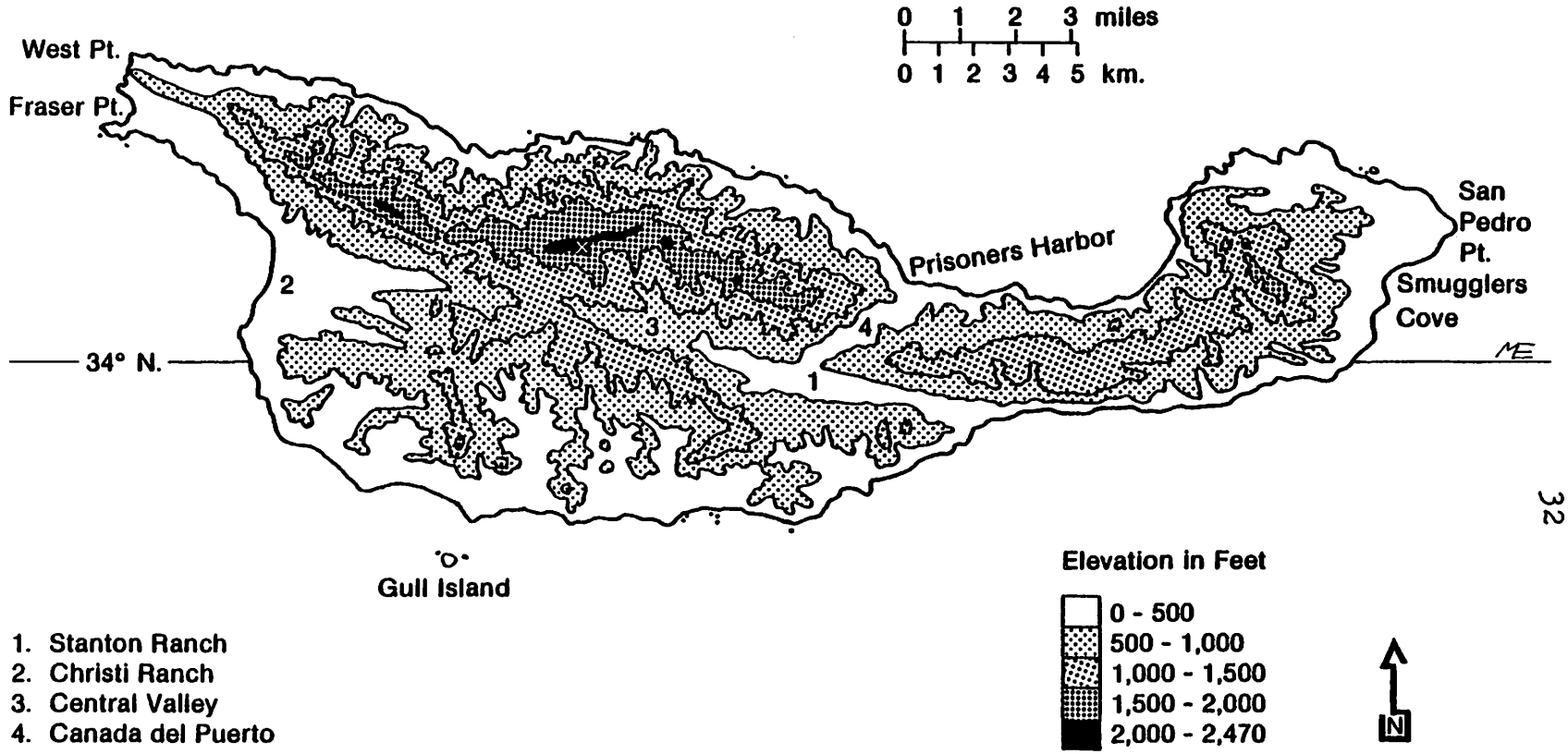


Fig. 6. Map of Santa Cruz Island.

Santa Cruz Island (SCR)

Santa Cruz Island is sufficiently large and diverse so that an overall impression is not easily formed. It does, however, possess one conspicuous feature unique among the California Islands: a large central valley which effectively isolates the visitor from the immediate influence of the ocean. The valley strongly resembles a smaller version of the upper Santa Ynez Valley north of Santa Barbara, with its steep, brushy slopes enclosing a narrow, grassy plain studded with oak trees and watered by a stream which largely dries up in the summer. The Central Valley drains to the north, however, and the Santa Ynez River runs west. Stately eucalyptus groves are found in the Central Valley with massive trees reaching over 250 feet in height (Bills 1969). The Central Valley shelters the headquarters of the Santa Cruz Island Company, and nearby is the Santa Cruz Island Reserve headquarters, which is part of the University of California's Natural Land and Water Reserve System. Late afternoons during the summer take on an almost magical quality there as the sun lingers at the head of the valley, filling it with golden light and the perfect tranquility of stillness and isolation.

The earliest European explorers found eleven Canalino villages on Santa Cruz Island and over a thousand inhabitants (Glassow 1980). The provincial capitol of the island Chumash was located in the Central Valley near the present Stanton ranch

headquarters. According to one legend (Applegate 1974), the mainland Chumash believed Santa Cruz Island to be the place where the mother goddess created man, from which he populated the mainland by crossing a rainbow bridge extending from Picacho Diablo to Chismahoo Mountain near Carpinteria, Santa Barbara County. Those who disobeyed divine warnings not to look down fell into the Santa Barbara Channel and became porpoises.

After the removal of the Canaliños, a Mexican land grant initiated private ownership of the island, beginning with the Castilleros in the middle of the nineteenth century. One of the most important early owners was Justinian Caire, who developed an extensive ranch on the island in the last quarter of the century. He planted vineyards in the fertile Central Valley and built many of the fine old structures which now grace the island from bricks made of native clay. Santa Cruz Island wines were among the finest in early California until Prohibition ended production. The Stanton family acquired most of the island in 1937. Some of Caire's descendants, the Gherinis, now own the eastern one-tenth of the island, running a sheep ranch based at Smugglers Cove. McElrath (1967) and Eaton (1980) describe the lives of some early residents of Santa Cruz Island.

The island is presently occupied by a Navy communications installation which relays signals from the missle-tracking facility on San Nicolas Island to the Point Mugu headquarters (Hillinger 1958), a General Motors research installation, as well

as the two private ranches and occasional hunting parties. The Nature Conservancy, a private conservation organization, entered into a complex agreement with the Santa Cruz Island Company in 1978 which grants the organization a conservation easement on the majority of the island (Stanton, pers. comm. 1982). The Santa Cruz Island Company's land will come under the Nature Conservancy's full control in 2008, or when Dr. Stanton dies. Although all of the island is officially included in the new Channel Islands National Park, the Nature Conservancy's holdings are specifically exempt from being condemned and purchased by the federal government. The organization's proposed conservation and research programs will not be directly affected by the National Park Service. The Santa Cruz Island Company will probably continue to run cattle indefinitely, but all parties concerned foresee the removal of sheep from the island as a highly difficult procedure essential to the preservation of native vegetation.

Largest of the Channel Islands and third in size among the California Islands as a whole, Santa Cruz Island is about twenty-four miles long and up to seven miles wide, ninety-six miles square. The eastern end of the island lies nineteen miles from the mainland and five miles from Anacapa Island, and the western end is twenty-five miles south of Coal Oil Point and six miles east of Santa Rosa Island. The island is topographically diverse, being dominated by two ridges separated by the Central

Valley (Fig. 6). The northern ridge is the longer and higher of the two, extending the length of the island and reaching 2,470 feet (the highest point on the Channel Islands), at Picacho Diablo.

The western end of Santa Cruz Island, in the vicinity of the Christi Ranch, resembles adjacent parts of Santa Rosa with its relatively gentle, grassy hills, sandy beaches, windswept chaparral, and foggy bishop pine forests. The Sierra Blanca in the southwestern part of the island has an uncanny similarity to parts of the Sierra Nevada near timberline, an illusion caused by stunted pines set in light-gray scree fields, but shattered by the bark of sea lions wafted up from the beaches below. The bulk of the island is broken into a rugged and complex system of ridges and valleys characterized by steep, rocky slopes and arborescent chaparral. Toward the eastern end, the isthmus is a relatively low, rolling saddle in the northern ridge covered mostly with grasses and wind-sculptured scrub oak. Beyond the severely overgrazed badlands around High Mount, the infrequently-visited eastern end is again grassy and gently sloping.

The extremely complex geology of Santa Cruz Island is dominated by a major fault running through the Central Valley. The northern part of the island has moved one mile west and the southern part has risen 7,500 feet relative to each other (Weaver 1969).

> "North of the fault on Santa Cruz is a stratal sequence that is strikingly distinct from the one to the south, although they are in part of the same age . . . The northern regime is dominated by mid-Tertiary volcanics and volcaniclastics overlain by siliceous Monterey shales and Pleistocene terrace deposites. The early and mid-Cenozoic sequence of the southern regime rests upon subsurface Upper Cretaceous sandstone and shale and on the surface is largely in fault contact with a basement of diorite and schist" (Weaver 1969:9).
>
> "One of the more dramatic proposals is that, between middle and late Miocene times, the southern half of Santa Cruz Island moved from a former site west of what is now San Diego to its present location against the northern volcanic part of the island (Howell 1976:452 and his Fig. 2)" (Wenner and Johnson 1980:506).

Erosion and crustal movements have caused some unusual changes in the drainage of the Central Valley (Bremner 1932). The eastern valley's flow was once a simple run-off to the east, but stream capture has now caused major diversions and reversals of parts of the original streams. As a result, the major flow is now to the north, through Cañada del Puerto. Some other geological features of interest include a smoking vent (or fumarole) above China Harbor, reportedly the result of a petroliferous deposit which has been smouldering for many years (Wenner, pers. com. 1978). There are also deposits containing plant fossils of the Pleistocene, including the Willow Creek flora (Chaney and Mason 1936) and logs of Douglas fir (Pseudotsuga) up to three feet in diameter (Remington 1971).

Meteorological records for Santa Cruz Island are relatively complete, especially for the ranch headquarters (Hobbs 1978, Hochberg 1980a, Laughrin 1976, Weissman and Rentz 1977, Yeaton

1972). Prevailing westerly winds are strongest at the western end of the island, where fog is most frequent. Rainfall averages about twenty inches at the ranch (Weissman and Rentz 1977) but probably varies with proximity to the highest peaks, being considerably higher or lower in different parts of the island. Temperatures are generally very mild, averaging 60.4 F to 67 F annually with January lows averaging 40 F to 50 F and July highs averaging 77 F to 87 F, depending on the exact location. Cold air drainage results in much lower temperatures at the main ranch, which sits in the lowest part of the Central Valley (Hochberg 1980a). Rare extremes of 15 F and 110 F occur in the Central Valley (Stanton, pers. comm. 1982) and perhaps elsewhere. Humidity is usually high, averaging nearly 70% annually.

The diversity of geology, topography and micro-climates is relfected in the diversity of vegetation types on Santa Cruz Island. Although grasslands cover the greatest area, chaparral is the most conspicuous plant community in many areas. Island chaparral attains a more arborescent form and stands are generally more open than on the adjacent mainland, resulting in an aspect similar to woodland or savannah. In windy areas, however, chaparral plants may grow prostrate. Fairly large stands of coastal sage scrub, oak woodland, island woodland, and bishop pine forest are also scattered over the island. Coastal bluff vegetation and riparian woodlands are less extensive. A coastal marsh is found at Prisoners Harbor which holds water that is

relatively fresh. Dune vegetation is restricted to the western and southwestern beaches and a few scattered pocket beaches along the otherwise vertical coastline. Minnich (1980) has analyzed and mapped the vegetation of Santa Cruz Island, and Philbrick (1978) provides a general impression of its flora. Other studies of Santa Cruz Island's vegetation include Bjørndalen (1978) and Hochberg (1980a, 1980b). The Nature Conservancy has recently commissioned the Santa Barbara Botanic Garden to conduct detailed studies, the results of which have not been published.

As many as eleven plants may be completely restricted to this island:

Arctostaphylos insularis*
A. tomentosa subcordata*
A. viridissima*
Castilleja* affinis insularis?
Dudleya nesiotica*
Garrya sp.*
Lotus argophyllus niveus*
Malacothamnus fasciculatus nesioticus*
Mimulus brandegei*
Ribes thacherianum*
Thysanocarpus laciniatus conchuliferus*

Arbutus menziesii may also be slightly differentiated on Santa Cruz Island (Philbrick 1980). Some endemics and near-endemics which are common, widespread, or conspicuous on the island include:

Arctostaphylos insularis*
Ceanothus arboreus*
C. megacarpus insularis*
Cercocarpus betuloides blanchae*
Chorizanthe wheeleri
Comarostaphylis diversifolia planifolia
Coreopsis gigantea

Dendromecon rigida harfordii*
Eriogonum arborescens*
E. g. grande*
Lotus scoparius dendroideus*
Lyonothamnus floribundus asplenifolius*
Malacothrix saxatilis implicata*
Mimulus flemingii*
Pinus muricata remorata
Prunus ilicifolia lyonii*

The vertebrate fauna of Santa Cruz is the most diverse of the Northern Channel Islands and includes all of the species native to the group. Resident species include two salamanders Batrachoceps p. pacificus* and B. nigriventris), a tree frog (Hyla regilla), three lizards (Gerrhonotus m. multicarinatus, Sceloporus occidentalis beckii*, and Uta stansburiana), three snakes (Coluber constrictor mormon, Hypsiglena torquata, and Pituophis melanoleucus pumilis*), two mice (Peromyscus maniculatus santacruzae* and Reithrodontomys megalotis* santacruzae), the spotted skunk (Spilogale gracilis amphialus*), and the island fox (Urocyon littoralis santacruzae*). The fox and deer mouse are abundant, but the skunk and harvest mouse are very rare. A unique and distinctive race of the Scrub Jay (Aphelocoma coerulescens insularis*) is common. The island is also the primary residence of the island Rufous-crowned Sparrow (Aimophila ruficeps obscura*). The other resident bird endemics include:

Empidonax difficilis insulicola
Eremophila alpestris insularis*
Lanius ludovicianus anthonyi*
Melospiza melodia clementae*
Selasphorus sasin sedentarius*
Thryomanes bewickii nesophilus*
Vermivora celata soridida*

The Santa Catalina Island race of the California quail (Lophortyx californica catalinensis) has been introduced to this island and is now common. Turkeys and peafowl occur in small numbers in the Central Valley, and European Starlings have colonized the island. Chickens, dogs, horses, and cattle are raised in domestication. Besides feral sheep and pigs, no other introduced vertebrates are established on Santa Cruz Island. Fossils of the dwarf mammoth have been reported, but apparently no reliable specimens are currently available from this island.

The biogeographic affinities of Santa Cruz Island are strongest with Santa Rosa Island, as might be expected considering their proximity and ecological similarities. Several endemic plants and animals are found only on these two islands. Many species are also shared with the Northern Channel Islands in general, and with those islands supporting chaparral and woodland vegetation. A few two-island endemic plants with disjunct distributions suggest ties with Santa Catalina Island to the southeast (Cercocarpus betuloides* traskiae, Sibara filifolia*) and San Miguel Island to the west (Galium buxifolium*, Malacothrix indecora*).

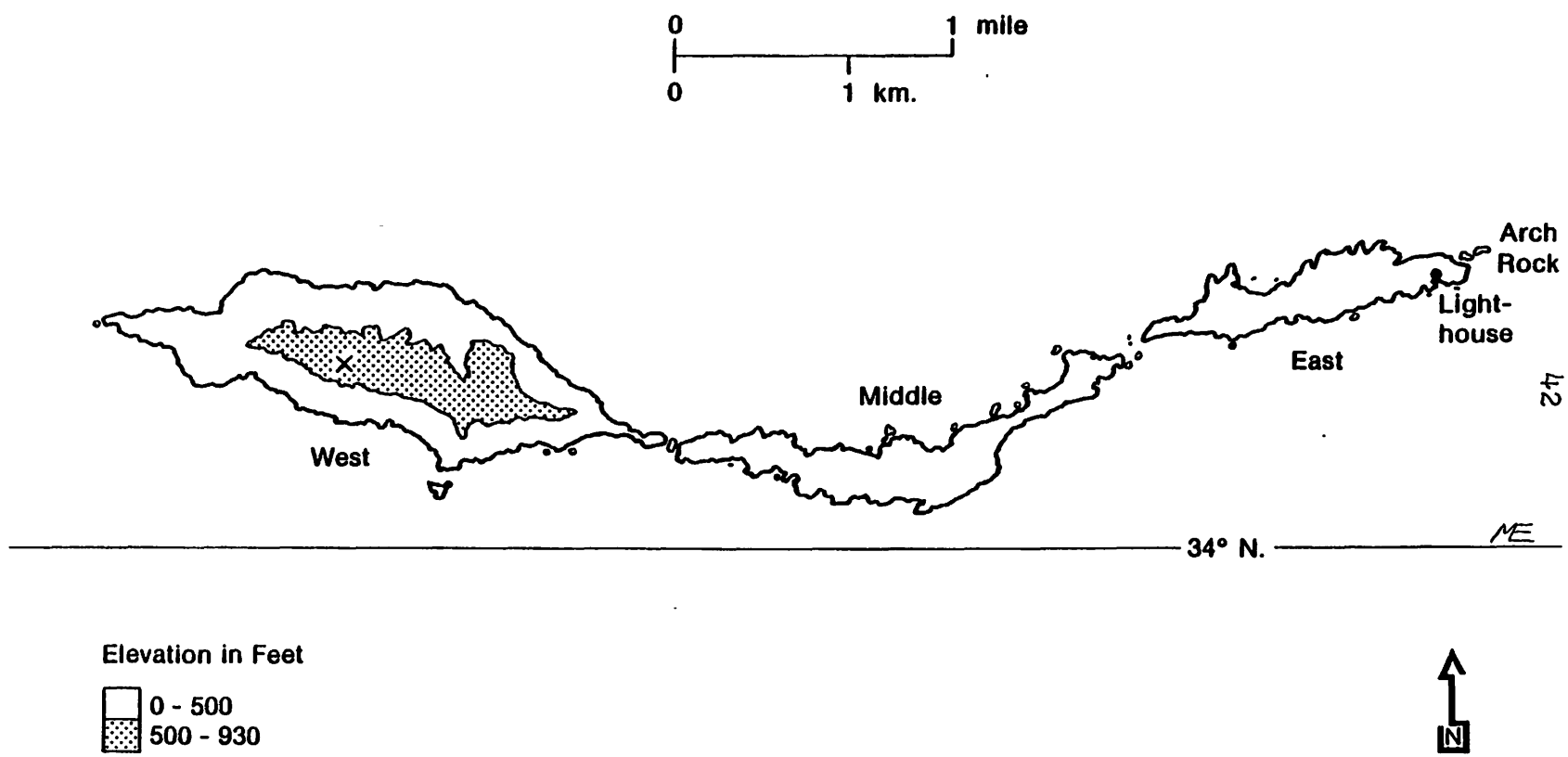


Fig. 7. Map of Anacapa Island.

Anacapa Island (ANA)

Considered by many who sail by her rugged shores to be little more than a string of three dry, lifeless rocks, Anacapa Island is a surprisingly beautiful place on closer inspection. In spring, sea birds nest among a rich tapestry of red, yellow, and blue wildflowers set on a tableland overlooking herds of seals and sea lions swimming in the surf at the bottom of precipitious cliffs. Across narrow gaps exposed at low tide, the other segments of the island stretch away in a graceful, rocky arc which includes Santa Cruz Island to the west (see Power 1980a: cover photograph).

Because of a complete lack of surface water (besides a few springs near the base of the sea cliffs), no Canaliño villages are known from Anacapa Island, though it was visited occasionally by these early seafarers (Glassow 1980). The island's name is apparently a corruption of the Chumash name "Eneeapah" meaning deception, illusion or mirage, perhaps referring to distortions of its shape when viewed from the mainland (an effect caused by the persistant marine layer in the coastal atmosphere) or to the island's deceptive topography (Glassow 1977:50).

The following centuries brought a long series of visitors to Anacapa Island, including hunters, fishermen, whalers, castaways, and James McNeil Whistler, who made a famous copper engraving of East Anacapa and Arch Rock while employed as an engraver for the

U.S. Boundary Survey in 1854, prior to his renown as a painter (Doran 1980). Sheep were grazed on at least some of the islets and a small light was installed early in this century. A much larger lighthouse, the one currently in use, was erected on East Anacapa in 1932. The island became part of the Channel Islands National Monument in 1938, along with Santa Barbara Island. The light and its bellowing foghorn were automated in 1966. The island is currently occupied by a few park service personnel on East Anacapa, where they live in a small compound of trim, little buildings.

Anacapa Island is the second smallest of the Channel Islands and smallest of the northern group. The island covers 1.1 square miles, about half of which is West Anacapa. The island is also the closest to shore among the Channel Islands, lying only thirteen miles off the coast of Ventura County, of which it is a part (the other northern islands being in Santa Barbara County). Of the three islets, West Anacapa is by far the highest, reaching 930 feet in elevation. Middle Anacapa is 325 feet high, and East Anacapa reaches only 250 feet. The two smaller islets are flat-topped, but the knife-like rige of West Anacapa rises to a sharp peak. All three islets are almost completely surrounded by unscalable cliffs. They form a chain about five miles long.

Anacapa Island is the exposed top of a Miocene volcanic ridge comprised mainly of basalt sculpted by Pleistocene marine terraces and overlain with thin, clayey soils. The south side of

the island has been extensively eroded by wave action, where the cliffs are highest.

Meteorological records for Anacapa Island are incomplete (Dunkle 1950, Weissman and Rentz 1977), but rainfall probably averages about eight inches on East and Middle Anacapa, and somewhat more on West Anacapa (Junak, pers. comm. 1982). Winds are mostly out of the west, but are not as strong or persistent as they are farther west. Temperatures are also probably slightly warmer than in coastal areas of the other Northern Channel Islands.

The vegetation of Anacapa Island reflects its dry and exposed nature (Dunkle 1942, Junak et al. 1980). Coastal sage scrub predominates, especially on south-facing slopes, and grades into coastal bluff vegetation on northern slopes. Grasslands were apparently more prevalent on the mesas during the period of grazing, but are now being replaced by scrub (Hochberg et al. 1980). On the northern slope of West Anacapa, two gullies support a few groves of trees and shrubs approaching the island chaparral or woodland communities. A few stunted, introduced eucalyptus trees occur on Middle Anacapa Island.

Only one plant is restricted to the island, an unnamed species of Malacothrix* related to M. foliosa, which was recently described from East Anacapa Island (Davis 1980). Smith (1976: 147) also reports an undescribed species of Erysimum* from the island, and Dunkle (1942) described Castilleja* anacapensis from

the west and middle islands. Visitors to East Anacapa are likely to encounter the following endemics and near-endemics:

Coreopsis gigantea
Eriogonum arborescens*
E. g. grande*
Hemizonia clementina*
Lotus scoparius dendroideus*
Malacothrix saxatilis implicata*

Although the three islets share many species, the distribution of some endemics is rather enigmatic in their absence from one or two of the islets. In some cases, such as the presence of trees and shrubs on West Anacapa, the disjunctions can be explained on the basis of ecological differences, but in other instances this is not a covenient explanation. The annual Malacothrix species* mentioned previously is found on East and West Anacapa, but is replaced by M. squalida* on Middle Anacapa (Hochberg et al. 1979). The latter is one of the more interesting biogeographic patterns on the islands.

As might be expected for such a small and ecologically restricted island, Anacapa supports few native land vertebrates, including one salamander (Batrachoceps p. pacificus*), two lizards (Gerrhonotus m. multicarinatus and Uta stansburiana), and the deer mouse (Peromyscus maniculatus* anacapae). Another endemic (extinct) deer mouse (P. anyapahensis) is known from late Pleistocene deposits on West Anacapa Island. The black rat has become established on the island. Hopefully the latter will soon go the way of the European rabbits which were introduced to East

Anacapa, where they flourished in the late 1930's, but which have since been exterminated (Collins, pes. comm. 1981). The endemic land birds which have been known to breed on Anacapa Island include:

Aimophila ruficeps obscura*
Empidonax difficilis insulicola
Eremophila alpestris insularis*
Lanius ludovicianus anthonyi*
Selasphorus sasin sedentarius*
Thryomanes bewickii nesophilus*
Vermivora celata sordida*

The avifauna of Anacapa Island appears to be changing as vegetation becomes denser following the cessation overgrazing in years past (Diamond and Jones 1980).

Proximity to the mainland seems to have given Anacapa Island a flora and fauna which resembles that of the adjacent coast more than does the biota of the islands to the west or south. The Anacapa populations of some plants (e.g., Dudleya* caespitosa and perhaps Malacothrix saxatilis*) are considered nonendemic versions of forms endemic to the other Northern Channel Islands, and at least two birds (Eremophila alpestris insularis* and Selasphorus sasin sedentarius*) are less strongly differentiated there. The undescribed Malacothrix* species and Hemizonia clementina* suggest a biogeographic affinity with the Southern Channel Islands (especially Santa Barbara) which is unique in the northern group, but easily explained by the island's relatively dry climate and geographic position.

Although the island itself supports relatively few organ-

isms, the waters surrounding it are rich in life. The largest colonies of Western Gulls and Brown Pelicans on the Channel Islands occur on the island, as well as rookeries of several other sea birds (Hunt et al. 1980). The pelican rookery on the north-facing cliffs of West Anacapa is the only substantial one left on the Pacific coast of the United States, and access to that islet is restricted during the breeding season. California sea lions and harbor seals commonly bask on the shores of the island, and gray whales and other cetaceans may be viewed from its cliffs. The tide pools of Anacapa Island are rich in abalones and other invertebrates no longer common along the mainland coast. Dawson and Neushul (1966) have studied the subtidal marine algae of Anacapa Island, where they found a number of previously undescribed species, some of which may be endemic.

The Southern Channel Islands

When the Northern and Southern Channel Islands are arranged in two parallel series according to area, some interesting similarities become apparent. In order of increasing size, the resulting north-south island pairs are Anacapa-Santa Barbara, San Miguel-San Nicolas, Santa Rosa-San Clemente, and Santa Cruz-Santa Catalina. The topographical and ecological resemblances between the islands in each of these pairs are generally more striking than between adjacent members of each island group. Such comparisons could form the basis of some interesting studies, though the analogy between Santa Rosa and San Clemente islands is comparatively weak. The islands are presented in the order of increasing size and elevation.

SANTA BARBARA ISLAND (SBA) is like a compressed and isolated version of Anacapa Island in many respects. Though the smallest and least diverse of the Channel Islands, Santa Barbara is a spectacular place on a clear day. Its central location affords a panoramic view of all eight islands except San Miguel, which is hidden behind Santa Rosa Island (Philbrick 1972). Sutil Island, a large rock which is an important breeding ground for sea birds (Hunt et al. 1980), lies offshore. The only plant communities present on this island are grasslands and coastal bluff vegetation, which have been severely damaged by introduced rabbits and fires (Philbrick 1972, Hochberg et al. 1979). Native land ver-

tebrates are limited to one lizard and a deer mouse. The former is the island night lizard, (Klauberina [Xantusia] riversiana), the most distinctive vertebrate endemic to the California Islands, which also occurs on San Nicolas and San Clemente islands (Bezy et al. 1980). The island also hosts a surprising array of endemic land snails (Hochberg 1979).

SAN NICOLAS ISLAND (SNI) is somewhat larger than San Miguel, but they share a low, sandy, and rather barren aspect, large colonies of pinnipeds, and the strong influence of the cool California Current. The last of the Channel Island Indians, Juana Maria, survived alone on this remote island for eighteen years until she was found in 1853 and taken to the mainland, where she soon died (Hillinger 1958, Doran 1980). San Nicolas currently supports a missile-tracking installation, and the U.S. Navy restricts public access. The island supports significant areas of coastal marsh, dune, sage scrub, and grassland vegetation (Foreman 1967). Two lizards, a mouse, and the island fox are native, and feral cats are abundant.

SAN CLEMENTE ISLAND (SCL) resembles Santa Rosa mainly in its gentle grassy slopes cut by steep, wooded canyons; otherwise the islands are quite different. High, volcanic cliffs support a relatively level mesa occupied by military installations. Besides coastal marsh, dune, bluff, sage scrub, and grassland vegetation, San Clemente Island has some interesting cactus scrub and island woodland (Raven 1963, 1965; Thorne 1969b). Floristic-

ally, the island represents a strong biogeographic link between the Northern Channel Islands and remote Guadalupe Island far to the south. The most distinctive plant is Munzothamnus blairii, a monotypic genus which is related to Malacothrix*. The native land vertebrates are two lizards, a deer mouse, and the island fox. Goats have severely overgrazed the island, resulting in the extinction of several endemic plants and birds. Feral cats have aided in the destruction of the latter.

SANTA CATALINA ISLAND (SCA) is smaller than Santa Rosa, but more closely resembles Santa Cruz Island with its rugged terrain and aborescent vegetation. The plant communities of the two islands are the same, except for the absence of pine forests and the presence of some maritime cactus scrub on Santa Catalina (Thorne 1967, 1969b; Minnich 1980). The relatively diverse vertebrate fauna includes two salamanders, a frog, three lizards, five snakes (including a rattlesnake), a shrew, two mice, a ground squirrel, and the island fox. Avalon, which has been a popular tourist resort since the late nineteenth century, is the only town on the Channel Islands. Although the island is grazed by a variety of introduced herbivores, including bison, the greatest ecological damage is caused by goats (Coblenz 1980).

Despite the numerous similarities which unite the Channel Islands as a group, the northern and southern subsets demonstrate several differences which separate them into internally consistent units. The Southern Channel Islands are uniformly more

isolated from each other, and none of them is believed to have been connected to any other existing landmass during glacial periods. In terms of the island pairs mentioned previously, the southern islands are all more isolated from the mainland and they are slightly drier and warmer than their northern counterparts (Dunkle 1950, Weissman and Rentz 1977). With the following exceptions, the Southern Channel Islands are also smaller (San Nicolas) and lower in elevation (San Clemente).

Although several endemics are shared by both the Northern and Southern Channel Islands, many species are represented on the southern islands by a related, but more distinctive endemic. Taxa with different endemics on the Northern and Southern Channel Islands include:

(Plants)

Arctostaphylos*
Ceanothus arboreus*
Dendromecon rigida*
Dudleya*
Eriogonum*
Eriophyllum*
Galium buxifolium* aff.
Haplopappus*
Lavatera assergentiflora*
Lotus*
Lyonothamnus floribundus*
Malacothamnus fasciculatus*
Mimulus brandegei* aff.
Platystemon californicus*
Solanum wallacei*

(Invertebrates)

Haplotrema*
Arachnis picta*
Argyrotaenia*
Bembix americana*
Efferia*
Okanogona hirsuta*
Trigonoscuta*

(Vertebrates)

Lanius ludovicianus*
Melospiza melodia*
Thryomanes buwickii*
Peromyscus maniculatus*
Reithrodontomys megalotus*
Urocyon littoralis*

In general, the Southern Channel Islands are more thoroughly studied than the northern group, and much of what has been pub-

lished about the California Islands as a whole applies mainly to these islands. The Los Angeles County Museum has long been one of the main centers of study on these islands in a variety of disciplines. Much of the museum's early work was published in The Bulletin of the Southern California Academy of Sciences "Contributions from the Los Angeles Museum -- Channel Islands Biological Survey". The Rancho Santa Ana Botanic Garden in Claremont has been actively interested in these islands and maintains both living and pressed collections of endemic plants. Various colleges and universities in the Los Angeles area have also contributed greatly to the study of the Southern Channel Islands.

THE BAJA CALIFORNIA ISLANDS

There are relatively few parameters which characterize the Baja California Islands as a group, since they consist of both the largest and smallest of the California Islands with practically no intermediates. They do, however, share Mexican nationality (sufficient reason in itself to unite them) and a drier, slightly warmer climate than that of the Channel Islands. Also, all of the islands except Guadalupe lie on the continental shelf in fairly shallow water close to shore, and they were probably connected to the mainland during the Pleistocene (Wilcox 1980).

The small islands can be compared to East and Middle Anacapa islands and the large ones to Santa Cruz and Santa Rosa, though the physical resemblances are not striking. Despite the approximately 450 miles which separate them, the four largest California Islands do share some important ecological characteristics and several endemics. Biogeographic affinities are stronger with the Southern Channel Islands, however (Raven 1967).

The Baja California Islands are poorly studied for the most part. Besides the references mentioned for the California Islands as a whole, comprehensive treatment has been attempted only by Bostic 1975, though many gaps and problems exist in that text. Wiggins (1980) discusses the islands' flora to some extent. Brandegee (1900) was one of the pioneering botanists on these islands.

The Northern Baja California Islands

This is the most internally consistent subgroup of the California Islands in terms of physical and ecological characteristics. All four islands are small, nearshore, and low in elevation. Coastal sage scrub is the principal vegetation (Savage 1967), with a greater admixture of desert scrub toward the south (as the islands are presented here). They are relatively barren and uninteresting. Nevertheless, they extend the range of 'natural experiments' in ecology among the California Islands, making them a worthy object of study. They share few endemics with the Northern Channel Islands, but some local endemics are found on these islands. Taxa with different endemics on the Northern Channel Islands and the Northern Baja California Islands include:

(Plants)	(Vertebrates)
Dudleya*	Melospiza melodia*
Galium*	Pituophis melanoleucus*
Hemizonia*	Aimophila ruficeps*
Lavatera*	Peromyscus maniculatus*

LOS CORONADOS ISLAND (LCO) consists of four islets which lie just south of the international border near Tijuana. Reaching an elevation of about 670 feet, South Coronados is the highest of the small Mexican islands. The island is composed of extrusive Tertiary volcanics. The vertebrate fauna includes two salamanders, five lizards, three snakes (including a rattlesnake), and

three rodents. Howell (1917) includes this island in his discussion of the birds of the Channel Islands, as does Diamond (1969). Kuper (1978) reviews the island's natural history.

TODOS SANTOS ISLAND (TSA) is made up of two islets near Ensenada. The rocks are ancient intrusive volcanics. Native land vertebrates include one salamander, three lizards, three snakes, and two rodents. The flora is discussed by Moran (1950), Moran and Lindsay (1949), and Thorne (1980).

SAN MARTIN ISLAND (SMA) lies near San Quentin. Two prominent ash cones emphasize the recency of the volcanic activity which formed this island. The original vertebrate fauna consisted of two lizards, three snakes, a shrew, and two rodents, though some of these may be extinct (Bostic 1975).

SAN GERONIMO ISLAND (SGE) is the smallest and lowest of the main California Islands, being only two-tenths of a mile square and 130 feet high. This tiny island lies south of El Rosario and Punta Baja. The rocks are Cretaceous metamorphics. Only four plants are native, as are two lizards, one snake, and a deer mouse.

The Southern Baja California Islands

This is the least coherent subset of the California Islands in all respects, consisting of islands large and small, nearshore and remote, low and mountainous, desert and forested. All of them except Guadalupe appear to be extensions of the Serra Vizcaino (Wiggins 1980). They all lie south of the other California Islands, and desert scrub predominates at lower elevations, except perhaps on Guadalupe. The islands will be discussed in the order of increasing distance from the mainland.

NATIVIDAD ISLAND (NAT) is the largest of the six small Baja California Islands, covering nearly three miles square. Hale (1941) discusses floristic relationships with Cedros Island. The native land vertebrates include two lizards, a snake, and a deer mouse.

CEDROS ISLAND (CED) is the largest of all the California Islands with 134 miles square. The island is extremely rugged and has three main ridges which converge in the central part of the island, reaching peaks nearly 4,000 feet high. Geologically complex, Cedros Island is made up of ancient granites, volcanics, metamorphics, and some Pliocene sediments. This is the most ecologically diverse of the Baja California Islands, with desert scrub and elephant trees mainly below 2,000 feet and extending into the highlands; coastal dune scrub; coastal sage scrub; chaparral; juniper woodland; and impressive forests of Monterey

pine on north- and west-facing peaks (Hale 1941). About one quarter of its plant species are shared with the Channel Islands (Eastwood 1929). The most diverse assemblage of terrestrial vertebrates among the California Islands is found on Cedros Island, which supports a frog, seven lizards, five snakes (including a rattlesnake), three rodents, a rabbit, and a black-tailed deer, most of which are endemic to this island. Man has introduced dogs, cats, goats, and burros, which are now feral. The hostile Indians encountered by early explorers had a material culture which was apparently copied from jetsam of the Chumash which was washed down by the California Current (Bostic 1975). Fishing, salt processing, and (formerly) mining support the several thousand inhabitants of the Mexican islands' only town.

SAN BENITO ISLAND (SBE) is the only one of the small Mexican islands which lies any great distance from shore, being 41 miles from Punta Eugenia (though only 17 miles from intervening Cedros Island). Like Anacapa Island, it consists of three islets of different sizes. The geology is fairly complex, but only desert scrub (Hale 1941, Moran and Lindsay 1950b) and two lizards are native to the island (Bostic 1975).

GUADALUPE ISLAND (GUA) is in many ways the most extreme of the California Islands. 157 miles from shore, it is more than twice as isolated as any other island. Guadalupe is the highest of the California Islands, reaching 4,257 or 4,600 feet (depending on the reference) in elevation, and is second only to Cedros

in size. The incidence of endemism in the island's biota is the highest among the California Islands (Table 2). Since Guadalupe is probably the most interesting of the sixteen islands (Cockerell 1938) and is the most thoroughly studied of the Baja California Islands, it deserves more detailed treatment here.

With 98 miles square, Guadalupe is only slightly larger than Santa Cruz Island. Extrusive volcanics make up the island, and the oldest lava flows are estimated at around seven million years in age (Lindberg et al. 1980). The waters surrounding Guadalupe Island are 12,000 feet deep, precluding any connection or recent proximity with other landmasses. The island bears certain geological, topographical, and biological resemblances to San Clemente Island, 250 miles to the north (Raven 1963). Bathing in the southern part of the California Current, Guadalupe Island has a mild climate with temperatures averaging between 60 F and 65 F, and more than seven inches of rain at lower elevations, mainly in the winter and spring (Bostic 1975). Heavy rain, snow, and ice are known to occur at higher elevations.

The investigation of Guadalupe's unique biota began in 1875, when Dr. Edward Palmer spent an unexpectedly long period alone there (Blake 1961). Desert scrub predominates at the southern end of the island; coastal sage scrub was probably dominant at lower elevations elsewhere (Moran, pers. comm. 1981); and forests of palm, juniper, oak, cypress, and pine grow on the northwest side and around the summit (Moran and Lindsay 1950, Bostic 1975).

Stands of chaparral also probably once occurred in the highlands (Moran, pers. comm. 1981). Over 80% of the native flora, including many endemics, is shared with the Channel Islands, especially San Clemente (Moran 1967, Raven 1963). Eastwood (1929) and Howell (1942) list most of Guadalupe Island's plants. Goats have long been a problem on the island, where they have destroyed most of the native vegetation except large trees and cliff-hangers (Lindsay 1966). Several endemic plants, including a monotypic genus, are now extinct. The weedy tree tobacco (Nicotiana glauca), a poisonous native of South America, has become abundant over large areas. Inner and Outer islets, two large offshore rocks capped with virgin vegetation, have a few species of plants not found on the main island. Some of these species are known to have grown there previously (Moran 1951a, 1967, 1969), though Inner Islet has never been effectively sampled due to the precipitous cliffs which surround it (Bostic 1975). The species of the islets are generally lumped with those of the main island in this thesis, even though the islets are larger than San Geronimo Island and can be considered distinct entities.

Native terrestrial vertebrates are not definitely known to have occurred on Guadalupe Island, though there were early reports of a few lizards (loc. cit.). Most of the land birds are endemic forms (Power 1980c), but several are now extinct due to habitat destruction by goats and predation by feral cats. Guada-

lupe Island was the last refuge for the northern elephant seal and Guadalupe fur seal, both of which were thought to be extinct early in this century. A few individuals of each species escaped slaughter on this remote island and the species are now recovering rapidly with protection (Le Boeuf and Bonnell 1980). Lindberg et al. (1980) give some insight into the Pleistocene marine fauna of Guadalupe Island.

The following taxa have different endemics on the Northern Channel Islands and the Southern Baja California Islands, especially on the highlands of Cedros and Guadalupe:

(Plants)

Arctostaphylos*
Astragalus*
Castilleja*
Dudleya*
Eriogonum
Erysimum*
Eschscholzia*
Galium*
Gilia*
Hemizonia*
Lavatera*
Lotus*
Mimulus*
Phacelia*
Pinus
Salvia*
Solanum wallacei*

(Invertebrates)

Haplotrema*
Helminthoglypta*
Vertigo california*

(Vertebrates)

Pituophis melanoleucus*
Carpodacus mexicanus*
Pipilio erythrophthalmus*
Thryomanes bewickii*
Peromyscus maniculatus*

SECTION TWO:

THE ENDEMIC FLORA AND FAUNA

OF THE NORTHERN CHANNEL ISLANDS

EXPLANATORY NOTES

The following abbreviations and conventions are used throughout this section.

Islands:

ANA - Anacapa
CED - Cedros
GUA - Guadalupe
LCO - Los Coronados
NAT - Natividad
SBA - Santa Barbara
SBE - San Benito
SCA - Santa Catalina
SCL - San Clemente
SCR - Santa Cruz
SGE - San Geronimo
SMA - San Martin
SMI - San Miguel
SNI - San Nicolas
SRO - Santa Rosa
TSA - Todos Santos

Distributions:

ANA - presently well-established on Anacapa Island

ANA? - presence or taxonomic status on ANA questionable

(ANA) - locally extinct on ANA

(ANA)? - population questionably extinct on ANA

(ANA?) - presence or taxonomic status of a now extinct population on ANA questionable

(ANA?)? - taxonomic status of a possibly extinct population on ANA questionable.

Authors of scientific names are given only in the species descriptions for illustrated taxa and closely related forms which are endemics or near-endemics of the Northern Channel Islands. Synonyms are given in brackets only if they are still in use and are extremely different from the valid name. The organization of species is generally taxonomic; plants and birds are listed alphabetically by genus for easy reference. The scale indicates the horizontal plane in each figure.

PLANTS

The flora of the Northern Channel Islands is not well-documented, with the exception of most endemics. G. Wallace of the Los Angeles County Museum of Natural History is preparing floral lists for the Channel Islands, and R. Philbrick of the Santa Barbara Botanic Garden is working on a comprehensive flora of the northern Islands.

NEAR-ENDEMICS

Various species have been excluded from detailed treatment in this thesis because they are very weakly differentiated on the islands or occur fairly widely on the mainland. Other species which are not island endemics in the strictest sense have been illustrated (*) because they are found mainly on the islands or because they are ecologically or scientifically important there. Some of the plants which are found on the mainland to some extent include:

Astragalus* curtipes (glabrous; Munz 1959:879)
Calystegia m. macrostegia*?
Castilleja* mollis
Ceanothus megacarpus insularis*? (Smith 1976:189)
Cercocarpus betuloides blanchae*
Chorizanthe wheeleri
Comarostaphylis diversifolia planifolia
Coreopsis gigantea
Dichondra occidentalis
Elymus condensatus (glaucous; Philbrick 1980, Smith 1976:78)
Eriophyllum staechadifolium depressum*

Erysimum* spp.
Eschscholzia ramosa*? (Wiggins 1980:759)
E. californicia maritima
Grindelia l. latifolia
Jepsonia malvaefolia*? (Abrams 1944:351)
Lepechinia fragrans
Lotus scoparius* vars.
Malacothrix* coulteri cognata
M. incana/succulenta
M. saxatilis implicata*? (Smith 1976:301)
Opuntia littoralis
Orobanche parishii brachyloba*
Pinus muricata remorata
P. torreyana
Pityrogramma triangularis viscosa
Platystemon californicus* vars.
Prunus ilicifolia lyonii*? (Raven 1963)
Quercus* macdonaldii (C.H. Muller, pers. comm. 1980)
Q. morehus
Q. parvula (Nixon 1980)
Salvia brandegei*
Sanicula hoffmannii
Thysanocarpus laciniatus* vars.? (Smith 1976:152)
Trifolium mocrodon pilosum

Endemics which are taxonomically weak or questionable (besides several of the above) include:

Achillea borealis (pink flowered; Philbrick 1980)
Adenostoma fasciculatum (prostrate; loc. cit.)
Amsinckia spectabilis nicolai
Arbutus menziesii (SCR; loc. cit.)
Artemisia californica (prostrate; loc. cit.)
Castilleja* sp. (SMI; Smith 1976:313)
C. affinis insularis
C. anacapensis (Dunkle 1942)
Dudleya greenei*
D. g. nana
Eriogonum* fasciculatum (prostrate; Philbrick 1980)
Erysimum* sp. (ANA; Smith 1976:147)
Galium* sspp.
Garrya* sp.
Heteromeles arbutifolia* macrocarpa
Madia sp. (SCR; Philbrick, pers. comm. 1979)
Marah macrocarpus major (Raven 1963)
Quercus* dumosa (prostrate; Philbrick 1980)
Rhamnus pirifolia*
Ribes thacherianum*

Sanicula arguta (SMI; Cockerell 1939)
Silene laciniata (pale flowers, SCR; Philbrick 1980)
Sisyrinchium bellum (dwarf; loc. cit.)

The marine algae of the Northern Channel Islands have received little attention (Murray et al. 1980). Consequently, the endemics which have been described from the islands are of uncertain validity, both taxonomically and biogeographically. Of the many endemics described by Dawson (1949), none have been retained as strict endemics by Abbot and Hollenberg (1976). Because of this lack of knowledge, and due to the inconspicuous nature of the proposed endemics (except Egregia menziesii insularis, which is taxonomically questionable), none of them has been given full treatment in this thesis. Several species were described and illustrated by Dawson and Neushul (1966) from a single transect off Anacapa Island. The following species have been retained by Abbott and Hollenberg (Woodhouse 1981):

Dictyopteris johnstonei
Lejolisea pusilla
Platysiphonia parva
Pollexfenia anacapensis
Predaea masonii
Reticulobotrys catalinae
Rhodymenia sympodiophyllum

COMMUNITIES

The vascular plant communities of the islands and adjacent mainland have been described by various authors (Barbour and Major 1977, Dunkle 1950, Hochberg et al. 1979, Philbrick 1978,

Smith 1976).

> "There is an initial suspicion that the current concepts of California plant communities do not fit all insular associations . . . Another conspicuous feature of island communities is that many species, including insular endemics, are relatively wide-ranging and are not restricted to particular communities" (Philbrick and Haller 1977:895).

Local exposure to wind, fog, salt spray, water, and sun are especially important in determining the vegetation of particular areas. Although the island soils have not been well studied (Hochberg 1980a), examples of edaphic endemics are known among beach plants, Arctostaphylos*, Hemizonia*, and Pinus torreyana. Affinities with communities found north of Point Conception are strongest in the coastal dune and bluff communities, native grasslands, bishop pine forests, and the relictual patches of maple and madrone on Santa Cruz Island.

SOUTHERN COASTAL SALT MARSHES on the Northern Channel Islands are rather few, depauperate, and poorly developed; apparently due to the absence of suitable substrata. They range from salty tidal marshes to the nearly fresh marsh at Prisoners Harbor on Santa Cruz Island. Most are located at the mouths of streams. The only endemics or near-endemics which may rarely be found in coastal marshes are Amsinckia spectabilis nicolai and Grindelia l. latifolia.

SOUTHERN BEACH AND DUNE VEGETATION on the islands occurs mainly in dry, sandy areas exposed to the full force of the north-westerly winds. It is most extensive on San Miguel and

Santa Rosa Islands, though patches occur at the western tip of Santa Cruz Island and on isolated pocket beaches along the sheltered sides of all the northern islands. Dune vegetation varies considerably from low annuals and perennials in the drifting foredunes to brushy perennials and grasses in the stabilized backdunes, where the community grades into coastal sage scrub and grassland. The following endemics and near-endemics are characteristic of dune vegetation on the islands:

Amsinckia spectabilis nicolai
Astragalus miguelensis*
Castilleja* mollis
Eriogonum grande* rubescens
Erysimum* spp.
Gilia tenuiflora hoffmannii*
Grindelia l. latofilia?
Lotus scoparius* veatchii
Malacothrix* incana / succulenta
Phacelia divaricata insularis*
Platystemon californicus ornithopus*

VALLEY AND FOOTHILL GRASSLAND is the most widespread type of vegetation on the Channel Islands, occupying much of each island. It generally occurs on slopes, marine terraces, and alluvial plains with fairly deep, usually clayey soils; where woody plants can not grow due to wind, seasonal dryness, grazing, or burns. Grasslands also form an understory in the more open coastal sage scrub, woodland, and chaparral communities; members of these communities can often be found isolated in grasslands. In their original state, the island grasslands were comprised mainly of perennial bunchgrasses and herbaceous annuals. Native grasses (Stipa) still occur in some numbers on West and Middle Anacapa

islands (Hochberg et al. 1979). In their present, highly disturbed condition, island grasslands consist mostly of introduced annual grasses and weeds. Endemics characteristic of the pristine island grasslands include:

Gilia* spp.
Grindelia l. latifolia
Lepidium oblongum insulare
Malacothrix* spp. (annuals)
Platystemon californicus* vars.
Phacelia divaricata insularis*
Thysanocarpus laciniatus* vars.
Trifolium microdon pilosum

SOUTHERN COASTAL BLUFF SCRUB reaches its fullest expression on the Channel Islands, especially San Miguel. Cliffs are a particularly difficult habitat for plants to colonize. Soil is scarce, erosion creates instability, and runoff removes what little precipitation falls on the vertical surface. These problems are enhanced on sea cliffs by salt spray and fluctuating sea levels. The lush coastal bluff vegetation of the islands undoubtedly exists because the islands support the only significant north- and east-facing sea cliffs on the California coast, where shade and fog provide ample moisture. On the mainland and on south-facing slopes of the islands, coastal bluff vegetation blends imperceptibly into coastal sage scrub. Point Mugu, at the western end of the Santa Monica Mountains, supports a scrub community which resembles that of the islands in some respects. Coastal bluff vegetation consists mainly of low, perennial growth, succulents, and lichens, which form a complex mosaic covering the rocks and terraces, mainly below 1,000 feet. This

community abuts on all of the other island plant communities where cliffs break the landscape, and members of these other vegetation types have invaded the cliffs to some extent, especially those removed from the immediate coast. This has provided certain endemics with their final refuge from grazing pressures, and some of the supposedly extinct plants of the islands may still be discovered clinging to a precipitious cliff someday. Coastal bluff vegetation as a whole is highly sensitive to grazing and may have been formerly much more extensive on the islands (Philbrick and Haller 1977). The character and composition of bluff vegetation varies considerably from coastal to interior sites, north to south-facing slopes, cliff face to marine terrace, and island to island. Vivrette (1980) has examined the factors controlling the distribution of some nonendemic species of this community on Santa Cruz Island. Some of the endemics to be found among coastal bluff scrub on the Northern Channel Islands (in various places) include:

Arabis hoffmannii*
Calystegia m. macrostegia*
Coreopsis gigantea
Dudleya* spp.
Eriogonum* spp.
Eriophyllum stechadifolum depressum*
Eschscholzia ramosa*
Galium buxifolium*
G. californicum miguelense*
Gilia nevinii*
Haplopappus detonsus*
Heuchera maxima*
Lavatera a. assergentiflora*
Lotus* scoparius* vars.
Malacothrix* spp.

Mimulus* flemingii*
Platystemon californicus* vars.

COASTAL SAGE SCRUB is not as highly developed on the islands as it is on the adjacent mainland, partly because it favors rather dry, hot regions. Consisting mainly of low, scrubby, summer deciduous, aromatic (allelopathic) growth interspersed with grasses, sage scrub occurs mainly on steep, rocky, south-facing slopes and marine terraces. Cactus (Opuntia spp.) was a major component until the parasitic cochineal scale (Dactylopius sp.), formerly a major source of scarlet dyes, was successfully introduced on Santa Cruz Island in 1951 (Goeden et al. 1967). The insect has since spread to Santa Rosa and Anacapa islands, (Hochberg 1979). The destruction of cactus has reduced an important habitat for endemic land snails, resulting in the decline of the latter (loc. cit). Like coastal bluff vegetation, the coastal sage scrub on the islands has been greatly reduced by grazing due to its small stature, succulent leaves, and fragile stems (Brumbaugh 1980). Where protected from overgrazing, recovery has been slow and incomplete on Santa Cruz Island, perhaps because of the scarcity of cactus patches to shelter some of the poorly dispersing species (Minnich 1980). Coastal sage scrub appears to be a very recent community, having attained its widespread distribution in the past 10,000 years (Axelrod 1978). Endemics and near-endemics typically found in coastal sage scrub on the islands include:

Calystegia m. macrostegia*
Castilleja hololeuca*

Chorizanthe wheeleri
Dichondra occidentalis
Dudleya* spp.
Eriogonum* spp.
Eschscholzia ramosa*
Galium angustifolium foliosum*
Gilia nevinii*
Grindelia l. latifolia
Helianthemum greenei*
Haplopappus dentonsus*
Hemizonia clementina*
Isomeris arborea insularis*
Lotus* spp.
Malacothamnus fasciculatus nesioticus*
Malacothrix* saxatilis implicata*
Marah macrocarpus major
Orobanche parishii brachyloba*
Salvia brandegei*
Sanicula hoffmannii

ISLAND CHAPARRAL is found only on the three largest Channel Islands (Santa Cruz, Santa Rosa, and Santa Catalina), mainly on steep, rocky, north-facing slopes. Chaparral elements are also found on West Anacapa and the highlands of Cedros and Guadalupe islands. It differs from mainland coastal chaparral both structurally and floristically. The more open, woodland aspect of the island chaparral and the greater height of its components are probably due at least in part to the islands' history of intense grazing and low incidence of fires, both of which favor the development of a few mature plants. Climatic and floristic considerations may also be important in encouraging aborescent growth, as opposed to the dense, uniform, and scrubby aspect of mainland chaparral (Bjørndalen 1978, Hochberg 1980a, 1980b). The island chaparral consists mainly of evergreen, sclerophyllous, allelopathic, broad-leaved shrubs and small trees, and differs

from mainland chaparral in the dominance of endemics and oaks (Quercus* spp.). The Peruvian pepper tree (Schinus molle) appears to be invading open stands of chaparral on Santa Cruz Island to some extent. Although browse sensitive, island chaparral has suffered only gradual attrition because of its longevity and large size. Chaparral is apparently fairly recent as a climax vegetation, and is probably seral to woodland (Axelrod 1977). Typical endemics and near-endemics of the island chaparral include:

Arctostaphylos* spp.
Castilleja* spp.
Ceanothus* spp.
Cercocarpus betuloides blanchae*
Comarostaphylis diversifolia planifolia*
Dendromecon rigida harfordii*
Dichondra occidentalis*
Dudleya candelabrum*
Galium nuttallii insulare*
Garrya* sp.
Haplopappus dentonsus*
Helianthemum greenei*
Heteromeles arbutifolia*
Jepsonia malvaefolium*
Lotus argophyllus niveus*
Lyonothamnus floribundus asplenifolius*
Marah macrocarpus major
Mimulus* spp.
Prunus ilicifolia lyonii*
Rhamnus pirifolia*
Sibara filifolia*
Solanum wallacei clockeyi*
Xylococcus bicolor

ISLAND WOODLAND occurs on the same islands as chaparral in similar, but moister situations, often at higher elevations and in washes. This community is also found on San Clemente Island, and marginally on West Anacapa, Cedros and Guadalupe islands.

Island woodland achieves its richest expression on the northern slopes of Santa Cruz Island. It differs from mainland woodland communities in the dominance of island endemics. The presence of a few madrone trees (Arbutus menziesii) and bigtooth maples (Acer macrophyllum) suggest an affinity with the mixed evergreen forests found in the Santa Ynez Mountains and farther north. The principal endemics and near-endemics of island woodland include:

Arctostaphylos* spp.
Ceanothus arboreus*
Comarostaphylis diversifolia planifolia
Heteromeles arbutifolia*
Heuchera maxima*
Jepsonia malvaefolium*
Lyonothamnus floribundus asplenifolius*
Prunus ilicifolia lyonii*
Ribes thacherianum*
Solanum wallacei clockeyi*
Quercus* spp.
Xylococcus bicolor

SOUTHERN COASTAL OAK WOODLAND is limited for the most part to stream beds on the three largest Channel Islands, reaching its fullest expression in Cañada del Puerto, which drains the Central Valley of Santa Cruz Island. Live oaks (Quercus* agrifolia) dominate the moist, alluvial deposits in such woodlands, which grade into island chaparral and coastal sage scrub. The few endemics and near-endemics of coastal oak woodland include:

Galium angustifolium foliosum*
G. nuttallii insulare*
Heteromeles arbutifolia*
Heuchera maxima*
Marah macrocarpus major
Prunus ilicifolia lyonii*
Solanum wallacei clockeyi*

SOUTHERN RIPARIAN WOODLANDS are extremely limited on the

Channel Islands, occurring in depauperate patches in streambeds on the three largest islands. Since most of the dominant members of this community are readily dispersed by the wind, their absence on the islands is undoubtedly due to the impermanence of groundwater there. The usual representatives on the islands are willows, cottonwoods, and elderberries. The sycamores of Santa Cruz Island are recent introductions by man (Smith 1976:159). The black locust tree (Robinia pseudo-acacia) has escaped and appears to be spreading in the Central Valley. Riparian woodland is the only winter-deciduous community on the islands. This community is so fragmented on the islands that no particular endemics can be said to characterize it, though several species are usually found around streams in general.

PINE FORESTS on the Northern Channel Islands consist of two types. The most widespread is closed-cone pine forest, in which bishop pine (Pinus muricata and P. m. remorata) is the dominant tree. This community occurs on the mainland from Monterey County northward and in scattered patches south to northern Baja California (Linhart et al. 1967). The southernmost mainland locations, such as those of the Purisima Hills vicinity of northern Santa Barbara County and near San Vicente in northwestern Baja California, Mexico closely resemble the island communities (Axelrod 1967a). Bishop pines grow mainly on north-facing slopes of canyons and above the ocean in three main areas on Santa Cruz Island and are scattered about elsewhere. The species also grows

in a small area on the northeastern side of Black Mtn. on Santa Rosa Island, and an endemic form of the closely related Monterey pine is found on Guadalupe and Cedros islands (Axelrod 1980). The other type of native pine on the Channel Islands is Torrey pine (P. torreyana), which grows on the northeast corner of Santa Rosa Island (with a few individuals scattered nearby Smith 1976: 312) and near San Diego (Haller 1967), occurring on sandstone outcroppings in both areas. The Italian stone pine (P. pinea) has been introduced on Santa Cruz Island, where it is apparently spreading (M.C. Hochberg pers. comm. 1981). The western pine grove of Santa Cruz Island is the most extensive and vigorous stand, the others suffering from grazing, fires, and lack of moisture (Hobbs 1980). This is perhaps the most mesic community on the islands, depending heavily on fog condensation to supplement rainfall. The endemics and near-endemics of the two types of pine forests are largely similar, and include stragglers from other communities:

Arctostaphylos* spp.
Castilleja* spp.
Ceanothus* spp.
Comarostaphylis diversifolia planifolia
Galium* spp.
Helianthemum greenei*
Heteromeles arbutifolia*
Jepsonia malvaefolia*
Lyonathamnus floribundus asplenifolius*
Mahonia pinnata insularis*
Mimulus flemingii*
Pinus muricata remorata
P. torreyana
Pityrogramma triangularis viscosa

Quercus* spp.
Ribes thacherianum*
Solanum wallacei clockeyi*

SOURCES AND REFERENCES

Brandegee and Greene were the pioneering botanists on the Northern Channel Islands (Smith 1976). They were followed in subsequent generations by Blakeley, Dunkle, and Hoffmann. The current crop of island botanists involved in field work on the islands include Wayne Ferren, Nancy Viverette, and Ralph Philbrick and his staff at the Santa Barbara Botanic Garden. The important herbaria containing collections of endemics from the Northern Channel Islands include the California Academy of Sciences, the Smithsonian Institute, the Los Angeles County Museum of Natural History, Notre Dame University, the University of California at Berkeley and Santa Barbara (including the Santa Cruz Island field station), the Santa Barbara Museum of Natural History, the Santa Barbara Botanic Garden, and the Rancho Santa Ana Botanic Garden in Claremont, California. Both of the gardens also maintain living specimens of island endemics.

The standard reference manuals for the botany of California are by Munz and Keck (1959), and Munz (1968, 1974). Although the latter volume is more taxonomically current and focuses on southern California, the 1959 text is often preferable for work on the islands, since it contains the many northern species which are most closely related to the insular flora, and because the spe-

cies are arranged in a semblance of taxonomic relationships. Many of the taxonomic evaluations in this thesis are based on the latter text. Among the earlier published floras of the state, Abrams and Ferris (1940-1960) is valuable for the detailed illustrations of almost every species on the west coast, including most of the island endemics. Regional floras are available for Monterey County (Howitt and Howell 1964), San Luis Obispo County (Hoover 1970), Santa Barbara County (including all four islands; Smith 1976), the Santa Monica Mountains (Raven and Thompson 1966), Los Angeles County (Abrams 1917), Orange County (Boughey 1968), San Diego County (Higgins 1949), and Baja California (Wiggins 1980), thus covering all of the adjacent mainland in detail. The distribution of plants in this thesis is largely taken from Smith, with additional information on the Southern Channel Islands derived from Raven (1967) and other sources. A number of other details, such as flowering periods and ecological notes, are also taken from Smith.


a
ME
4 cm

Figure 8. ROCK CRESS

Arabis hoffmannii (Munz) Rollins

Brassicaceae

DISTRIBUTION: (SRO, SCR)?

ECOLOGY: sea cliffs, stream banks, and rocky places among chaparral and coastal bluff vegetation? Collected several times in the 1930's and not seen since; possibly extinct. Flowers in early spring.

DESCRIPTION: perennial herb with stem(s) 5-7 dm high from a scaly caudex; petals (a) white.

RELATIONSHIPS: similar to A. spariflora arcuata of the adjacent mainland (interior). A. glabra is on the mainland and SCR.

REFERENCES: Abrams (1944:314, Fig. 2134), Munz (1974:272), Munz and Keck (1959:262), Rollins (1941), Smith (1976:144).

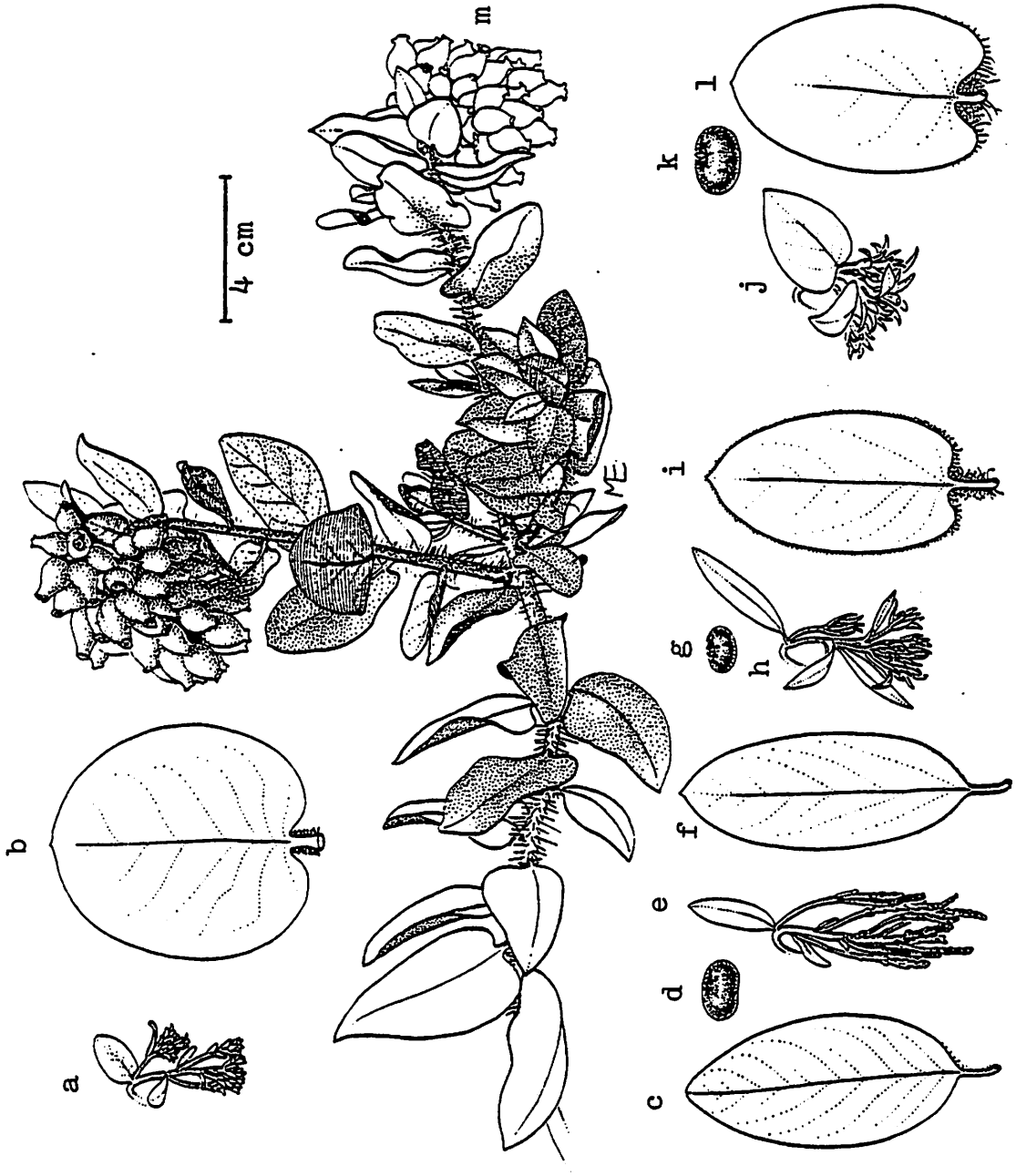

a
b
c
d
e
f
g
h
i
j
k
l
m
4 cm

Figure 9. MANZANITAS

(a,b) Arctostaphylos confertiflora Eastw.

(c,d,e) A. insularis Greene

(f,g,h) A. tomentosa (Pursh) Lindl. ssp. insulicola P.V. Wells

(i) A. t. ssp. subcordata (Eastw.) P.V. Wells

(j,k,l,m) A. viridissima (Eastw.) McMinn

Ericaceae

DISTRIBUTION: A. confertiflora SRO; A. insularis SRO?, SCR; A. t. insulicola SRO, SCR; A. t. subcordata SCR; A. viridisima SCR. Sympatry on SCR unusual.

ECOLOGY: chaparral, woodland, pine forests. Edaphic specialization on SCR. A. tomentosa crown-sprouting. Bloom mainly winter into spring, etc.

DESCRIPTION: evergreen bushes (A. tomentosa), shrubs, or small trees to 3 m high or more, A. confertiflora prostrate in windy areas; smooth, peeling, reddish bark; stiff, acid-green leaves (b,c,f,i,l); white flowers (m); flattened, brownish, berries (d,g,k). Species similar and variable, but with typical leaf shape, pubescence, immature inflorescence (a,e,h,j), etc.

RELATIONSHIPS: A. i. forma pubescens (Eastw.) P.V. Wells (c, right side), most common form on SCR, introgressed by A. t. subcordata?

REFERENCES: Abrams (1951:316-325, Figs. 3712, 3733), Munz (1974: 399-401, Fig. 41-c), Munz and Keck (1959:424-430), Smith (1976: 216-217), Wells (1968, 1969).

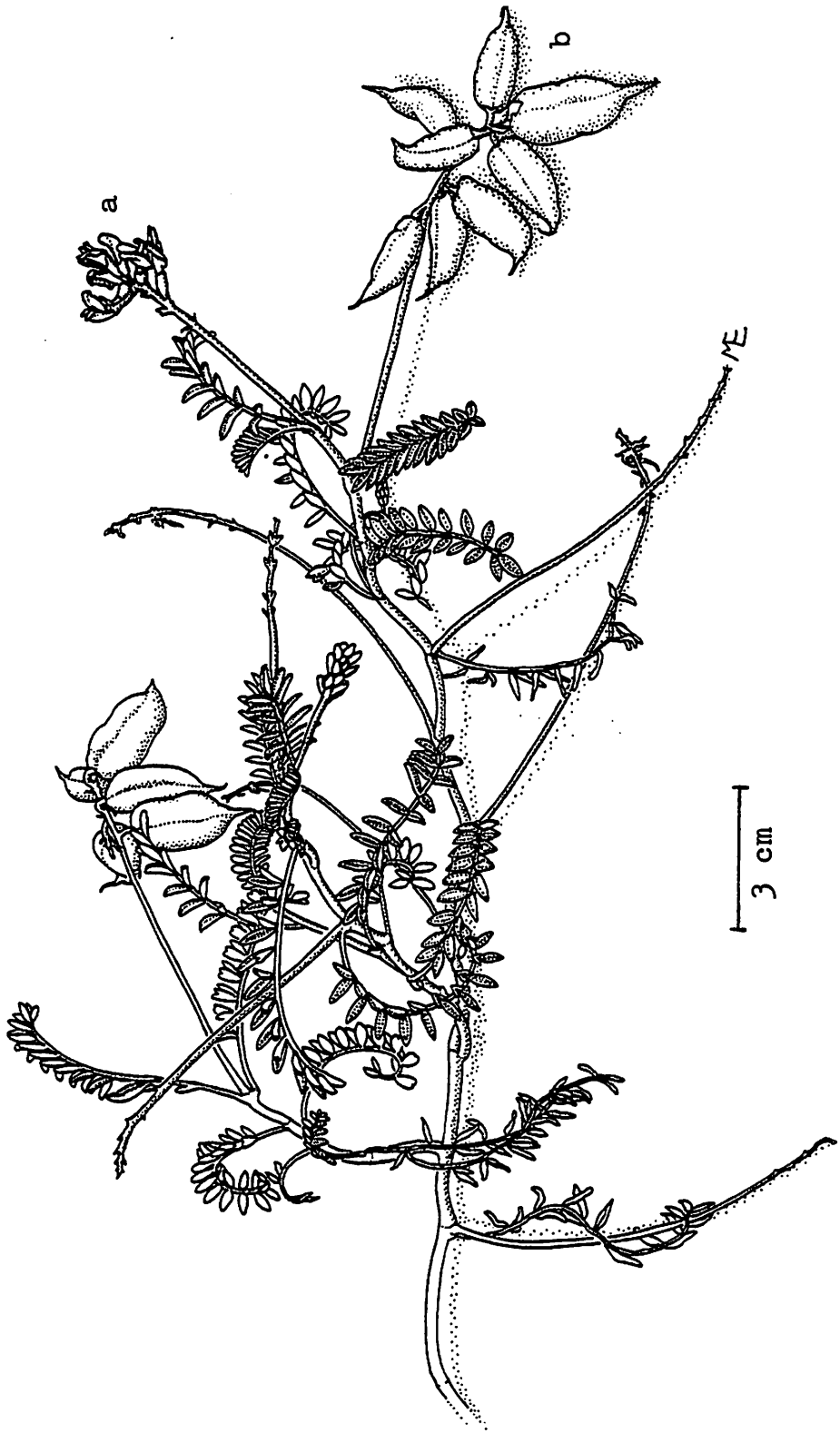

a
b
3 cm

Figure 10. LOCOWEED, MILK-VETCH

Astragalus miguelensis Greene

Fabaceae

DISTRIBUTION: SMI, SRO, SCR, West and Middle ANA, SCL.

ECOLOGY: abundant on sand dunes of SMI and western SRO (also on north side) in coastal dune scrub and sandy grasslands; also on rocky slopes in coastal bluff vegetation. Blooms mainly in spring and early summer; occasionally through the year. Avoided by sheep, poisonous (Cockerell 1939, Hochberg et al. 1980).

DESCRIPTION: Plant a low, evergreen clump of interlocking stems and leaves, covered with dense, white felt; leaves light, dull green, stems, calyx, and fruit brick red; petals (a) light yellow; dried parts tan; pods (b) papery, inflated.

RELATIONSHIPS: close to two narrow endemics of Bajia San Quentin, northwestern Baja California, Mexico; A. anemophilus especially. Two endemics of the Southern Channel Islands are superficially similar, but not closely related. Other species endemic to CED. Several nonendemic species occur on the islands.

REFERENCES: Abrams (1944:585, Fig. 2830), Barneby (1964:794-799), Hochberg et al. (1979), Munz (1974:432), Munz and Keck (1959:877), Smith (1976:167).

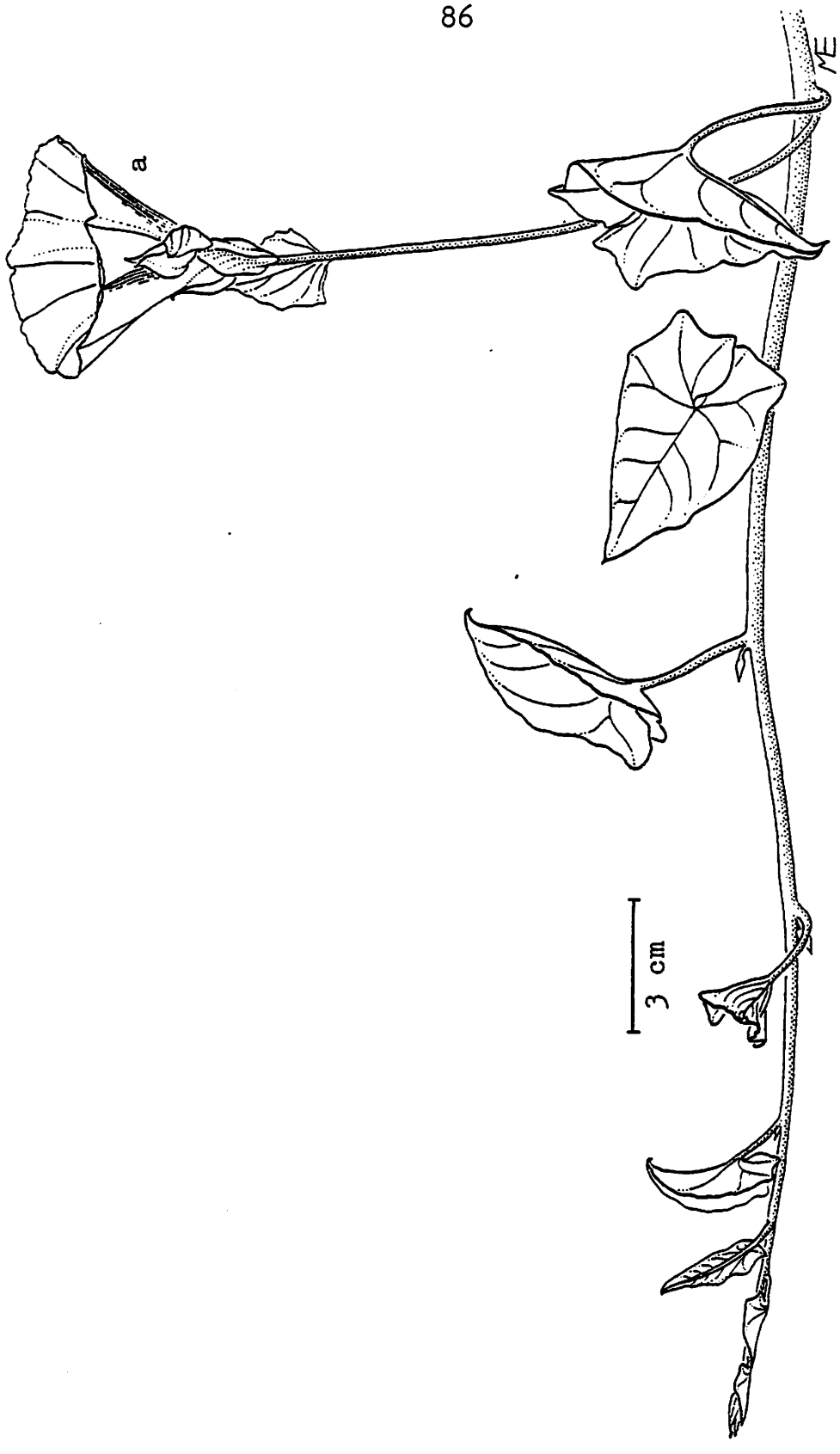

a
3 cm

Figure 11. ISLAND MORNING-GLORY

Calystegia [Convolvulus] macrostegia (Greene) Brummitt ssp. macrostegia

Convolulaceae

DISTRIBUTION: SMI, SRO, SCR, ANA, SBA, SNI, SCL, SCA, TSA, SMA, GUA; some mainland specimens from the Santa Barbara County coast resemble this form closely.

ECOLOGY: abundant on north-facing slopes and cliffs in coastal sage scrub on SMI, but also in coastal dune scrub, coastal bluff, chaparral, and other communities. Blooms in spring and summer.

DESCRIPTION: large, evergreen perennial, trailing or climbing vine with thick, dark green leaves; showy, white flowers (a) tinged with purple or pink, especially on SCR, ANA.

RELATIONSHIPS: intergrades with C. m. cyclostegia, which is found on the adjacent mainland and on all four islands (mainly on south-facing slopes; specimens from SMI tend to be the most distinctive. A recently described subspecies (C. m. amplissima) is endemic to SBA, SNI, and SCL (Brummitt 1980). Three subspecies intergrade on SCA. A couple of nonendemic species are also on the islands.

REFERENCES: Abrams (1951:383, Fig. 3856), Munz (1968:84, 1974: 374), Munz and Keck (1959:460), Philbrick (1972, 1980), Smith (1976:223), Thorne (1967, 1980).

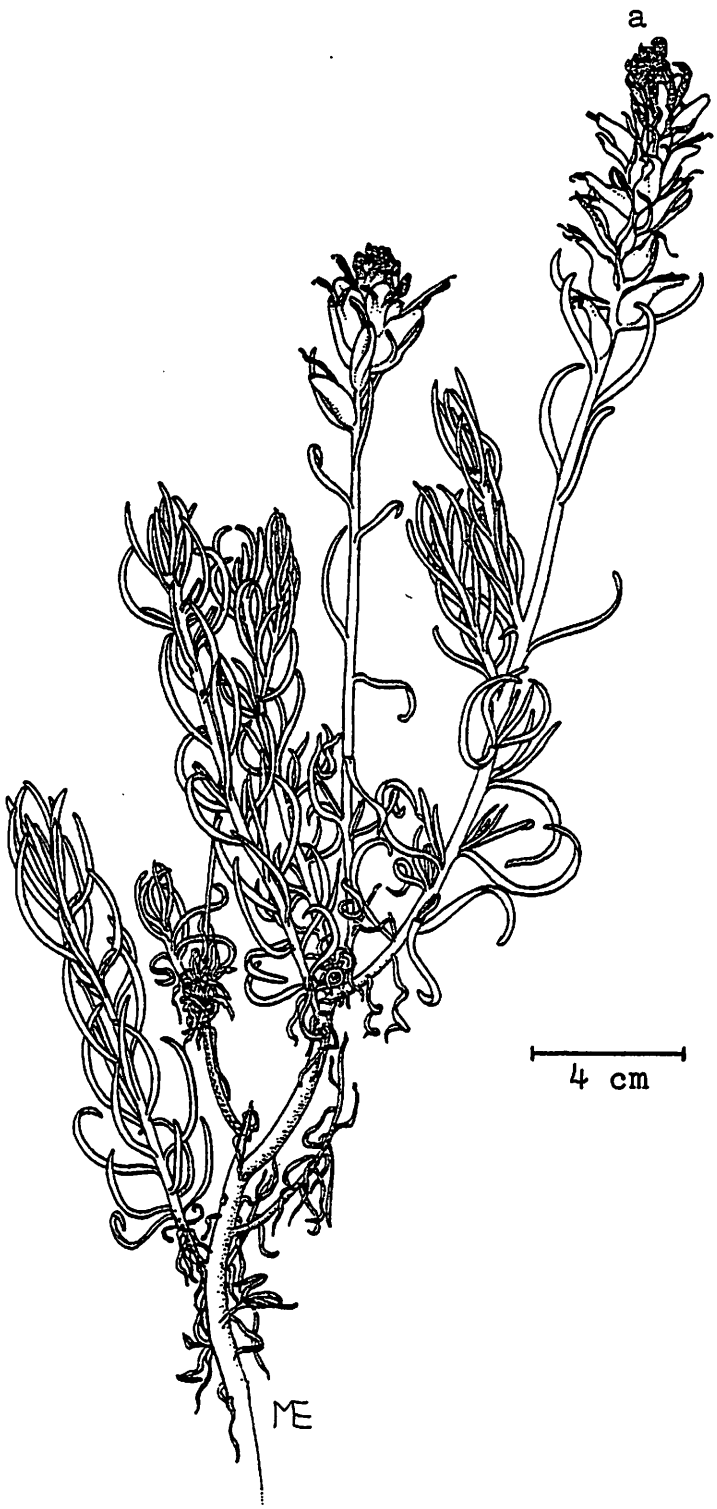

a
4 cm
ME

Figure 12. PAINT-BRUSH

Castilleja hololeuca Greene

Scrophulariaceae

DISTRIBUTION: SMI, SRO, SCR, West and Middle ANA.

ECOLOGY: localized colonies, mainly on rocky slopes in coastal sage scrub, but also occasional in dunes and chaparral; fairly common on West ANA. Semiparasitic on roots of other plants. Blooms in spring and summer, occasionally at other times.

DESCRIPTION: densely branched, bushy, evergreen perennial 3-8 dm high, covered with dense, white felt. Herbage soft, very pale, grayish-green; flower bracts (a) bright yellow (SMI, SRO, SCR) to pink and coral red (SCR, ANA); bark and dead leaves light gray.

RELATIONSHIPS: very similar to C. grisea of SCL and C. foliolosa of SCA and the adjacent mainland. The latter exhibits polymorphism of flower color in San Luis Obispo County, where yellow and orange colors occur along the coast, and red flowers are found inland. Similiar endemic(s?) on GUA. A few nonendemic and near-endemic species are also native to the islands, many synonymous with C. affinis.

REFERENCES: Abrams (1951:842, Fig. 4907), Hochberg et al. (1979), Hoover (1970:265), Munz (1968:99, 1974:796), Munz and Keck (1959:671), Philbrick (1980), Raven (1963), Smith (1976: 254).

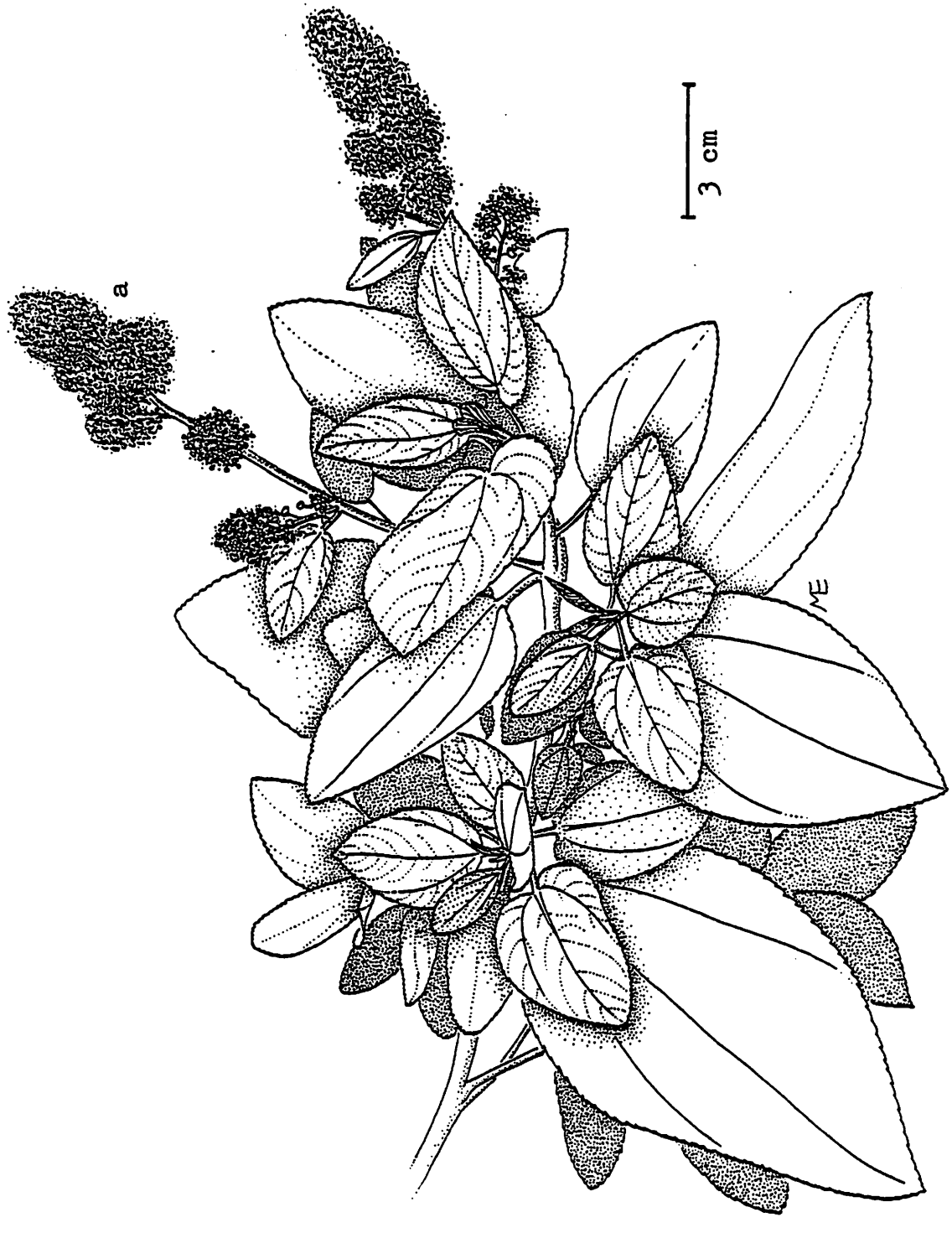

a
3 cm
ME

Figure 13. ISLAND CEANOTHUS, CALIFORNIA-LILAC

Ceanothus arboreus Greene

Rhamnaceae

DISTRIBUTION: SRO, SCR, SCA. Rarely cultivated in mainland gardens.

ECOLOGY: a fairly common species of pine forests, island woodland, and chaparral. Blooms from late winter into spring. Does not crown-sprout after fires (M.C. Hochberg, pers. comm. 1981).

DESCRIPTION: large shrub or small tree 3-7 m high with smooth, mottled gray bark; twigs soft, pubescent; leaves evergreen, dark green above, with dense white pubescence below; flowers (a) pale blue and fragrant; fruit small, hard, dark, pyramidal capsules.

RELATIONSHIPS: fairly distinct from other members of the section Ceanothus, such as C. coeruleus of the mountains of southern Mexico and C. tomentosus of the Sierra Nevada foothills. A single hybrid with C. spinosus was recently found on SCR; the latter species otherwise not known on the islands. The three island populations show slight variation in details of leaf, fruit, and seed morphology. Known from Tertiary mainland fossils.

REFERENCES: Abrams (1951:67, Fig. 3113), Axelrod (1967b), McMinn (1942), Munz (1974:733), Munz and Keck (1959:978), Philbrick (1980), Smith (1976:187).


a
c
b
3 cm

Figure 14. BIGPOD CEANOTHUS

Ceanothus megacarpus Nutt. ssp. insularis (Eastw.) Raven

Rhamnaceae

DISTRIBUTION: (SMI?)?, SRO, SCR, West ANA?, SCL?, SCA?, (GUA?)?; reported from the mainland at Gaviota Pass, Santa Barbara Co?

ECOLOGY: common in chaparral, especially on south-facing slopes; perhaps in island woodland and pine forests. Blooms winter into spring. Does not crown-sprout after fires.

DESCRIPTION: evergreen bush 1-3 m high with smooth, gray bark and arching branches (a). Leaves stiff, opposite or alternate, dull green; tiny flowers in small clusters, white with dark purple centers, fragrant; capsules (b) light green, becoming brown and falling from receptacle (c) at maturity.

RELATIONSHIPS: similiar to C. m. megacarpus of the adjacent mainland and perhaps the south side of SCR; West ANA (M.C. Hochberg, pers. comm. 1981), SCA, and SCL populations intermediate between the two. Apparently interfertile with all other species of section Cerastes. Known from Tertiary fossils on the mainland (Axelrod 1967b:289).

REFERENCES: Abrams (1951:73, Fig. 3136), Hochberg (1980a, 1980b), McMinn (1942), Munz (1974:735), Munz and Keck (1959:981), Nobs (1963), Raven (1963), Smith (1976:188).

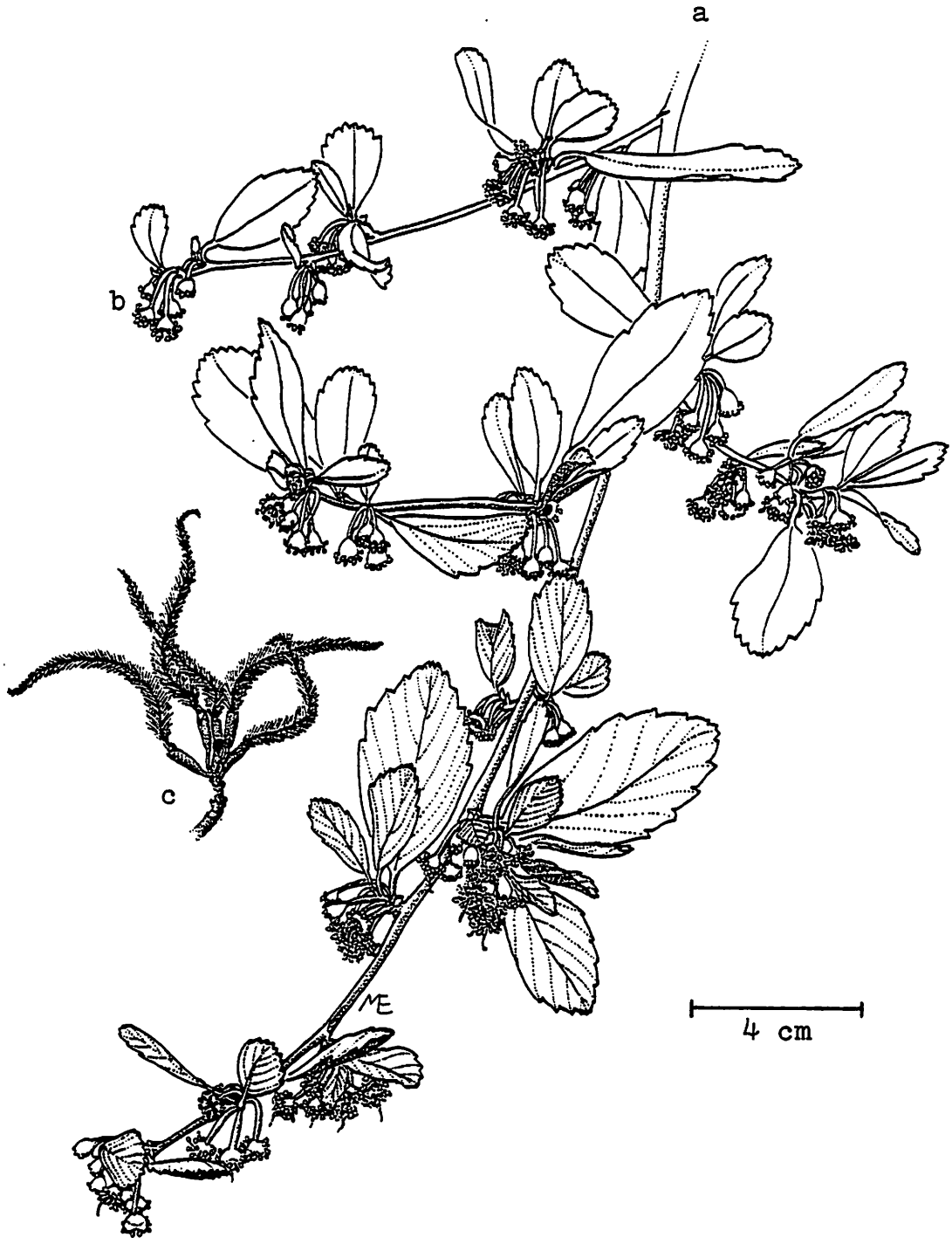

a
b
c
ME
4 cm

Figure 15. MOUNTAIN-MAHOGANY, HARDTACK

Cercocarpus betuloides Nutt. ex T. & G. var. blancheae (C.K. Schneid.) Little

Rosaceae

DISTRIBUTION: SRO, SCR, SCA; reported localized or sporadic on mainland from San Luis Obispo to Los Angeles counties.

ECOLOGY: abundant in chaparral, especially near streams. Blooms in spring, fruit matures in midsummer. Crown-sprouting after fires.

DESCRIPTION: evergreen shrub or small tree to over 30 feet tall, with smooth, brown bark and stiff or arching branches (a). Leaves dark green above, pale and downy beneath; flowers (b) lack petals, greenish-tan; fruit (c) in feathery clusters, reddish-brown with blond tail.

RELATIONSHIPS: highly variable, intergrades with the nonendemic C. b. betuloides and the rare endemic C. b. var. traskiae (Eastw.) Dunkle on SCR(?) and SCA. Coastal populations of the former sometimes resemble both endemic varieties. C. b. traskiae (and C. b. blancheae?) known from Tertiary fossils on the mainland.

REFERENCES: Abrams (1944:453, Fig. 2486), Dunkle (1940b), Hoover (1970:161), Munz (1974:743), Munz and Keck (1959:782), Smith (1976:160), Thorne (1967).

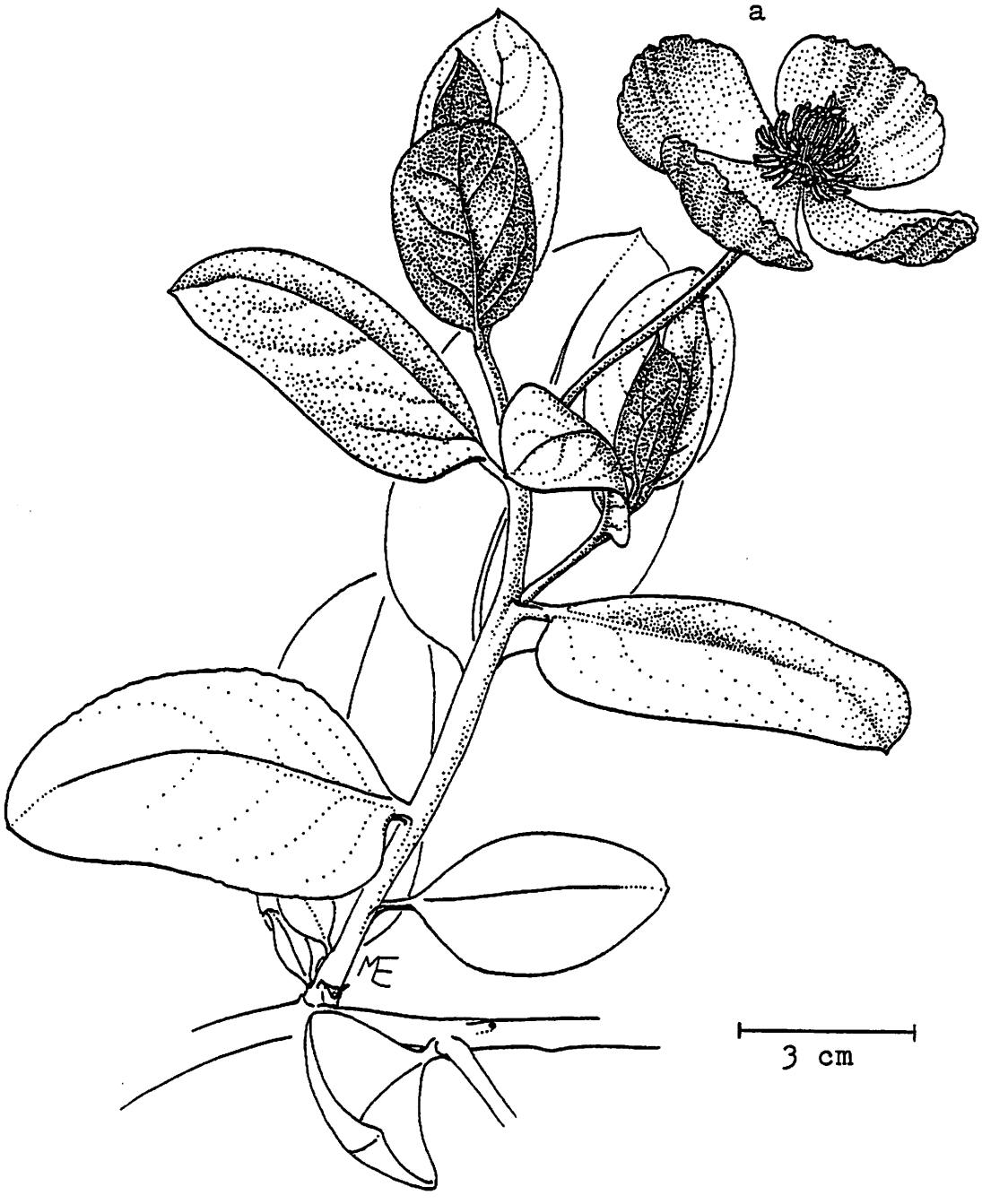

a
ME
3 cm

Figure 16. ISLAND BUSH POPPY

Dendromecon rigida Benth. ssp. harfordii (Kell.) Raven

Papaveraceae

DISTRIBUTION: SRO, SCR.

ECOLOGY: fairly common, especially in gullies on south-facing slopes among chaparral on SCR; uncommon on SRO. Blooms mainly from late winter through spring, but occasionally almost throughout the year. Seedlings are rare in nature; seeds sprout after scorching (M.C. Hochberg, pers. comm. 1981). Crown-sprouting after fires.

DESCRIPTION: rounded, evergreen shrub 2-6 m high with smooth, gray bark and spreading branches; leaves light, dull green; flowers (a) abundant, showy, bright yellow; fruit elongated, purple-tinged capsule which snaps open in summer, the sides pulling away from the base and attached at the tip.

RELATIONSHIPS: a highly variable species, this subspecies being one of the more phenotypically consistent populations; D. r. rhamnoides is found on SCA, SCL (and the Santa Monica Mts. Los Angeles Co.?). Not known from Tertiary fossils on the mainland? High polyploid.

REFERENCES: Abrams (1944:226, Fig. 1890), Hochberg (1980a, 1980b), Munz (1974:625), Munz and Keck (1959:195), Raven (1963), Smith (1976:139), Thorne (1967).

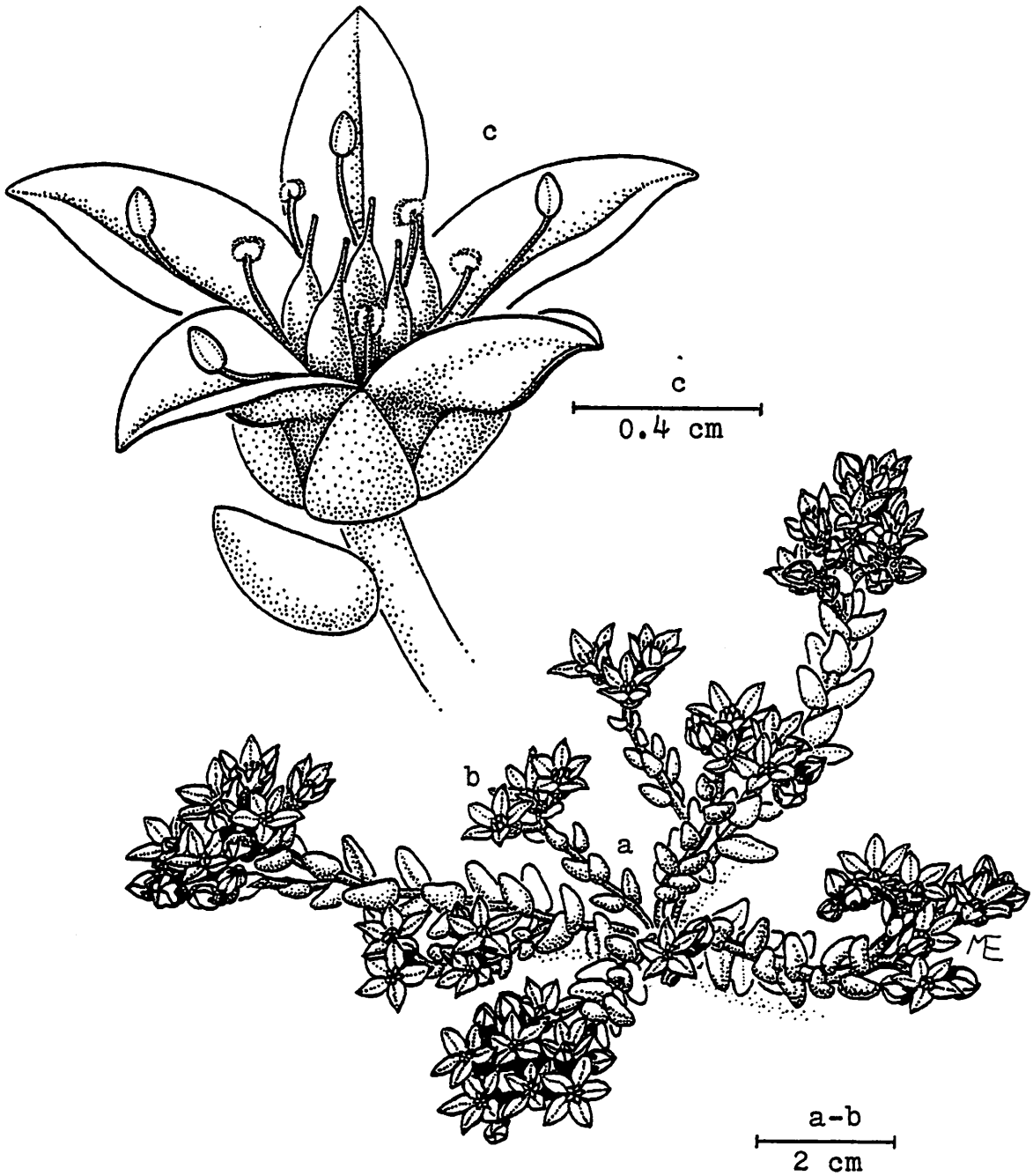

c
c
0.4 cm
b
a
ME
a-b
2 cm

Figure 17. LIVE-FOREVER

Dudleya blochmaniae (Eastw.) Moran ssp. insularis (Moran) Moran

Crassulaceae

DISTRIBUTION: SRO.

ECOLOGY: restricted to a few gravelly patches of bare ground among grasses on a low rise by the ocean at the eastern end of SRO; the entire population consists of perhaps several dozen individuals, making this one of the rarest plants in the world. The presence of several species of introduced grazers in the area poses a clear danger to this precariously situated species, as does the potential for collecting by succulent fanciers and the presence of an aggressive species of introduced ice plant (Mesembryanthemum nodiflorum) in small numbers nearby.

DESCRIPTION: inconspicuous herb beginning as a small, ephemeral rossette of thick leaves sent up from an underground, perennial base during the winter rains, followed in the spring by spreading branches (a) with gray-green leaves tinged with reddish-purple, topped with fragrant, white flowers (b,c) in early summer, then dying back.

RELATIONSHIPS: other subspecies occur on sterile slopes of mountains on the adjacent mainland. The only other member of the subgenus Hasseanthus on the California Islands is D. nesiotica* of nearby SCR. Diploid.

REFERENCES: Moran (1951b, 1960), Munz (1974:385), Munz and Keck (1959:726), Smith (1976:153).

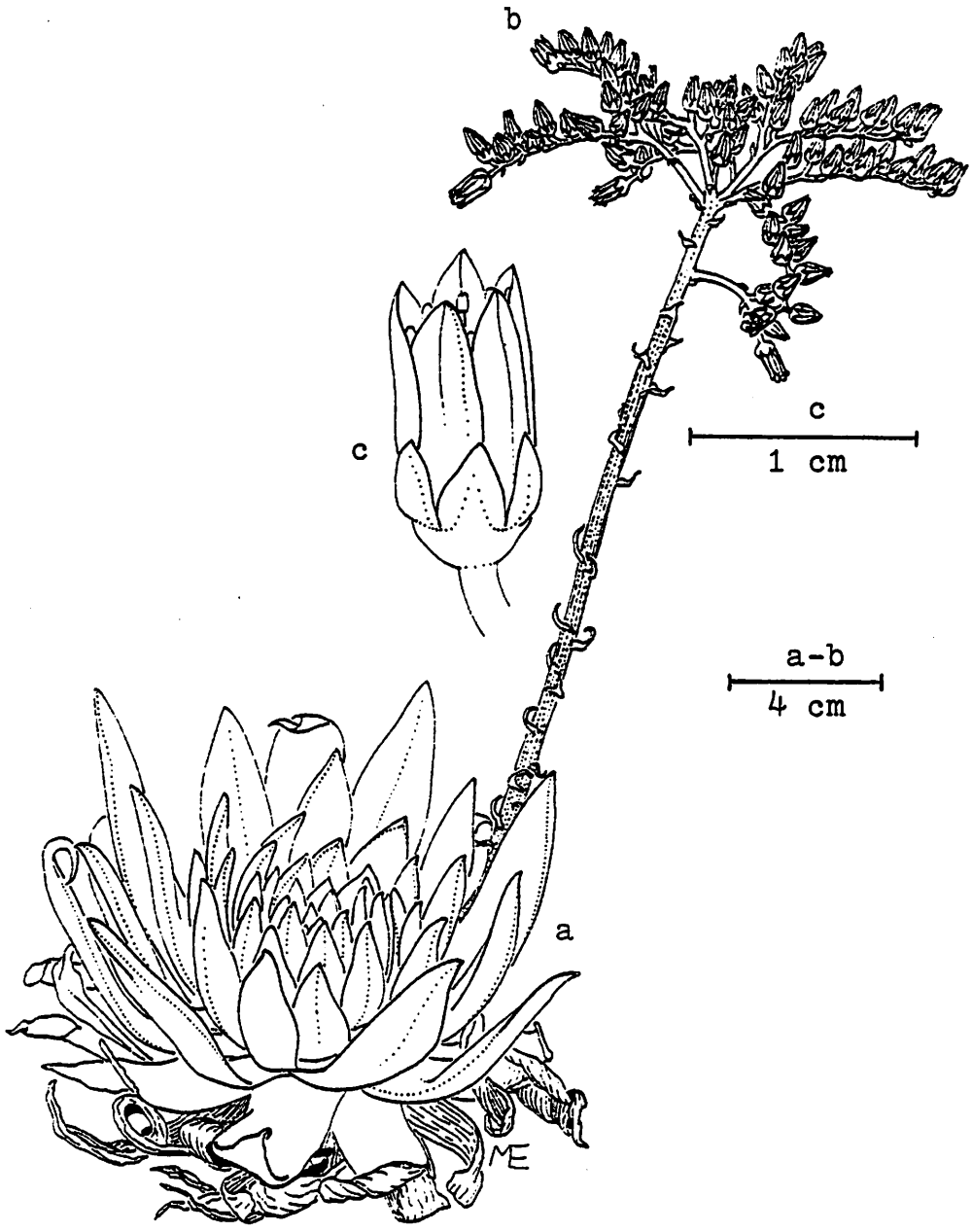

b
c
c
1 cm
a-b
4 cm
a
ME

Figure 18. LIVE-FOREVER

Dudleya candelabrum Rose

Crassulaceae

DISTRIBUTION: SRO, SCR.

ECOLOGY: forming scattered colonies on slopes and cliffs among coastal sage scrub (south-facing sea cliffs) or chaparral (north-facing interior sites). Rare on SRO. Blooms from late spring to early summer.

DESCRIPTION: rossettes (a) large, usually single, evergreen, arising from a heavy base. Leaves usually broader than illustrated, numerous, and relatively thin; light to medium acid-green becoming pale and reddish (tips) and finally brownish with age. Flowering stem(s) stout; reddish below. Flowers (b,c) with yellow-green sepals and pale yellow petals, becoming brown capsules.

RELATIONSHIPS: similar to other members of the subgenus Dudleya, including D. greenei*. Several other species are endemic to the islands to the south. Diploid.

REFERENCES: Abrams (1944:337, Fig. 2194), Moran (1951b, 1960), Munz (1974:385), Munz and Keck (1959:724), Smith (1976:153).

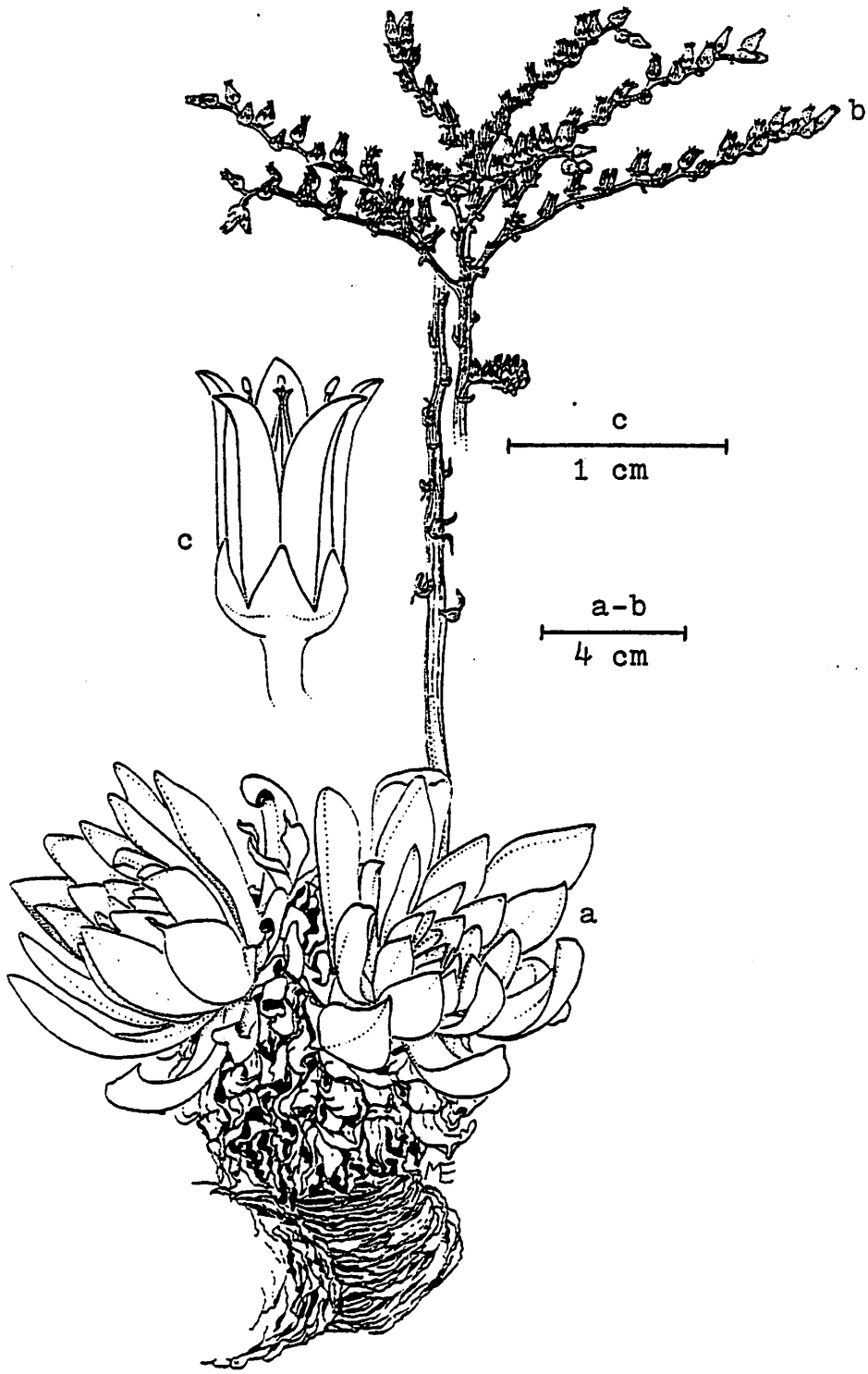

b
c
1 cm
c
a-b
4 cm
a

Figure 19. LIVE-FOREVER

Dudleya greenei Rose

Crassulaceae

DISTRIBUTION: SMI, SRO, SCR, ANA?, SCA?

ECOLOGY: locally abundant, especially on north-facing sea cliffs among coastal bluff vegetation. Abundant on SMI. Blooms in late spring and early summer.

DESCRIPTION: similar to D. candelabrum*, but caudex usually branching to support numerous rossettes (a), forming a rounded cluster 3-4 dm high; leaves usually narrower than illustrated, often thick and somewhat rounded, and either acid-green or whitish; flowering stems thinner and more branching; flowers (b,c) less stout; mature capsules (d) spreading somewhat at maturity.

RELATIONSHIPS: very similar to D. caespitosa of the adjacent mainland, to which species the ANA (and SCR?) population has been referred. Highly variable; a dwarf form from the eastern end of SRO has been described as D. g. forma nana Moran. Tetraploid (SRO, SCR) or hexaploid (SMI, SRO, ANA).

REFERENCES: Abrams (1944:337, Fig. 2193), Moran (1951b, 1960), Munz (1968:105, 1974:386), Munz and Keck (1959:724), Smith (1976:154), Thorne (1967).

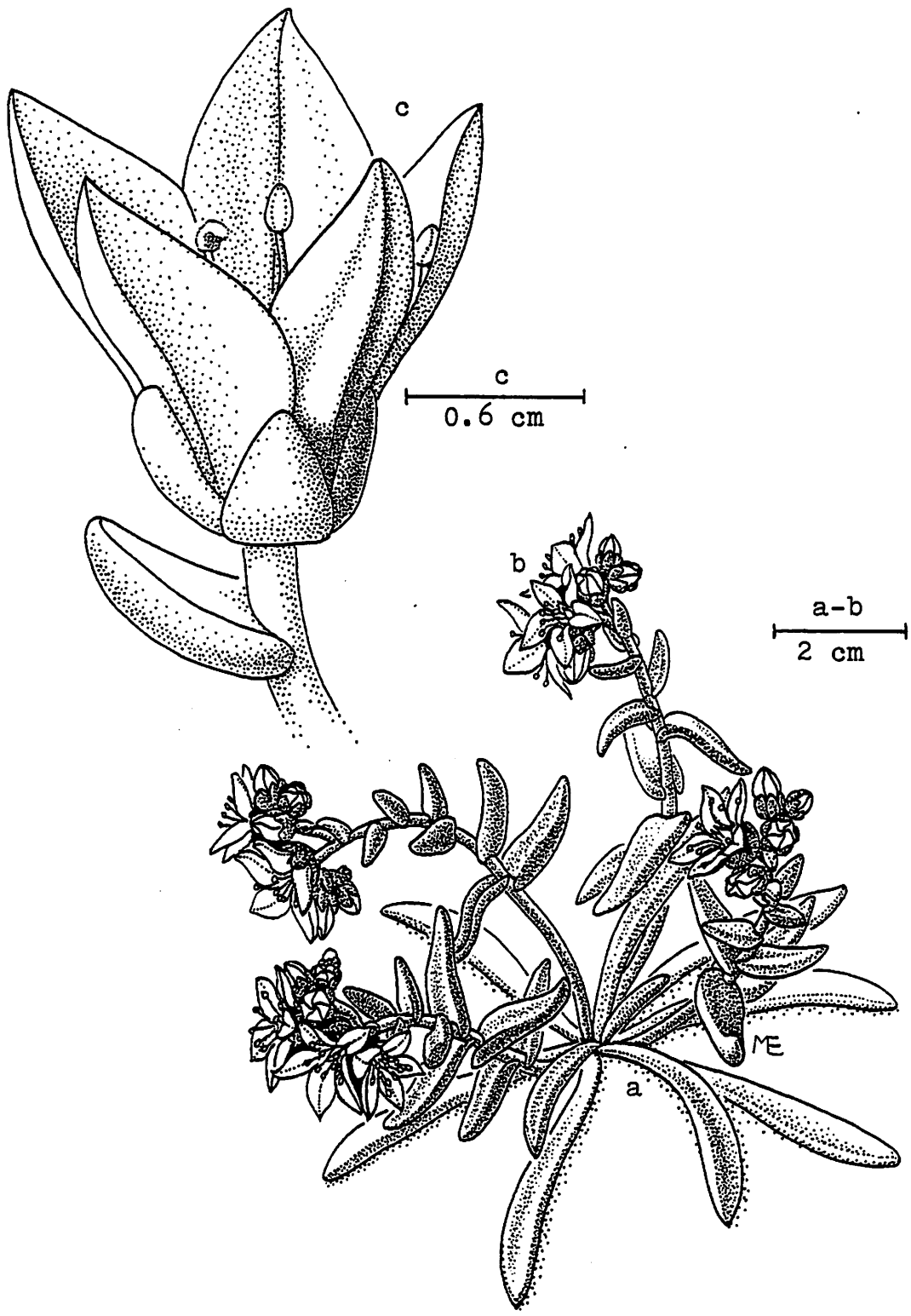

c
c
0.6 cm
b
a-b
2 cm
ME
a

Figure 20. LIVE-FOREVER

Dudleya nesiotica (Moran) Moran

Crassulaceae

DISTRIBUTION: SCR.

ECOLOGY: found only in a few patches totaling several acres on sea bluffs and fields at the western tip of SCR. The species appears to be doing well and has spread in recent years among grasslands and coastal bluff vegetation (Laughrin, pers. comm. 1978). Blooms in late spring and early summer.

DESCRIPTION: similar to D. blochmaniae insularis*, but slightly larger, with fewer basal leaves, and without a pronounced grayish cast (acid-green becoming paler and reddish). Basal rossette (a) usually withers in nature before flowers (b,c) appear.

RELATIONSHIPS: morphological features suggest that this tetraploid species is an unusual hybrid between the ancestor of D. blochmaniae insularis* and a member of the subgenus Dudleya (perhaps D. candelabrum*), since it differs modally from the other members of the subgenus Hasseanthus with which it might have hybridized.

REFERENCES: Moran (1951b, 1960), Munz (1974:387), Munz and Keck (1959: 726), Smith (1976:154).

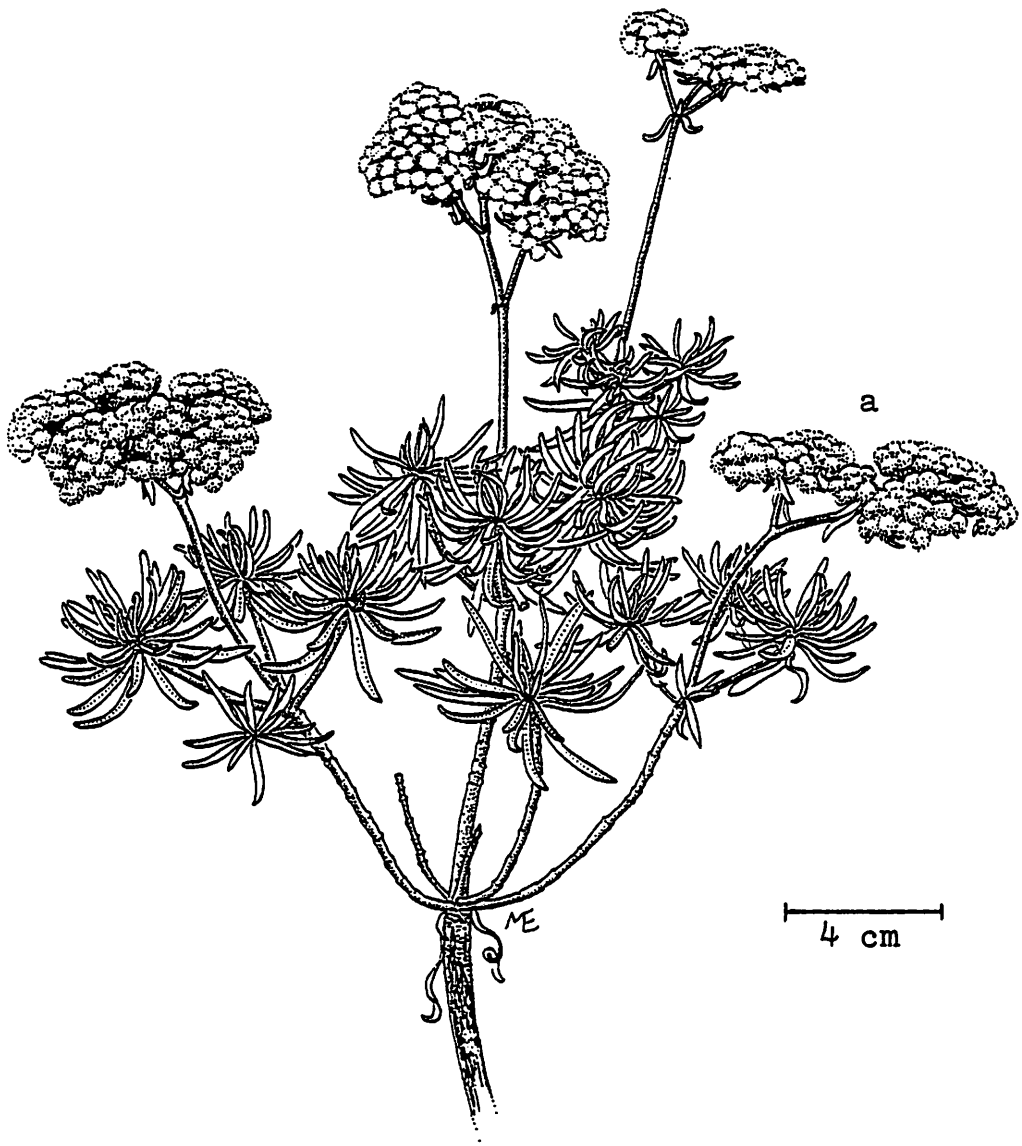

a
ME
4 cm

Figure 21. BUCKWHEAT

Eriogonum aborescens Greene

Polygonaceae

DISTRIBUTION: SRO, SCR, ANA. Rarely cultivated on adjacent mainland.

ECOLOGY: fairly common in dry areas, on rocky slopes and cliffs, mainly near the ocean in coastal sage scrub but also in grasslands, coastal bluff vegetation, and chaparral. Blooms mainly in spring, occasionally at other times.

DESCRIPTION: densely bushy, evergreen, usually forming an even, hemispherical mound densely covered with herbage, to 2 m high. Branches covered with fine, shedding, brown bark; leaves pale green, becoming brown; tiny flowers in flat, interconnecting clusters (a), white becoming pinkish and dark brown with age.

RELATIONSHIPS: morphologically distinct from E. giganteum, which has three forms endemic on the Southern Channel Islands. The latter has escaped from cultivation on SCR within the past 15 years, where it hybridized freely with the native species until eradicated recently (Laughrin, pers. comm. 1981). Both are apparently related to other endemics of CED and GUA (Moran 1951a), but do not closely resemble any of the numerous mainland species. E. cinereum is a nonendemic species found on SRO.

REFERENCES: Abrams (1944:47, Fig. 1426), Munz (1968:71, 1974: 681), Munz and Keck (1959:353), Philbrick (1980), Smith (1976:117).

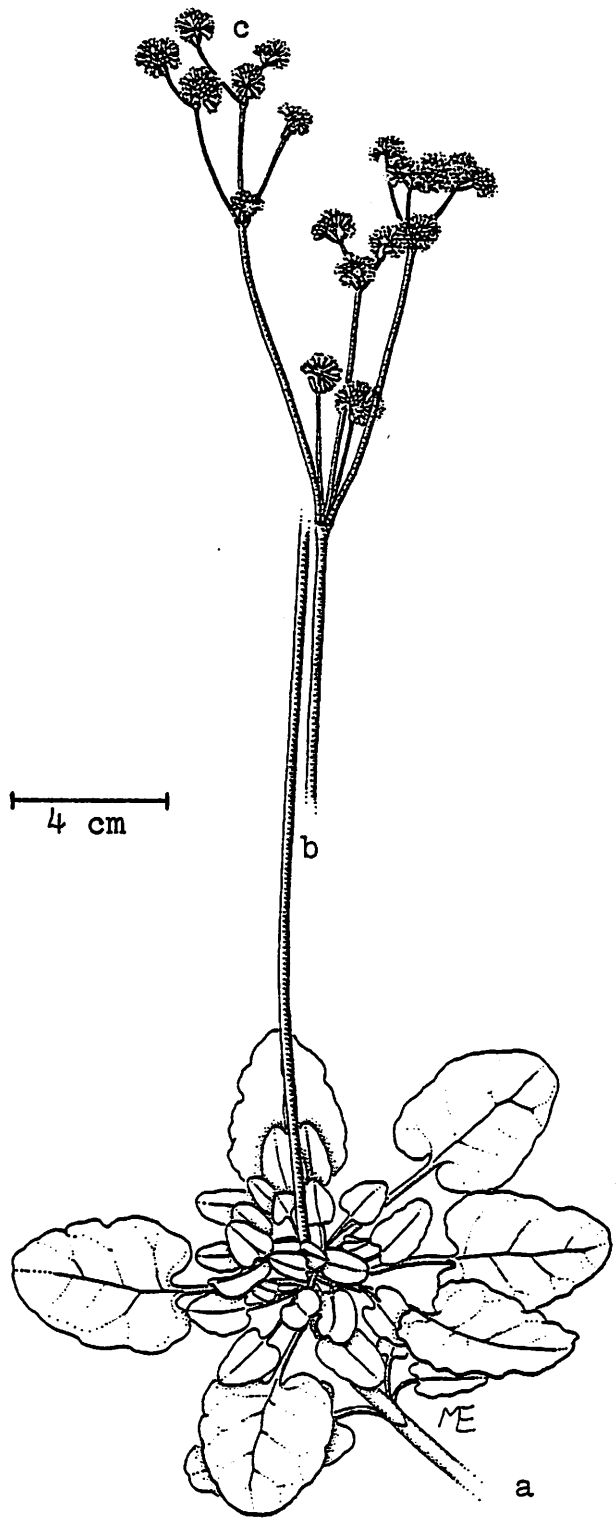

c
4 cm
b
ME
a

Figure 22. BUCKWHEAT

Eriogonum grande Greene var. grande

Polygonaceae

DISTRIBUTION: SRO, SCR, ANA, SCL, SCA.

ECOLOGY: about the same as the preceeding species, with which it is often found.

DESCRIPTION: straggly, evergreen perennial with branched, woody base forming a loose, low mound. Leaves mostly at tips of branches (a), dark green above, white and wooly beneath, becoming tan; flower stalks (b) tall and slender; flowers tiny, white, in round clusters (c), becoming pinkish, brown at maturity.

RELATIONSHIPS: E. g. var. rubescens (Greene) Munz is endemic to sandy and rocky areas on SMI, SRO, the western tip of SCR, and ANA. It is similar to the typical form but smaller, with gray foliage and a compact inflorescence with red flowers; many specimens are intermediate. E. g. var. dunklei Reveal is a recently described form very similar to the preceeding, but with paler flowers (and less pubescent leaves?). It is apparently restricted to sea cliffs on SMI. Other varieties occur on SNI, TSA and the mainland of northwestern Baja California, Mexico (Reveal 1976). All are fairly similar to forms of E. nudum and E. latifolium of the adjacent mainland.

REFERENCES: Abrams (1944:46, Fig. 1420), Hochberg et al. (1979), Munz (1968:69-70, 1974:686), Munz and Keck (1959:351-352), Reveal (1981), Smith (1976:119).


a
4 cm
ME

Figure 23. GOLDEN YARROW

Eriophyllum staechadifolium Lag. var. depressum Greene

Asteraceae

DISTRIBUTION: SMI?, SRO, SCR, ANA; mainland around Point Conception, Santa Barbara Co.

ECOLOGY: occasional on sea cliffs among coastal bluff vegetation; also on stabilized dunes. Blooms mainly in spring, into summer and later.

DESCRIPTION: low, evergreen perennial forming low, dense mounds. Stems white, felty above, smooth, tan below; leaves initially whitish, becoming lusterous, dark acid-green above, white below, and yellowish then brown with age; flowers (a) deep yellow.

RELATIONSHIPS: weakly differentiated from E. s. artemisiaefolium of SRO (and other islands?) and the mainland coast to the north. Some specimens from ANA and eastern SCR show signs of intergradation with E. confertiflorum, a nonendemic common on all four islands. Apparently ancestral to E. nevinii, a distinctive and variable endemic of SBA, SCA, and SCL (Raven 1967).

REFERENCES: Munz (1974:165), Munz and Keck (1959:1149), Smith (1976:288).


c
d
b
e
f
a
a-b
4 cm
c-f
0.2 cm
ME

Figure 24. WALLFLOWERS

(e,f) Erysimum ammophilum Heller

(a,b,c,d) E. insulare Greene

Brassicaceae

DISTRIBUTION: E. ammophilum SRO, scattered locally along mainland coast from Monterey to San Diego counties; E. insulare SMI, SRO, West ANA?, GUA? (Outer Islet; Moran 1951a); mainland sites in northern Santa Barbara and San Luis Obispo counties, along coast.

ECOLOGY: E. ammophilum rare in sandy areas on the north side of SRO in coastal dune vegetation; E. insulare more common in similar situations on SMI. Both bloom in spring.

DESCRIPTION: E. ammophilum biennial or short-lived perennial with few erect branches, pod flattened in cross-section (e), and flat, winged seeds (f). E. insulare perennial, evergreen bush from a light brown, woody base, with many branches sprawling out with age to form loose mat; leaves slightly succulent, pale green; flowers (a) bright yellow; fruit (b) purple-tinged, squarish in cross section (d), with plump, brown wingless seeds (c).

RELATIONSHIPS: both are similar to species found on the adjacent mainland. The genus is taxonomically uncertain, and the status of West ANA populations is especially so (Philbrick, pers. comm. 1980). GUA population described as E. moranii Rollins.

REFERENCES: Abrams (1944:318, Fig. 2143), Hoover (1970:145), Munz (1974:290), Munz and Keck (1959:269-270), Smith (1976:147).

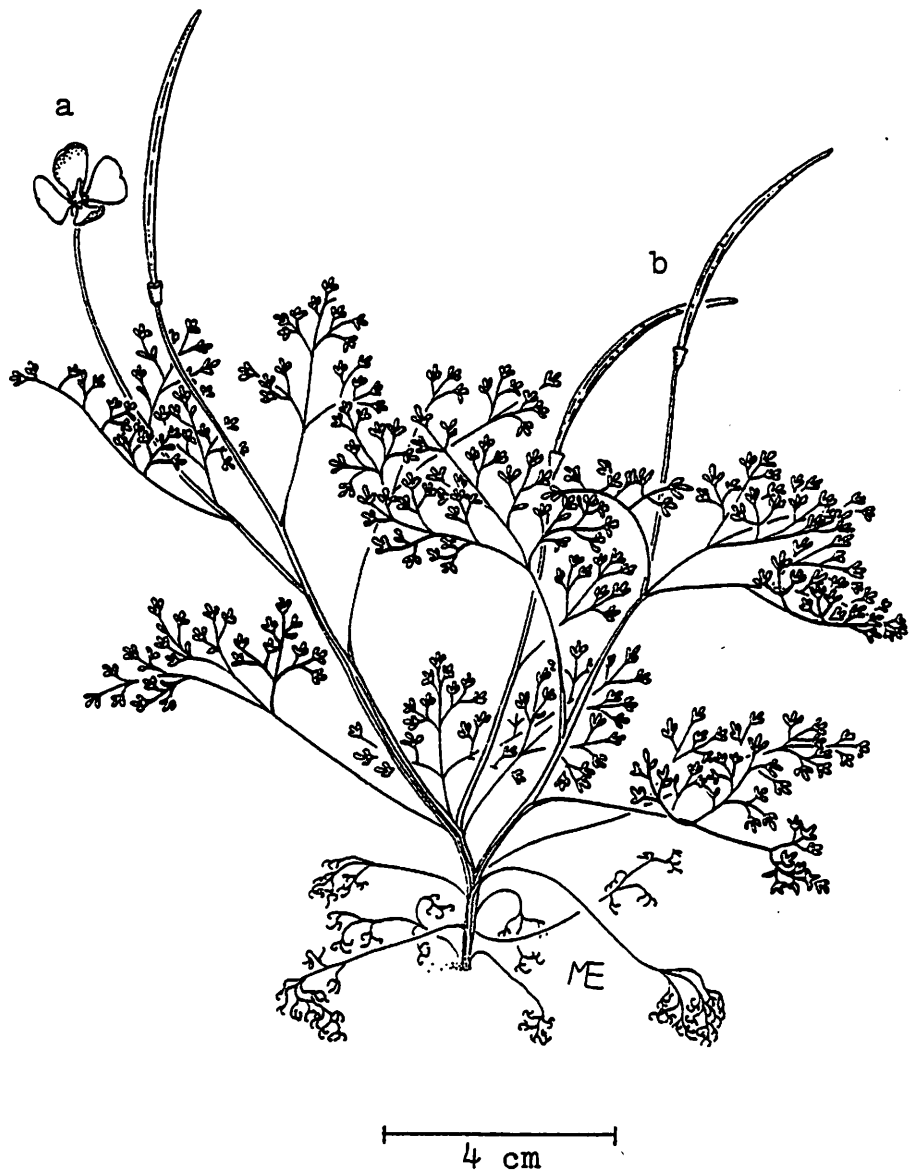

a
b
ME
4 cm

Figure 25. CALIFORNIA POPPY

Eschscholzia ramosa (Greene) Greene [E. elegans Greene in part] Papaveraceae

DISTRIBUTION: SRO, SCR, ANA?, SBA, SNI, SCL, SCA, LCO, TSA, SMA, SGE, NAT, CED, SBE, GUA; reported from sea cliffs of mainland northwestern Baja California, Mexico (Wiggins 1980:759)?

ECOLOGY: although abundant on some of the islands to the south, extremely rare on northern group. Found on steep slopes and nearshore rocks on south sides of islands among grasslands and coastal sage scrub.

DESCRIPTION: erect annual wth glaucous leaves and small deep yellow flowers (a) and pods (b) typical of genus.

RELATIONSHIPS: highly variable on a seasonal and geographic basis; similar to other members of the genus, such as E. minutiflora of the interior deserts. As many as three closely related species are endemic to GUA, but their taxonomy is somewhat confused. E. elegans is a polyploid species of GUA with which E. ramosa has been confused by several authors. Diploid. The widespread and variable E. californica occurs on SMI, SRO, and SCR.

REFERENCES: Abrams (1944:227, Fig. 1893), Munz (1974:628), Munz and Keck (1959:197), Philbrick (1972, 1980), Smith (1976:141).

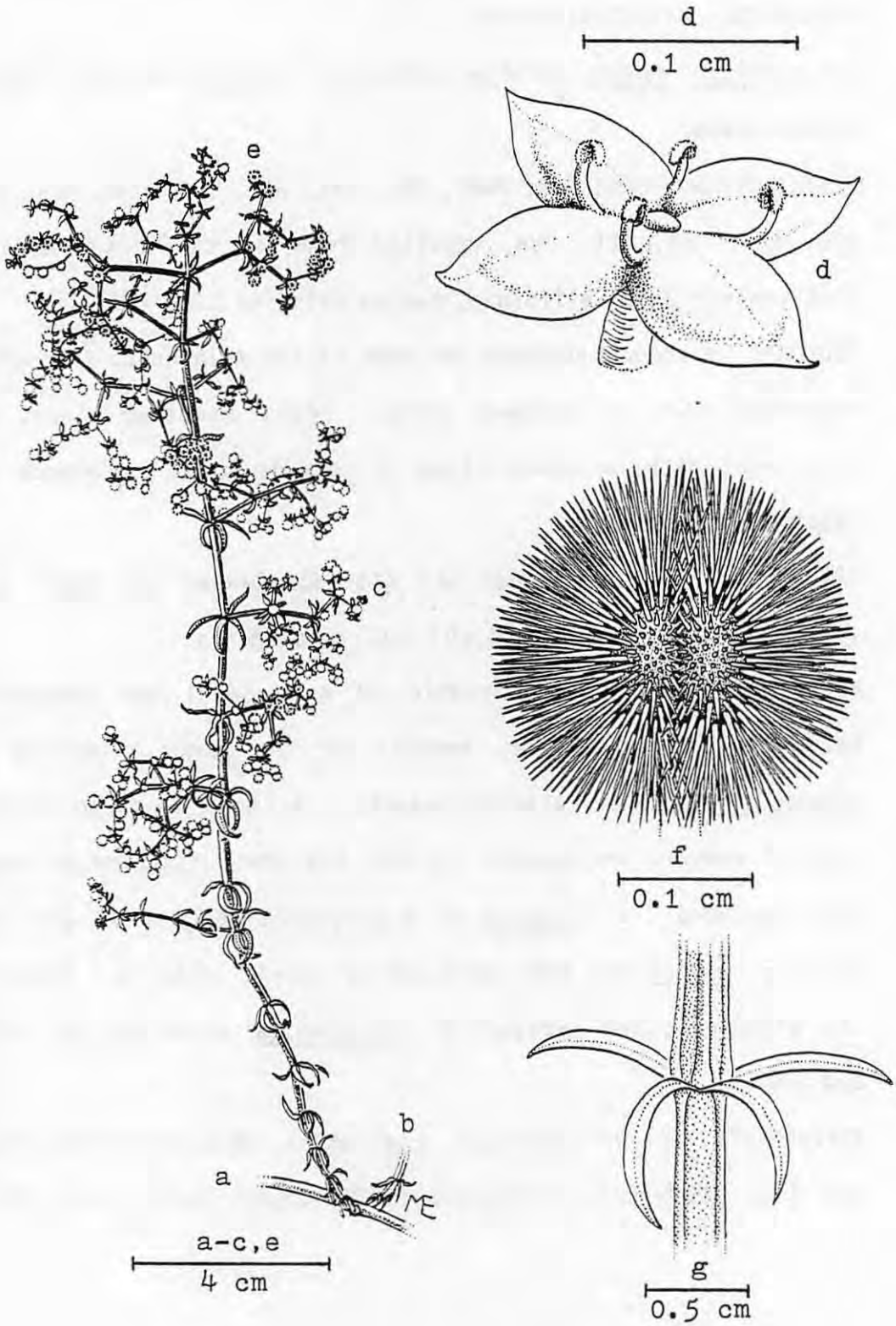

d
0.1 cm
d
e
c
b
a
ME
a-c, e
4 cm
f
0.1 cm
g
0.5 cm

Figure 26. BEDSTRAW

Galium angustifolium Nutt. ssp. foliosum (Hilend & Howell) Demp. & Steb.

Rubiaceae

DISTRIBUTION: SRO, SCR, ANA; rarely on mainland in Ventura Co.?

ECOLOGY: occasional; mostly in dry, open areas near streams among coastal sage scrub and coastal oak woodland. Blooms in spring and early summer.

DESCRIPTION: bushy, summer-deciduous perennial 1-3 dm high. Several smooth, tan, woody scaffolding stems (a) give rise to numerous secondary stems (b) which are light, acid-green, becoming tan or slightly purplish with age, as do the leaves (g); flowers (c,d) dioecious, minute, greenish; fruit (e,f) brownish with dense, white bristles.

RELATIONSHIPS: similar to the typical (polyploid) form of the mainland, SCA, and CED? A few nonendemic species are found on the islands. Diploid, apparently relictual.

REFERENCES: Abrams and Ferris (1960:38), Dempster and Stebbins (1971), Munz (1974:764), Munz and Keck (1959:1043), Smith (1976:266).

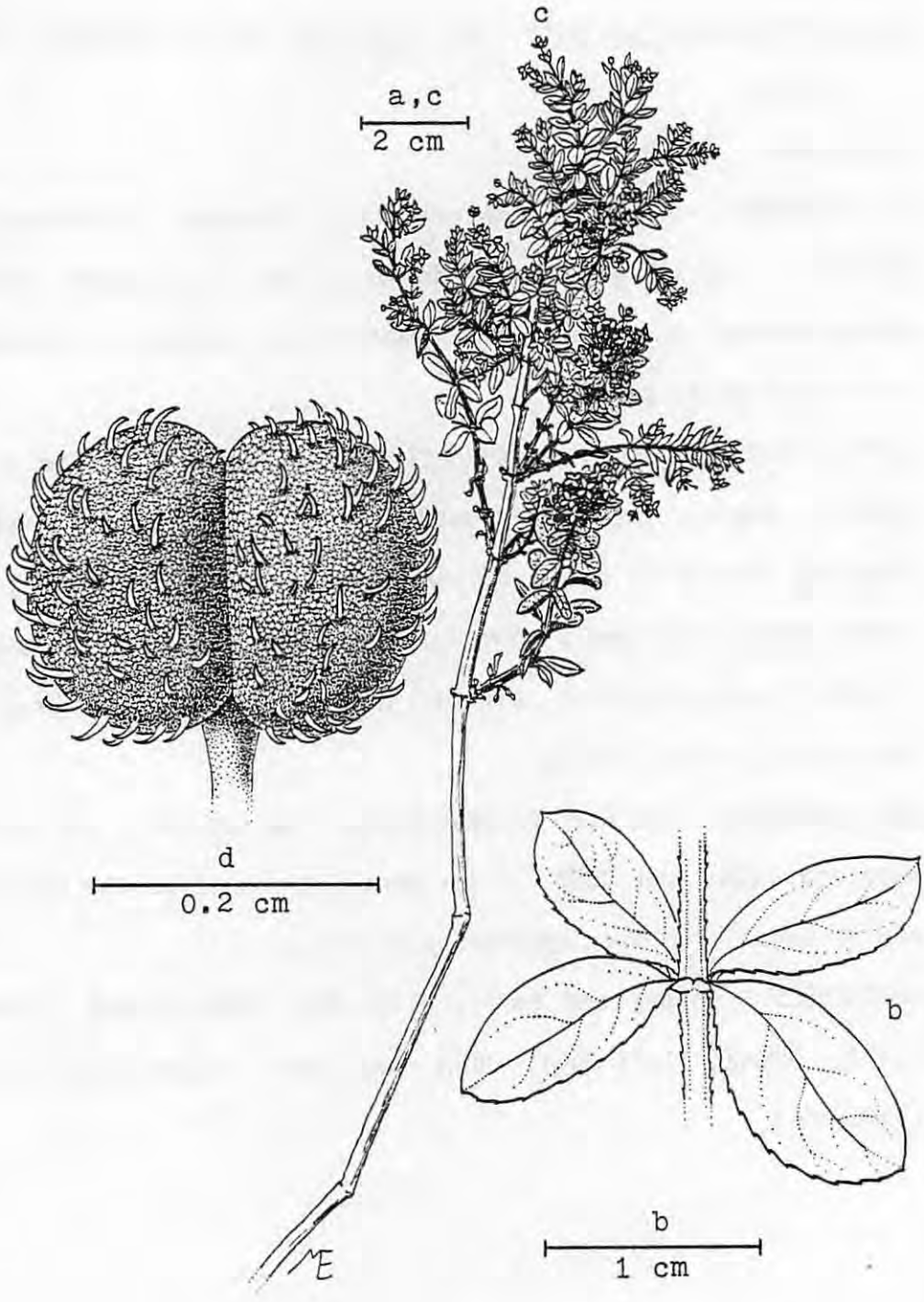

c
a,c
2 cm
d
0.2 cm
b
b
1 cm

Figure 27. BEDSTRAW

Galium buxifolium Greene

Rubiaceae

DISTRIBUTION: SMI, SCR.

ECOLOGY: extremely rare and apparently diminishing in some places. Found only on a few steep, north-facing slopes on rocky headlands and marine terraces, among coastal bluff vegetation (and pine forests?). Blooms in spring.

DESCRIPTION: bushy perennial forming a dense, low mound to 6 dm high; main stems light gray, branches (a) brown to red to green near tips; leaves (b) dark acid-green (evergreen?) becoming brown; flowers (c) light green tinged with red; fruit (d) slightly fleshy, dusky-purple.

RELATIONSHIPS: closely related to G. catalinense, which is endemic in different forms on SCL and SCA. Although both species are only distantly related to mainland species, G. coronadoense of LCO seems to link them with G. angustifolium. Apparently diploid (sometimes tetraploid?).

REFERNECES: Abrams and Ferris (1960:33), Dempster (1973), Munz (1974:766), Munz and Keck (1959:1043), Smith (1976:266).

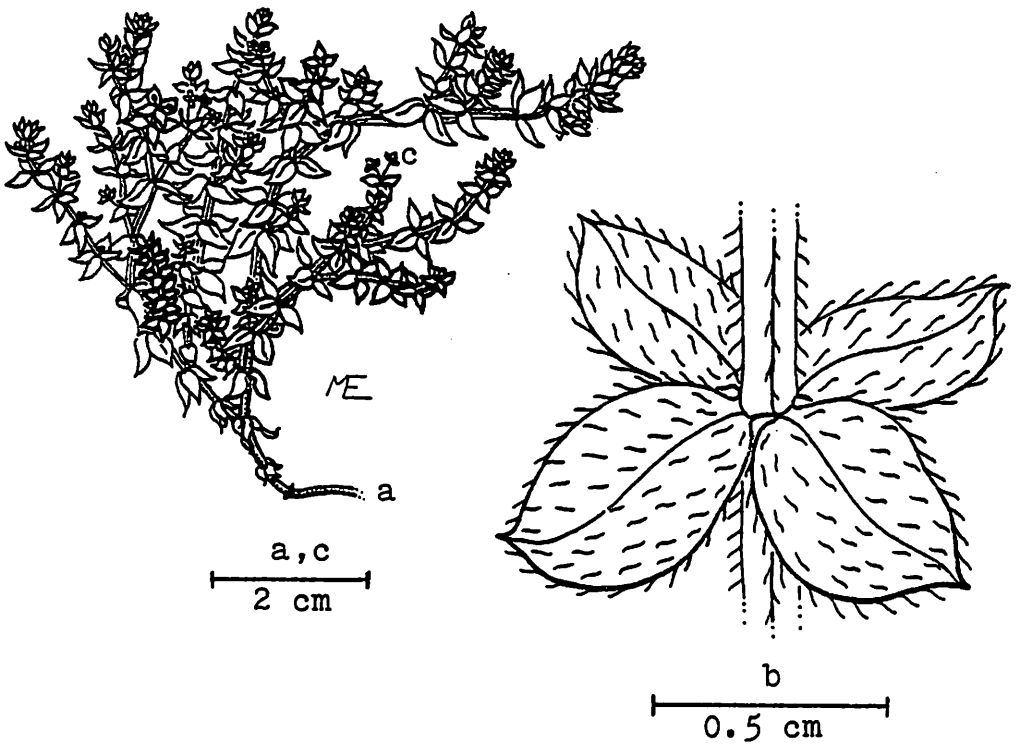

c
ME
a
a,c
2 cm
b
0.5 cm

Figure 28. BEDSTRAW

Galium californicum H. & A. ssp. miguelense (Greene) Demp. & Steb.

Rubiaceae

DISTRIBUTION: SMI, SRO, SCR?

ECOLOGY: rare; typically on sandy, north-facing slopes of marine terraces, among coastal dune or coastal bluff vegetation, sometimes in woodland-chaparral?

DESCRIPTION: nearly glabrous; forming a dense mat from persistent, slightly woody stems (a); leaves (b) fleshy, shiny (probably not so hairy when fresh), bright green, becoming brown, persistent; flowers tiny, greenish; fruit fleshy, whitish, becoming dark when dried.

RELATIONSHIPS: integrading with G. c. flaccidum on SRO and SCR; specimens growing in the shade of woody plants on SMI also resemble the nonendemic subspecies. Similar to G. c. maritimum of the adjacent mainland to the north. Polyploid? Closely related to the following species.

REFERENCES: Abrams and Ferris (1960:35), Dempster and Stebbins (1968), Munz (1974:765), Munz and Keck (1959:1042), Smith (1976:266).

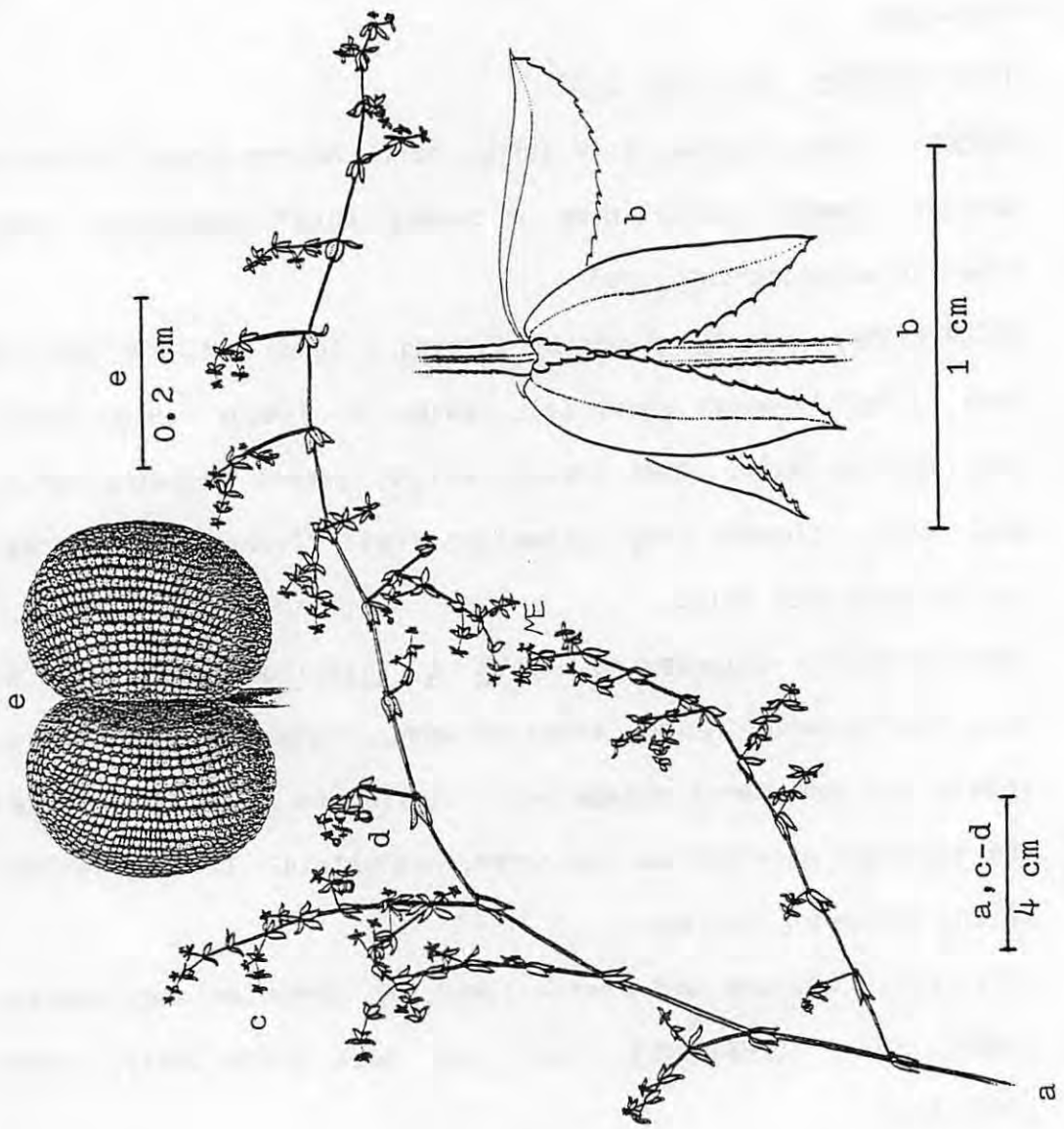

a
a,c-d
4 cm
b
b
1 cm
c
d
e
e
0.2 cm

Figure 29. BEDSTRAW

Galium nuttallii Gray ssp. insulare Ferris

Rubiaceae

DISTRIBUTION: SRO, SCR, SCA.

ECOLOGY: common in chaparral, coastal oak woodland, island woodland, and pine forests. Blooms in spring and early summer.

DESCRIPTION: summer deciduous; extremely variable. Specimens growing in shade with long, delicate stems (a) rising from a woody base, clambering over other plants and with relatively broad leaves (b). Specimens growing in open sun are compact and bushy, with nearly glabrous, linear leaves. Stems reddish-purple; leaves light acid-green or darker, becoming tan; flowers (c) minute, greenish, dioecious; fruit (d,e) fleshy, white, becoming dark when dry.

RELATIONSHIPS: very similar to the typical form of the adjacent mainland. The sun-form is superficially similar to G. angustifolium foliosum* when not in fruit, but may be distinguished from the latter by its more reddish stems, retorse hairs (which feel sticky), and drooping branchlets. Diploid?

REFERENCES: Abrams and Ferris (1960:36), Dempster and Stebbins (1968), Munz (1974:768), Munz and Keck (1959:1042), Smith (1976: 267).

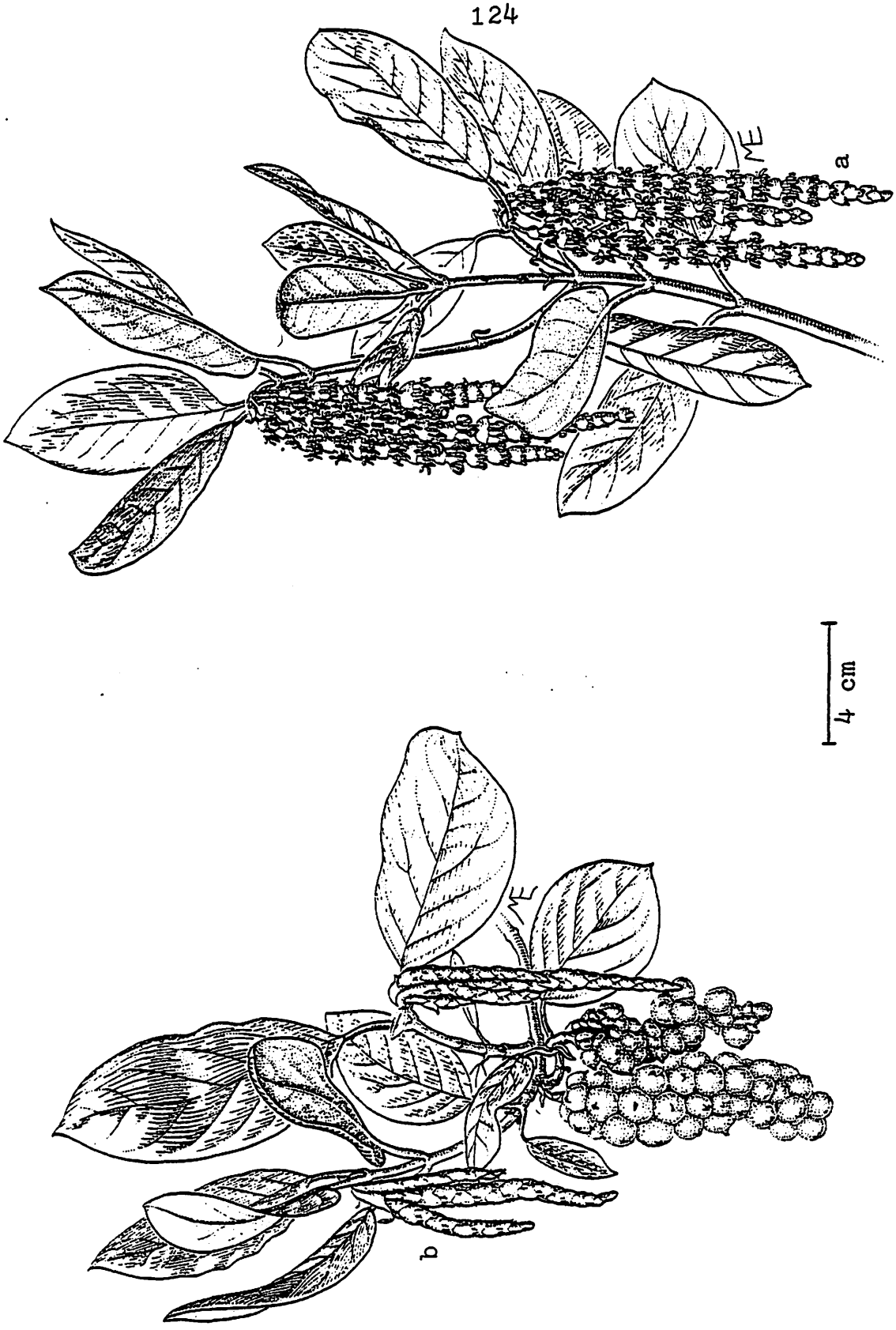

ME
a
4 cm
ME
b

Figure 30. SILK-TASSEL

Garrya sp. nov.

Garryaceae

DISTRIBUTION: SCR.

ECOLOGY: extremely rare; a few bushes scattered among chaparral on north side. Crown-sprouting after fires. Blooms in late winter.

DESCRIPTION: evergreen bush to at least 2 m high; dioecious. Bark smooth, gray; leaves dark green and glossy above, white and felty below, slightly undulate along margins; bracts of staminate (male) flowers (a) pale green tinged with purple, petals white; pistillate (female) flowers (b) gray; berry (c) fuzzy, gray, becoming darker.

RELATIONSHIPS: this recently discovered plant has not yet been formally described by Steven Junak and Ralph Philbrick of the Santa Barbara Botanic Garden (pers. comm., 1978-81). It shares certain characteristics of G. elliptica and G. veatchii, both of which are found on the adjacent mainland (G. veatchii is also on CED). This population has been included in the former species by some authors (Dahling 1978), though it is apparently distinct. G. elliptica has been reported from late Pleistocene deposits on SCR (Chaney and Mason 1930).

REFERENCES: Munz (1974:485), Smith (1976:215).

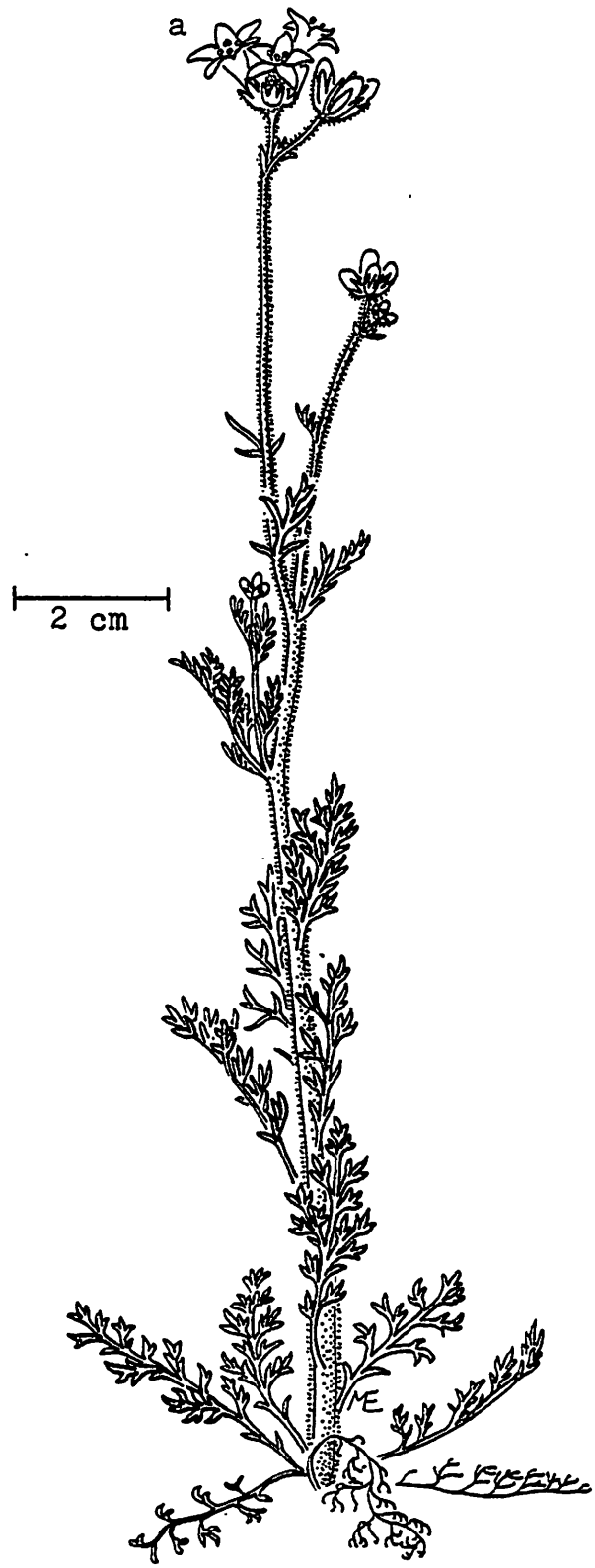

a
2 cm

Figure 31. GILIA

Gilia nevinii Gray

Polemoniaceae .

DISTRIBUTION: SCR, West ANA, SBA, SCL, SCA, GUA.

ECOLOGY: rare on the northern islands on cliffs, canyon slopes, and stream banks among coastal bluff, coastal sage scrub, grassland, and perhaps other plant communities.

DESCRIPTION: an inconspicuous herb with pubescent stem, acid-green leaves, and lavender flowers.

RELATIONSHIPS: difficult to distinguish from a number of other species found on the islands and adjacent mainland. Closely related to a group of species found mainly along the coast of central California northward and in coastal Peru and Chile, South America; G. clivorum is the only other member of this group found sympatrically with the endemic, occurring on all of the Northern Channel Islands. Although crossing readily with some other species of the section Gilia (an unusual trait in this genus), the ancestral species of this tetraploid are unknown and may be extinct; morphologically similar to G. angelensis, which occurs on SCR and the adjacent mainland.

REFERENCES: Abrams (1951:465), V. Grant (1954; 1965; 1966, Fig. 3), Hochberg et al. (1979), Munz (1974:652), Munz and Keck (1959:483), Philbrick (1972), Smith (1976:228).

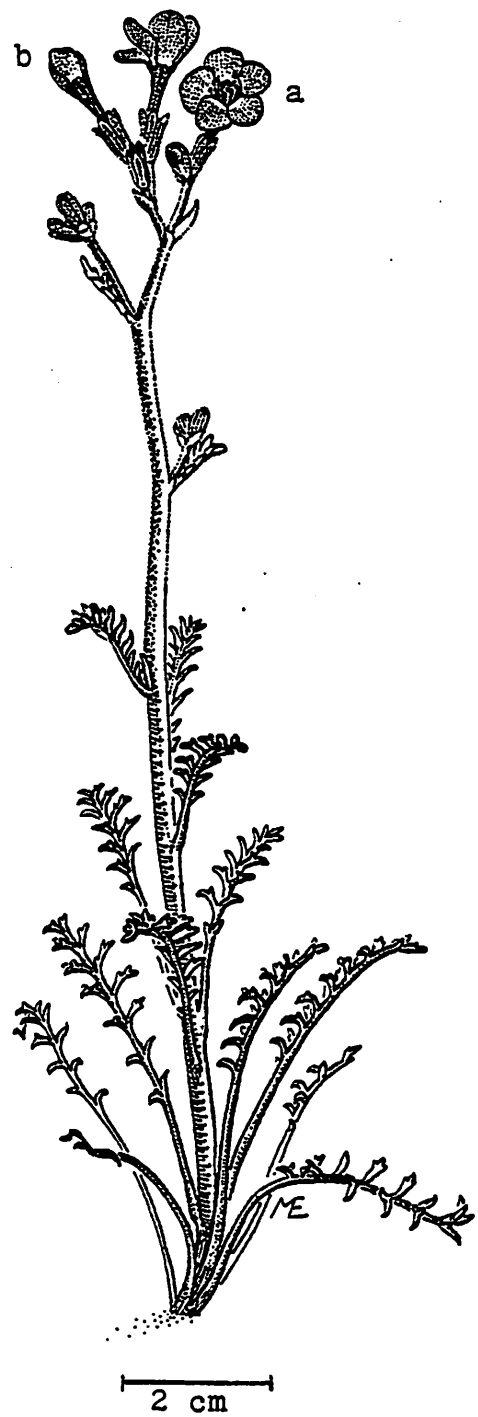

b
a
ME
2 cm

Figure 32. GILIA

Gilia tenuiflora Benth. ssp. hoffmannii (Eastw.) A. & V. Grant

Polemoniaceae

DISTRIBUTION: SRO.

ECOLOGY: locally abundant but restricted to two small areas near the northeastern corner. Found among coastal dune scrub and sandy grasslands. Blooms in spring.

DESCRIPTION: most specimens 6-12 cm high, unbranched, with spatulate basal leaves entire or with a few small lobes; a few (presumably biennials) to about 4 dm high, loosely branched, with three-pinnate leaves along stems; the specimen illustrated is somewhat intermediate, but tends toward the latter form. Stem dull red near base, bright green above with reddish tinges; leaves bright green, becoming red; petals (a) medium purple, white at base, tube and buds (b) dark purple, fragrant; anthers blue.

RELATIONSHIPS: similar to G. t. arenaria of the Monterey Peninsula. Most of the other members of the section Arachnion are found in the interior deserts and mountains.

REFERENCES: Grant and Grant (1956, 1960), Munz (1974:653), Munz and Keck (1959:488), Smith (1976:228).


a
b
4 cm
ME

Figure 33. GOLDENBUSH

Haplopappus [Hazardia] detonsus (Greene) Raven

Asteraceae

DISTRIBUTION: SRO, SCR, West and Middle ANA.

ECOLOGY: occasional on slopes and cliffs among coastal bluff, coastal sage scrub, and chaparral communities; fairly common on West ANA. Sensitivity to grazing pressures probably limits abundance and distribution on SCR and SRO.

DESCRIPTION: densely leafy, evergreen bush to 2.5 m high. Stems woody, tan below; leaves very pale greenish-white, becoming slightly greener with maturity, then tan; flowers (a) bright yellow, becoming brown; fruit (b) a dry achene with brownish pappus.

RELATIONSHIPS: hybridizes with H. squarrosus on SCR (and other islands?), imparting a high degree of variability to the populations affected. Very similar to and perhaps conspecific with H. canus, which is endemic to SCL and GUA. Morphologically similar to H. brickellioides of the interior desert mountains. Two or three nonendemic species also occur on the islands.

REFERENCES: Abrams and Ferris (1960:284), Clark (1979), Hochberg et al. (1979), Munz (1974:177), Munz and Keck (1959:1181), Raven (1963), Smith (1976:291).

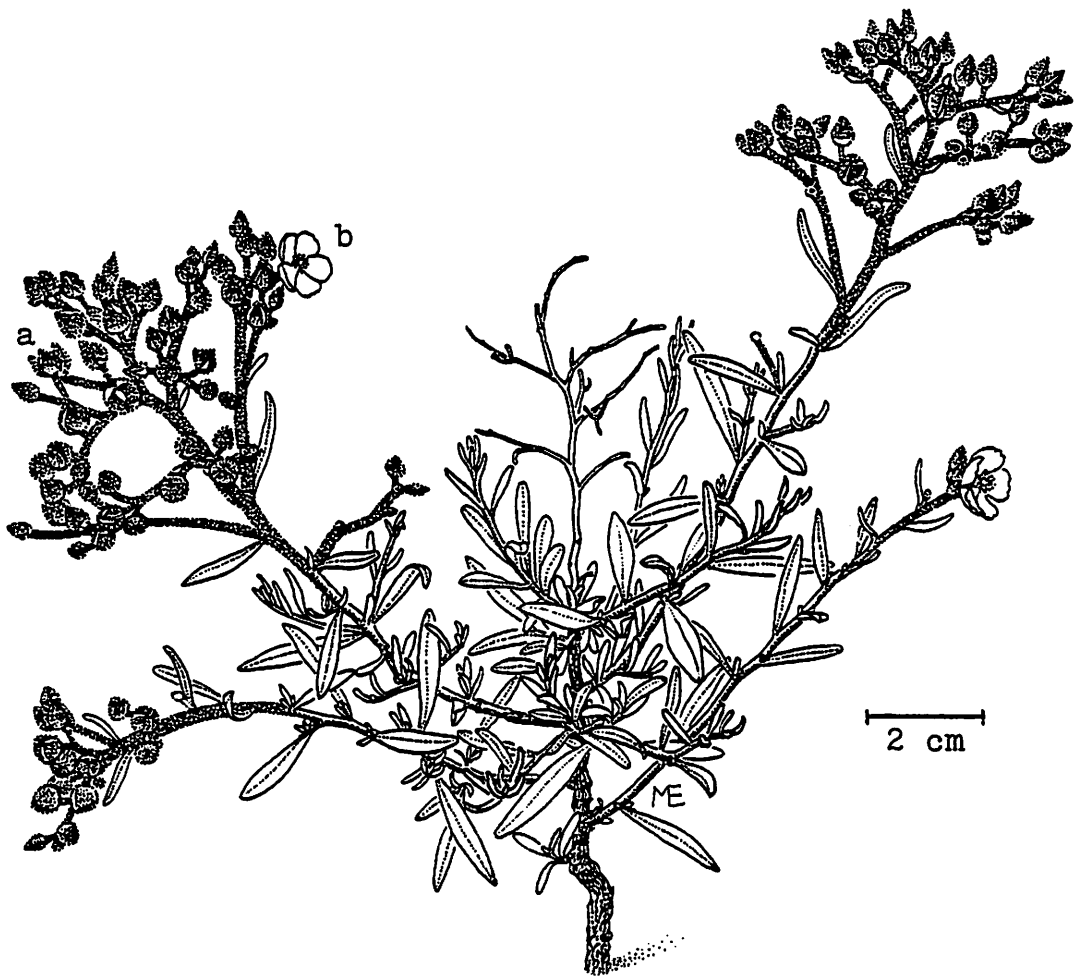

a
b
c
2 cm
ME

Figure 34. ISLAND RUSH-ROSE

Helianthemum greenei Rob.

Cistaceae

DISTRIBUTION: (SMI?)?, SRO?, SCR, SCA.

ECOLOGY: extremely rare and unusual; last collected on SMI in 1939. Usually on steep, grassy slopes and rocky places among coastal sage scrub, chaparral, and pines, especially on old burns. Blooms in spring and early summer.

DESCRIPTION: low, evergreen bush to 3 dm or more high with a distinct, gray-brown trunk. Stems dark brown; leaves acid-green, becoming red with age; entire inflorescence dull red with oily, glandular hairs; buds (a) greenish below, with long, white hairs; petals (b) light yellow, anthers orange.

RELATIONSHIPS: very different from H. scoparium, a much more common nonendemic with which it coexists on SRO, SCR, and SCA and rarely hybridizes.

REFERENCES: Abrams (1951:123, Fig. 3250), Hochberg et al. (1979), Munz (1974:370), Munz and Keck (1959:173), Raven (1963), Smith (1976:196), Thorne (1967).


b
3 cm
a

Figure 35. TARWEED

Hemizonia clementina Bdg.

Asteraceae

DISTRIBUTION: Middle and East ANA, SBA, SNI, SCL, SCA.

ECOLOGY: found in small colonies on heavy clay soils among coastal sage scrub and grasslands. Blooms in spring and early summer.

DESCRIPTION: a low, sprawling bush with a thick, brown, woody base (a) and most of the rather succulent herbage crowded near the tips of the branches; forming a thick, scraggly mat. Leaves bright acid-green; flowers (b) deep yellow with black anthers.

RELATIONSHIPS: although usually grouped with the other shrubby members of the genus (most of which are endemic to the Baja California Islands) in the section Fruticosae (Zonamra), there is considerable biogeographic, morphological, and cytotaxonomic evidence that this species was independently derived from the widespread, nonendemic annual H. fasciculata (Tanowitz, pers. comm. 1980-1981), which occurs in sandy soils on all of the Northern Channel Islands and which rarely hybridizes with the endemic (Thorne (1969b). The species is highly variable, with modal differences evident between the island populations, suggesting incipient adaptive radiation.

REFERENCES: Abrams and Ferris (1960:174, Fig. 5270), Carlquist (1965:115-118, Fig. 5.1), Munz (1974:185), Munz and Keck (1959: 1119), Philbrick (1972), Smith (1976:294).

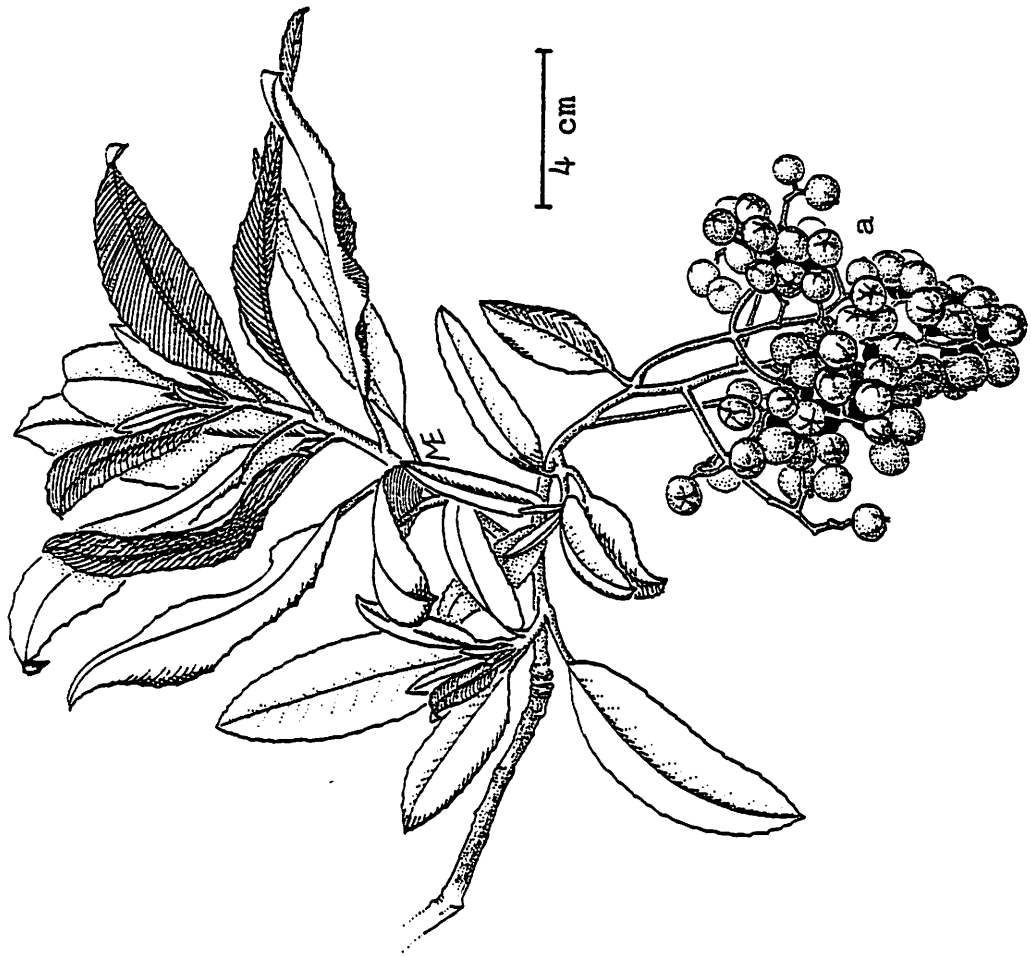

4 cm
a
ME

Figure 36. TOYON, CHRISTMAS BERRY

Heteromeles [Photinia] arbutifolia (Ait.) M. Roem.

Rosaceae

DISTRIBUTION: SMI, SRO, SCR, West ANA, SCL, SCA, TSA, CED, (GUA)?; widespread on mainland.

ECOLOGY: abundant in chaparral, coastal oak woodland, island woodland, and pine forests; extremely rare on SMI. Blooms in summer and fruits in autumn, with berries hanging on until spring. Crown-sprouting after fires.

DESCRIPTION: evergreen shrub or small tree to at least 30 feet high, with mottled gray bark. Leaves highly variable on Northern Channel Islands, dark acid-green above, paler below; flowers small, white, in pyramidal clusters; edible berries (a) bright red-orange or scarlet, rarely yellow.

RELATIONSHIPS: not usually considered an insular endemic on the northern islands, but high variability suggests some degree of divergence there, tending toward H. a. var. macrocarpa Munz of SCA and SCL on the basis of their large fruit (which is not readily eaten by birds) and less serrated leaf margins. The exact distribution of the endemic variety among the insular populations is unclear, so the species is treated here as a single, variable, near-endemic entity.

REFERENCES: Munz (1974:747), Munz and Keck (1959:795), Philbrick (1980), Raven (1963), Smith (1976:161), Thorne (1980).

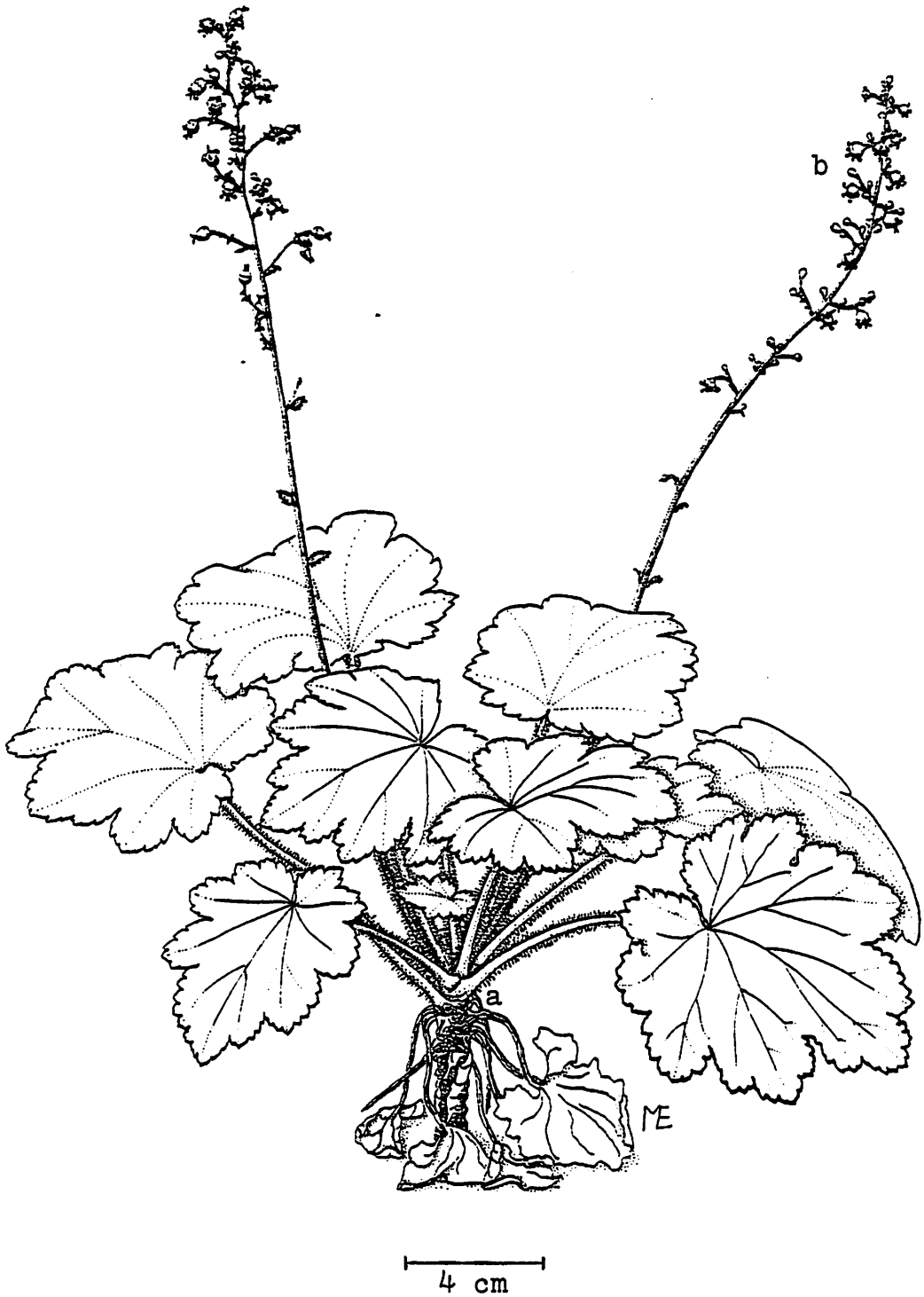

b
a
ME
4 cm

Figure 37. ISLAND ALUM-ROOT

Heuchera maxima Greene

Saxifragaceae

DISTRIBUTION: SRO, SCR, West ANA. Infrequently cultivated on the mainland.

ECOLOGY: a fairly uncommon plant of cool, moist, shady places, such as stream banks, canyon walls, and sea cliffs.

DESCRIPTION: large, dark green, persistent leaves clustered at the end of a long, scaly, perennial stem (a); flower stalk to five feet high; spring flowers (b) small, white to pinkish.

RELATIONSHIPS: similar to H. micrantha of the northern coast. The only plant on the island which could be confused with this species, at least with very young specimens, is Jepsonia malvaefolia*.

REFERENCES: Abrams (1944:381, Fig. 2293), Hochberg et al. (1979), Munz (1974:780), Munz and Keck (1959:742), Smith (1976: 154).


a
b
ME
3 cm

Figure 38. BLADDERPOD

Isomeris [Cleome] arborea Nutt. var. insularis Jeps.

Capparaceae

DISTRIBUTION: SRO, SCL?, SCA, LCO, CED?

ECOLOGY: a fairly common member of coastal sage scrub on SRO, especially near streams. Blooms in spring and early summer.

DESCRIPTION: a small, evergreen, rank-smelling shrub with rough, gray bark and twisted branches, to about 2 m high. Leaves pale green; inflorescence yellow-green; flowers (a) yellow, becoming straw-colored with age. The highly distinctive fruit (b) is an inflated capsule, light acid-green (with purple tinges dorsally when young), becoming dry and tan with age.

RELATIONSHIPS: other varieties are found on the adjacent mainland coast and in the deserts. The distribution of this weakly-defined endemic is unusual and unclear.

REFERENCES: Munz (1974:330), Munz and Keck (1959:207), Smith (1976:152).


a
c
b
b
ME
2 cm

Figure 39. JEPSONIA

Jepsonia malvaefolia (Greene) Small

Saxifragaceae

DISTRIBUTION: SRO, SCR, SNI, SCL, SCA, GUA; reported from coastal San Diego Co. (Abrams)?.

ECOLOGY: locally common in damp, mossy areas along streams, among chaparral, grasslands, and under pines; often on rocks. Pollinated by syrphid flies and halictid bees.

DESCRIPTION: although inconspicuous, this tiny, perennial herb is interesting in several respects. Its life cycle begins when it sends up a flowers stalk (a) from an underground base (b) in fall or early winter. The flowers are white, pale yellow-green, or pinkish. These are followed in the winter and spring by (usually) two dark green leaves (c), which wither in the summer. The species is distylous, with two slightly different forms which must cross-pollinate to reproduce.

RELATIONSHIPS: similar to J. parryi of the Peninsular Ranges to the south and J. heterandra of the Sierra Nevada foothills. The genus is restricted to the California region.

REFERENCES: Abrams (1944:354, Fig. 2233), Munz (1974:781), Munz and Keck (1959:733), Ornduff (1969), Smith (1976:155).

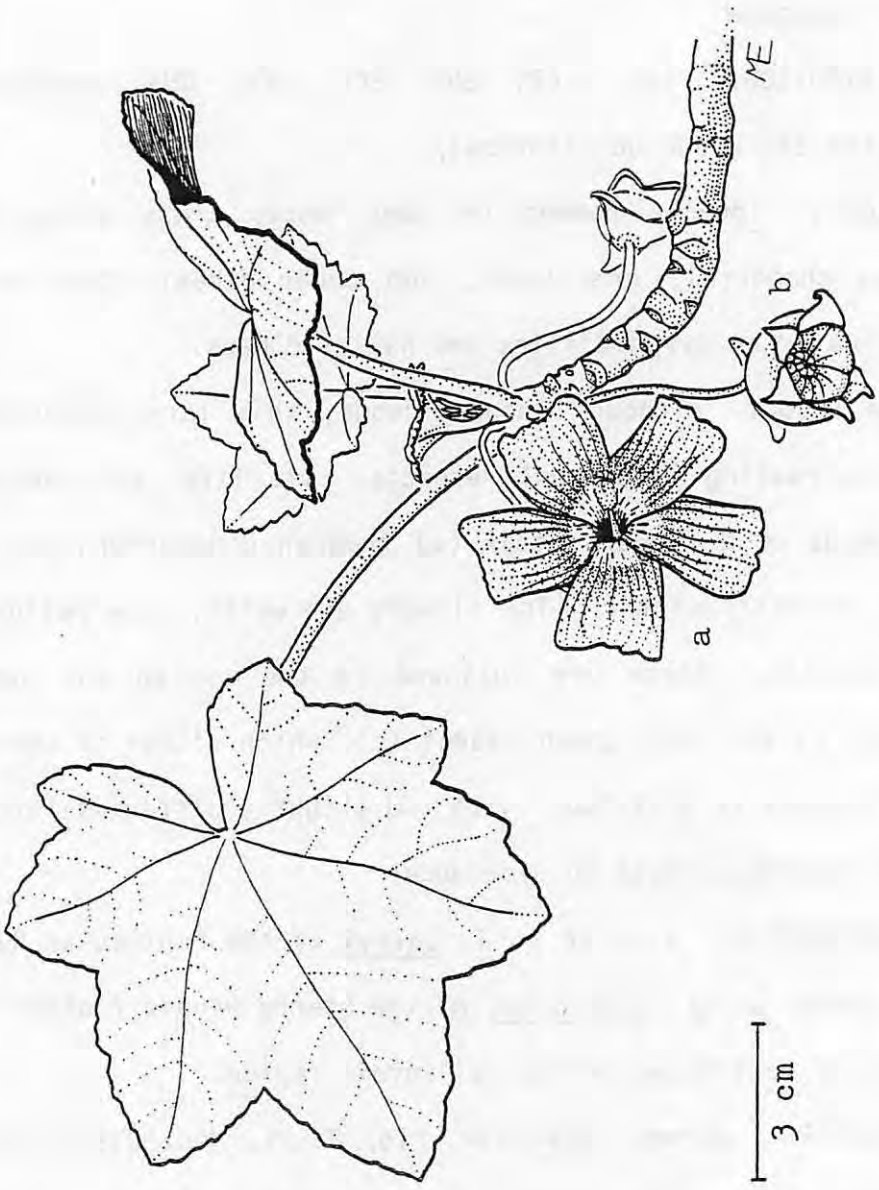

ME
b
a
3 cm

Figure 40. ISLAND TREE MALLOW

Lavatera assurgentiflora Kell. ssp. assurgentiflora

Malvaceae

DISTRIBUTION: SMI, SRO?, (SCR?), West and Middle ANA. Infrequently cultivated on the adjacent mainland and elsewhere.

ECOLOGY: very few specimens in two places on SMI, and on ANA. Cultivated specimens on SRO may have come from native stock, but the provenance of many specimens is in question. The nearly complete extinction of native stands due to grazing has further obscured the species' biogeography. Typically a member of the coastal sage scrub community, but also in dunes and coastal bluff vegetation. Blooms from late spring through summer.

DESCRIPTION: evergreen shrub 1-5 m high with smooth, light brown bark. Herbage acid-green; large, flowers (a) magenta and white; fruit (b) greenish.

RELATIONSHIPS: similar to L. a. glabra of (SNI?), SCA, SCL. Other species occur naturally on the Baja California Islands (and perhaps marginally on the adjacent mainland), in the Mediterranean region, on the Canary Islands, and in Australia; some of these are widely planted and escaping on the mainland. The genus presumably once occupied the North American mainland.

REFERENCES: Abrams (1951:109, Fig. 3223), Moran and Lindsay (1951), Munz (1974:564), Munz and Keck (1959:128), Philbrick (1980), Smith (1976:191, 313).


a
2 cm

Figure 41. SILVERY-CLOVER, TREFOIL

Lotus argophyllus (Gray) Greene ssp. niveus (Greene) Munz

Fabaceae

DISTRIBUTION: SCR.

ECOLOGY: formerly in streambeds (and coastal sage scrub?), now extremely rare and restricted to a few rocky areas among chaparral where somewhat protected from grazing. Blooms mainly in spring, occasionally through the summer.

DESCRIPTION: a beautiful, perennial herb with purplish, slightly woody stems near the base; the entire plant densely covered with bluish-white pubescence. Herbage silvery, small, yellow flowers embedded in white, silky heads (a), becoming rust-colored at maturity.

RELATIONSHIPS: other subspecies endemic on the islands to the south; L. a. niveus similar to some of the subspecies of the adjacent mainland mountains and northern coast. Many nonendemic species of Lotus occur on the islands.

REFERENCES: Abrams (1944:550, Fig. 2741), Dunkle (1950), Munz (1974:446), Munz and Keck (1959:848), Philbrick (1980), Raven (1963), Smith (1976:169).

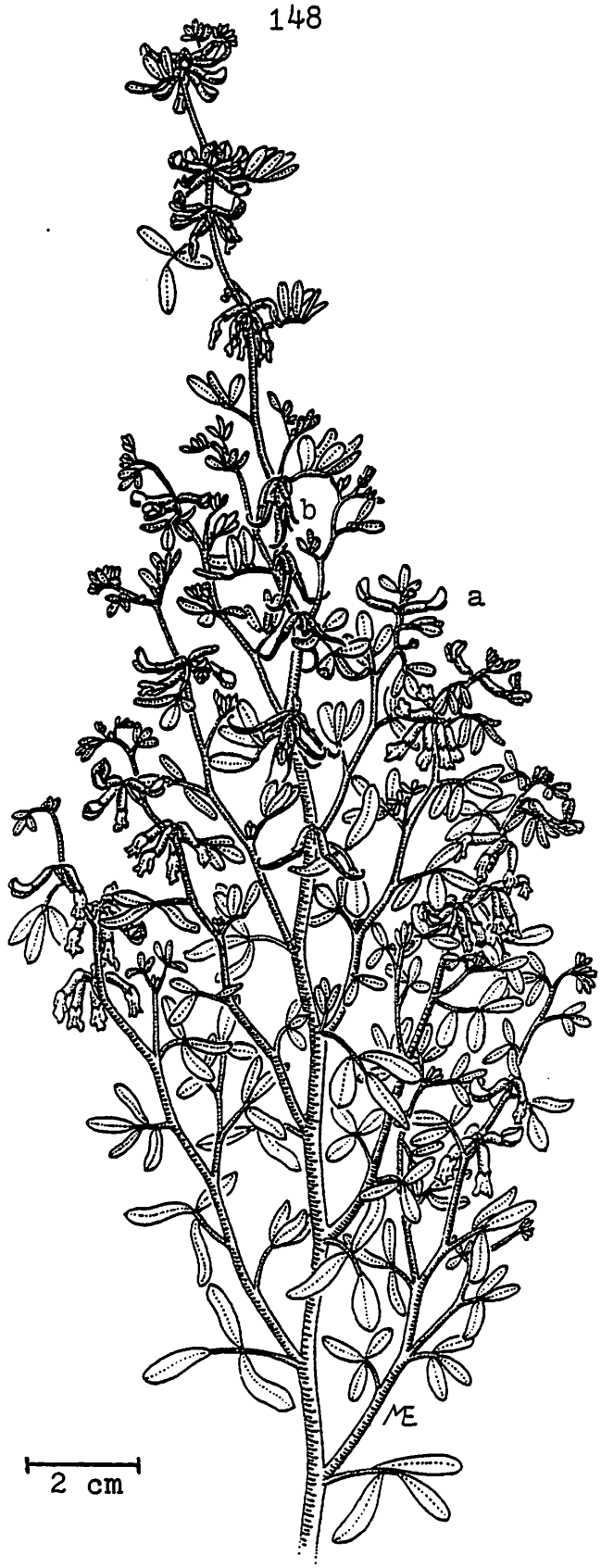

b
a
ME
2 cm

Figure 42. DEERWEED

Lotus scoparius (Nutt.) Ottley var. dendroideus (Greene) Ottley Fabaceae

DISTRIBUTION: SRO, SCR, ANA, SCA; adjacent mainland?

ECOLOGY: locally abundant in coastal sage scrub, grasslands, and disturbed or rocky areas. Flowering in spring, summer, and fall.

DESCRIPTION: largely evergreen bush 1-2 m high with a short, often twisted trunk with brown bark. Branches (a) frond-like; stems reddish-purple below; herbage dull acid-green or glaucous, becoming reddish and yellow with age; sepals light acid-green, petals (a) deep yellow to orange, becoming rusty-yellow with age; pods (b) dull red-purple to brown.

RELATIONSHIPS: intergrades with L. s. scoparius on the islands and mainland (where the latter predominates); L. s. veatchii (Greene) Ottley is on cliffs and dunes on SMI and intergrades with L. s. dendroideus on SRO, also reported from the mainland of San Luis Obispo County (Hoover 1970) and northwestern Baja California and CED (Hale 1941). L. s. traskiae is endemic to SCL.

REFERENCES: Abrams (1944:552, Fig. 2745), Carlquist (1974:375, Fig. 10.3), Isely (1978), Munz (1974:449), Munz and Keck (1959:849), Raven (1963), Smith (1976:171).


a
E
4 cm

Figure 43. ISLAND IRONWOOD

Lyonothamnus floribundus Gray ssp. asplenifolius (Greene) Raven

Rosaceae

DISTRIBUTION: SRO, SCR, SCL. Rarely cultivated on mainalnd.

ECOLOGY: groves common on SCR, occasional elsewhere; mainly at the heads of small streams. Characteristic of island woodland, also occurring in chaparral and pine forests. Flowers mainly in early summer, but occasionally at other times (e.g., late winter and early spring).

DESCRIPTION: a unique and beautiful evergreen tree to fifty feet high, with reddish bark weathering into light gray, exfoliating strips; twigs orange-brown. Leaves medium to dark acid-green above, grayish below, turning orange-brown; flowers (a) tiny, white, fragrant, in broad clusters; becoming reddish-brown capsules with tiny seeds. Seedlings extremely rare; runners form groves.

RELATIONSHIPS: at least two very similar forms known from Tertiary fossils in Nevada and other interior sites. Apparently ancestral to L. f. floribundus, a superficially different but closely related form which appeared in Pliocene sites along the California coast and is now found only on SCA. This is the only strictly insular genus on the Northern Channel Islands. Unrelated to other 'ironwoods.'

REFERENCES: Abrams (1944:409), Munz (1974:750), Munz and Keck (1959:756), Raven and Axelrod (1978), Smith (1976:162).

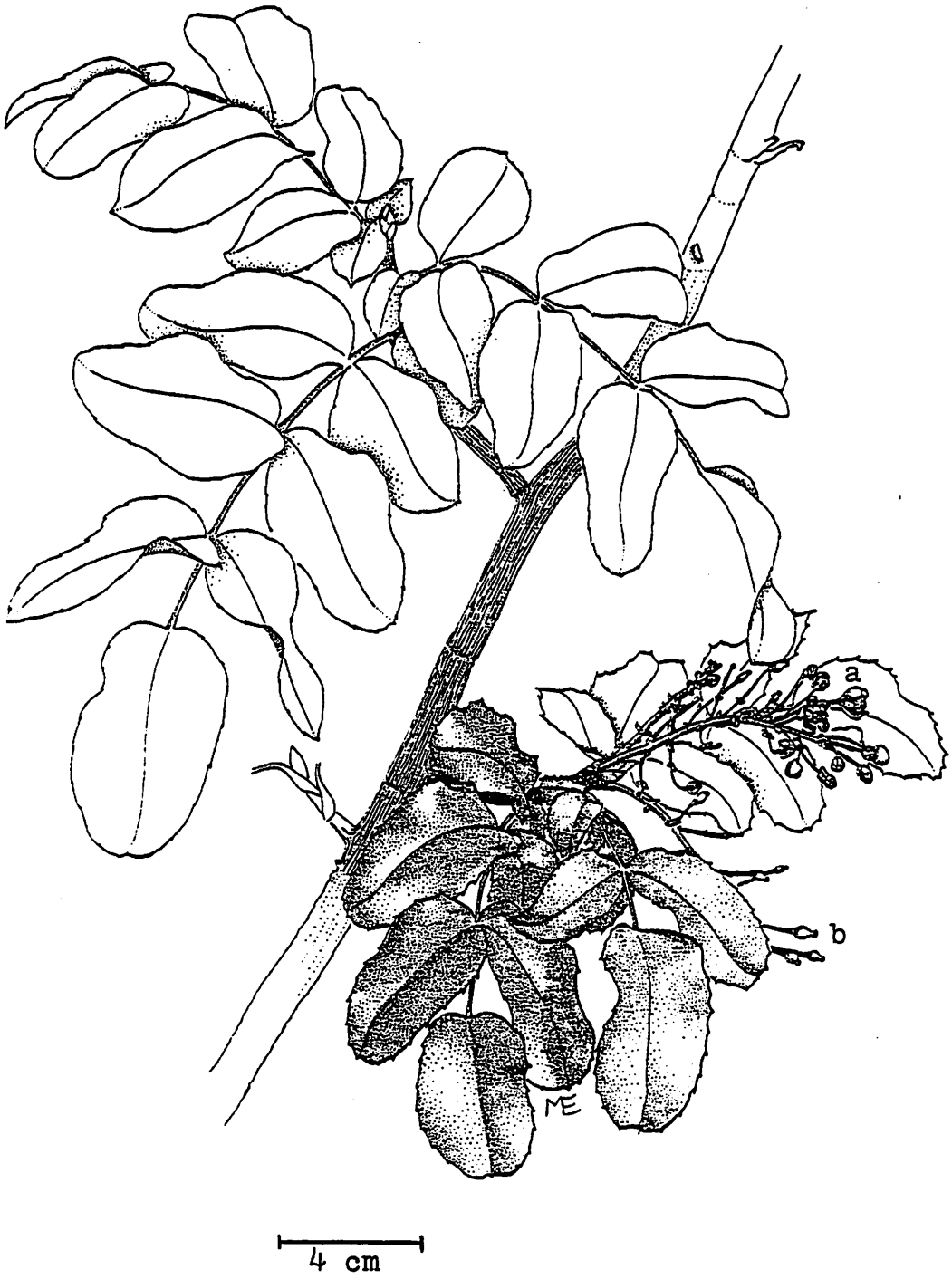

a
b
ME
4 cm

Figure 44. SHINYLEAF BARBERRY

Mahonia [Berberis] pinnata Lag. ssp. insularis Munz

Berberidaceae

DISTRIBUTION: (SRO)?, SCR, West ANA. Erroneously reported from SCA, LCO (C.F. Smith, pers. comm. 1981).

ECOLOGY: apparently extinct on SRO; rare elsewhere. Recently rediscovered in the wooded cayons of West ANA (M.C. Hochberg, pers. comm. 1981). The only population which is doing fairly well occurs in the western pine forest of SCR. Blooms rather briefly but profusely in March or April, fruits in summer.

DESCRIPTION: evergreen bush with long, weak stems 2-6 (-8) m long, leaning against tree trunks for support; with finely divided, brown bark. Leaves glossy, dark green; flowers (a) bright yellow; berries (b) blue with glaucous bloom, edible.

RELATIONSHIPS: M. p. pinnata occurs locally in the mountains of the adjacent mainland.

REFERENCES: Munz (1974:245), Munz and Keck (1959:109), Philbrick (1980), Smith (1976:139).

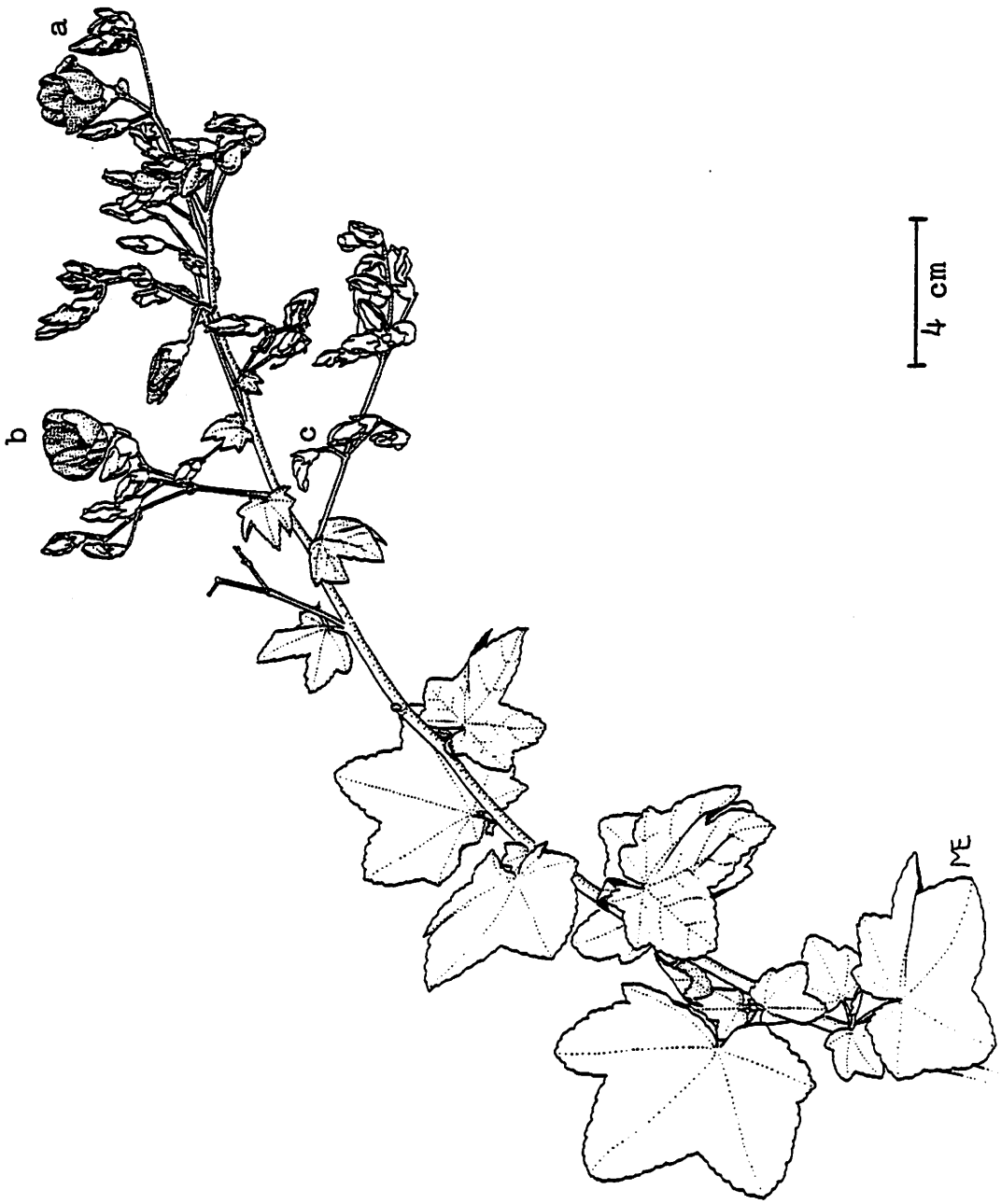

a
b
c
4 cm
ME

Figure 45. CHAPARRAL MALLOW

Malacothamnus fasciculatus (Nutt.) Greene var. nesioticus (Rob.) Kearn.

Malvaceae

DISTRIBUTION: SCR.

ECOLOGY: restricted to one small (but dense) colony of several dozen individuals on the south-facing side of a ravine near Christi Ranch at the western end of the island, among coastal sage scrub. Blooms in summer.

DESCRIPTION: bush to less than 2 m high; spreading branches covered with pale, tan felt. Leaves acid-green, paler beneath, evergreen?; petals reddish-violet in bud (a), purple in flower (b), becoming bluish then tan with age (c).

RELATIONSHIPS: very weakly differentiated from M. f. nuttallii of the adjacent mainland, with which it is included by some workers; another variety has been described as endemic to SCA and perhaps the Santa Monica Mts., Los Angeles Co. (Thorne 1967).

REFERENCES: Abrams (1951:94, Fig. 3183), Bates (1963), Munz (1974:568), Munz and Keck (1959:127), Smith (1976:192).

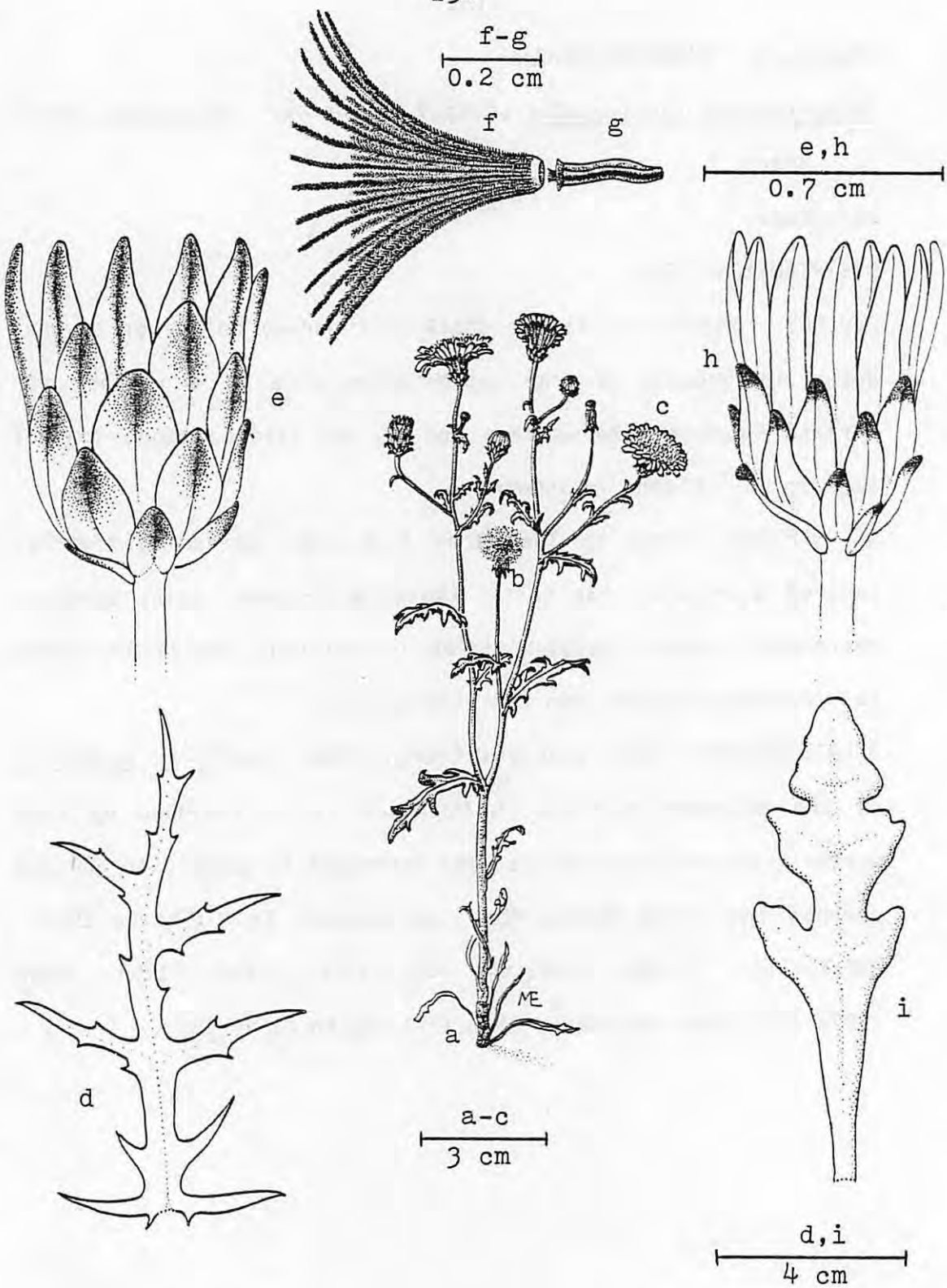

f-g
0.2 cm
f
g
e,h
0.7 cm
e
h
c
b
a
ME
a-c
3 cm
d
i
d,i
4 cm

Figure 46. ANNUAL CHICORIES

(a,b,c,f,g) Malacothrix sp. nov. Davis;

(h,i) M. indecora Greene

(d,e) M. squalida Greene

Asteraceae

DISTRIBUTION: M. sp. n. West and East ANA; M. indecora SMI, SCR; M. squalida SCR, Middle ANA.

ECOLOGY: very rare in grasslands and perhaps coastal sage scrub and coastal bluff vegetation. Bloom in spring.

DESCRIPTION: M. sp. n. relatively tall, branching, with poorly-developed basal leaves (a); stem purple-tinged below, acid-green above; leaves dull green, becoming tan; flowers (c) bright yellow; achene (g) tan; pappus bristles (b,f) white, deciduous. M. indecora and M. squalida very small, with mainly basal leaves (d,i); purple-tipped phyllaries of M. squalida (e) shaped very differently from other two species' (h). Other details of morphology and cytology differ.

RELATIONSHIPS: species sometimes lumped with M. foliosa of southern islands. Recent studies indicate a rapidly evolving hybridization complex; findings too involved to summarize here; closely related to other taxa endemic to Southern Channel Islands and LCO. Similar nonendemics on islands.

REFERENCES: Abrams and Ferris (1960:576-578, Figs. 5996-5998), Davis (1980), Hochberg et al. (1979), Munz (1974:207), Munz and Keck (1959:1299), Smith (1976:301-302).

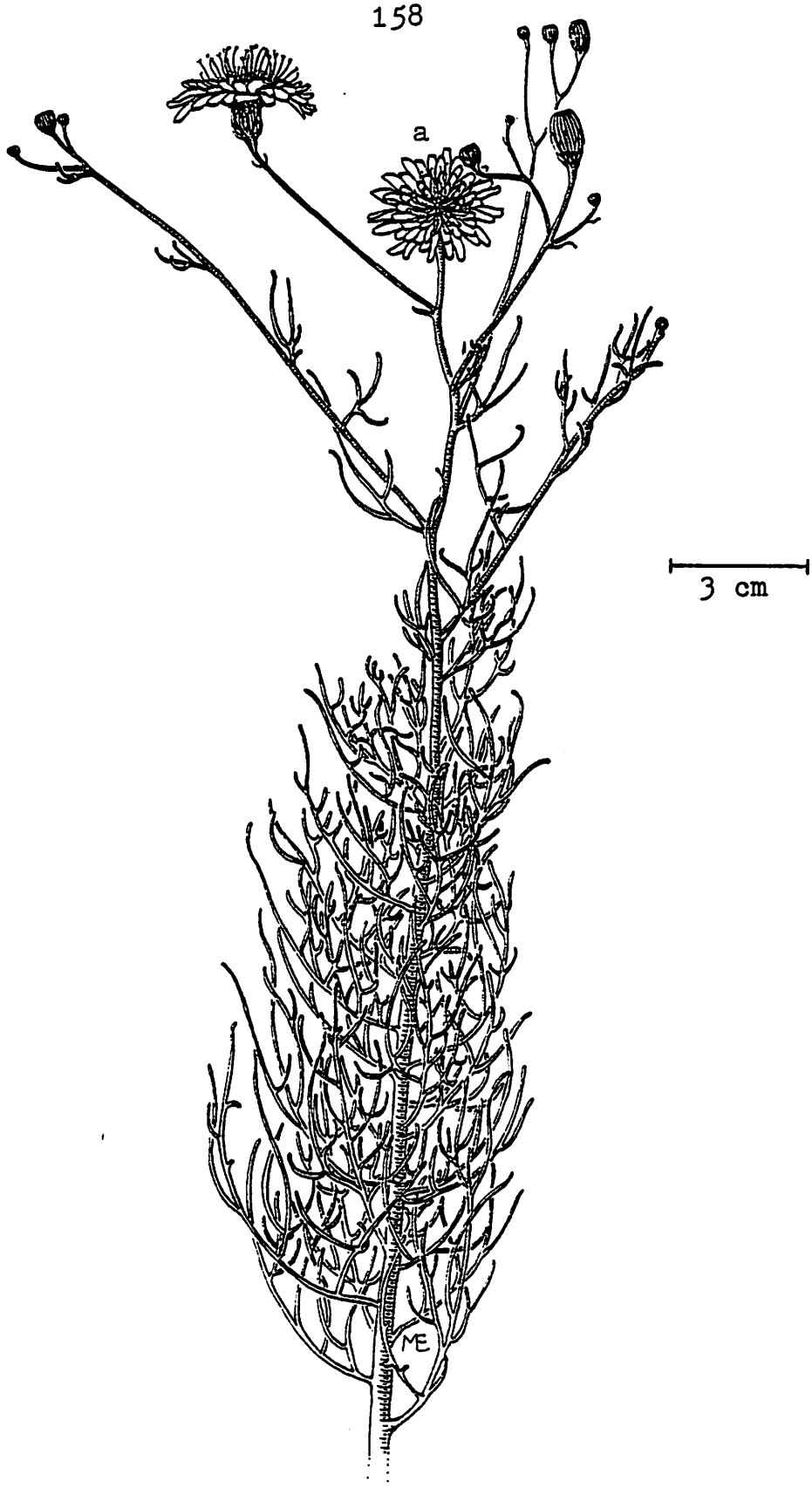

a
3 cm
ME

Figure 47. CLIFF ASTER

Malacothrix saxatilis (Nutt.) T. & G. var. implicata (Eastw.) Hall

Asteraceae

DISTRIBUTION: SMI, SRO, SCR, ANA, SNI; reported from the mainland at Gaviota Canyon, Santa Barbara Co.?

ECOLOGY: common on steep slopes and stream banks in coastal sage scrub, also in grasslands and coastal bluff vegetation. Blooms mainly spring to early summer. Dies back in summer and fall.

DESCRIPTION: bushy perennial with several stems to about 1 m high arising from a woody base; stems red-purple below, acid-green above; leaves dull acid-green, becoming red, then brown with age, with scurfy white axils; flowers (a) white, deep yellow toward the center, and usually pale rose toward the edges and below.

RELATIONSHIPS: closest to M. s. tenuifolia of the adjacent mainland coast, SCA, SCL (introduced; Junak pers. comm. 1982), and perhaps SMI, SRO, SCR, ANA. Probably ancestral to the numerous mainland varieties. Hybridizes with M. incana/succulenta on SMI (Philbrick 1980).

REFERENCES: Abrams and Ferris (1960:580), Davis (1980), Munz (1974:208), Munz and Keck (1959:1299), Smith (1976:301).

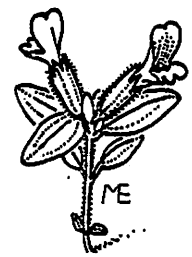

a
ME
2 cm

Figure 48. MONKEY-FLOWER

Mimulus brandegei Penn.

Scrophulariaceae

DISTRIBUTION: (SCR)?

ECOLOGY: last collected in 1932, possibly extinct. Presumably occurred on stony ridges near the west end. Bloomed in early spring.

DESCRIPTION: annual herb; many have attained a larger size than available specimens indicate. Flowers (a) purple.

RELATIONSHIPS: very closely related to M. traskiae (which was collected only once, on SCA in 1901) and M. latifolius of GUA, with which it is sometimes combined. All are similar to M. congdonii of the adjacent mainland mountains. Several other species occur on SRO, SCR.

REFERENCES: Abrams (1951:730, Fig. 4626), Munz (1974:809), Munz and Keck (1959:623), Smith (1976:257).


b
a
2 cm
ME

Figure 49. BUSH MONKEY-FLOWER

Mimulus flemingii Munz [*Diplacus parviflorus* Greene]

Scrophulariaceae

DISTRIBUTION: SRO, SCR, West ANA, SCL.

ECOLOGY: common in shady places on hillsides, sea cliffs, etc., among coastal bluff vegetation, chaparral, woodland, and pine forests. Apparently avoided by sheep. Blooms mainly in spring, but occasionally through much of the year.

DESCRIPTION: small evergreen bush to about 1 m high with long, orange-brown stems. Leaves glossy green, becoming dull purple then brown with age. Flowers (a) deep red-orange with orange below and within (rarely pure yellow), becoming dark reddish-brown then tan; conspicuous, fuzzy white stigma (b).

RELATIONSHIPS: hybridizes extensively with *M. longiflorus*, which occurs in drier habitats on SCR. Apparently primitive, sharing certain features with *Berendtia laevigata* of Mexico; and contributing genetically to other species of the section *Diplacus*, especially *M. puniceus* of SCA and the adjacent mainland. Self-compatible.

REFERENCES: Abrams (1951:718, Fig. 4591), Hochberg et al. (1979), McMinn (1951), Munz (1974:811), Munz and Keck (1959:625), Smith (1976:256).


c
b
ME
a
2 cm

Figure 50. BROOMRAPE

Orobanche parishii (Jeps.) Heckard ssp. brachyloba Heckard

Orobanchaceae

DISTRIBUTION: SMI, SRO, SCR, SNI, SCA; locally on mainland from San Luis Obispo Co. to northwestern Baja California, Mexico.

ECOLOGY: perennial, underground root parasite, mainly on Haplopappus* venetus but perhaps on other species of the genus, Atriplex, and Eriogonum grande*; rather specialized in this and other respects. Very rare, and inconspicuous, forming small colonies in sandy soils near the beach, usually among coastal sage scrub. Blooms from summer to early fall.

DESCRIPTION: inflorescence (a) pale greenish-brown; dry flowers (b) red-brown; fresh flowers (c) purple-tinged on inner lips, yellowish inside tube.

RELATIONSHIPS: SCA and mainland specimens resemble O. p. parishii, which parasitizes a variety of plants in the lower mountains of the adjacent mainland. SNI specimens are the most distinct. Several nonendemic species are native to the islands. Tetraploid.

REFERENCES: Heckard (1973), Munz (1974:619), Smith (1976:264).

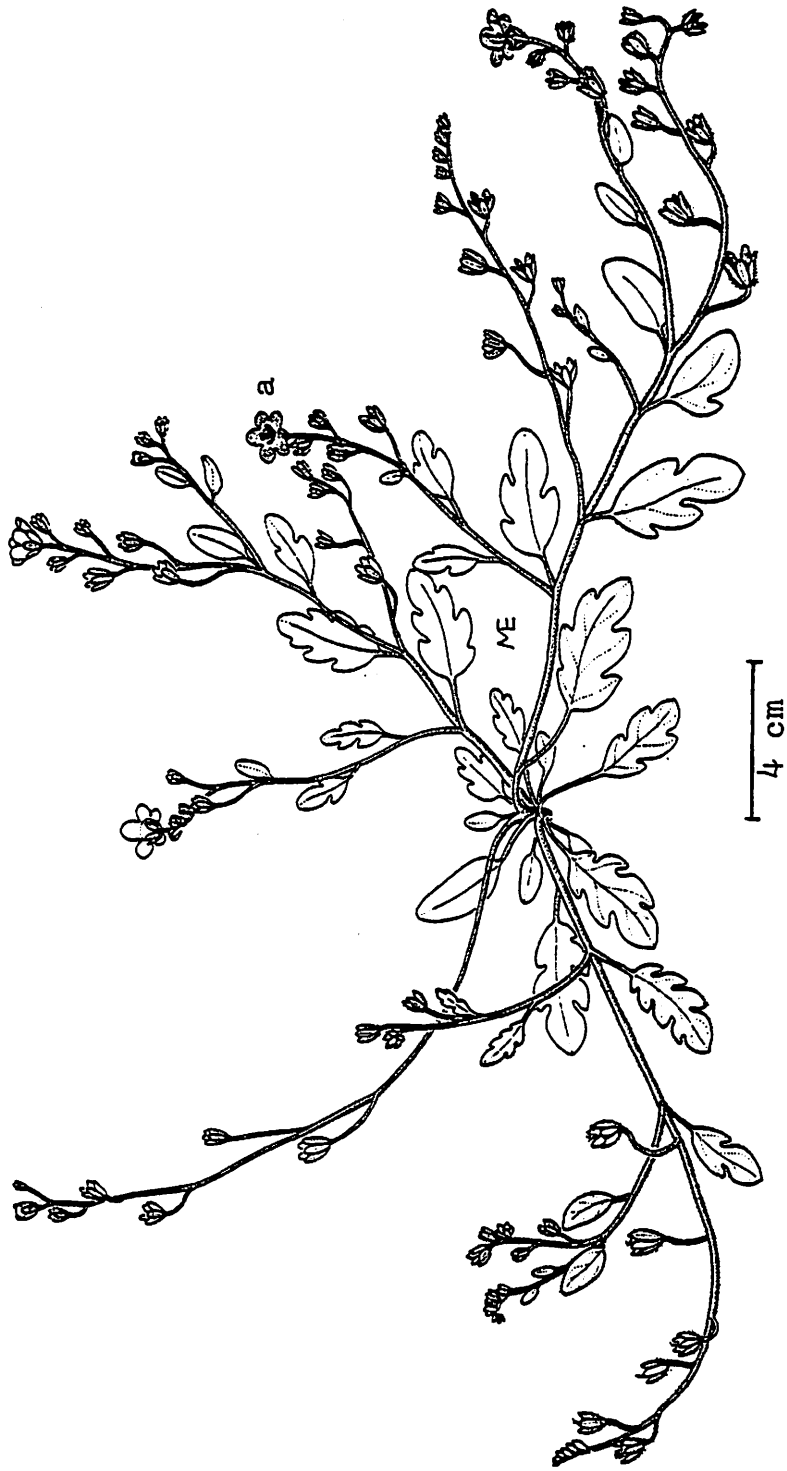

a
ME
4 cm

Figure 51. PHACELIA

Phacelia divaricata (Benth.) Gray var. insularis (Munz) Munz Hydrophyllaceae

DISTRIBUTION: SMI, SRO.

ECOLOGY: extremely rare in sand dunes and sandy grasslands, also apparently in coastal marshes and on rocky slopes. Blooms in spring.

DESCRIPTION: annual herb, erect when small, becoming decumbent or prostrate with age. Flowers (a) few, light blue with white centers.

RELATIONSHIPS: similar to P. d. continentis of the northern California coast. Several nonendemic species native to the islands; other species endemic on the islands to the south. Morphologically primitive.

REFERENCES: Abrams (1951:508), Howell (1945), Munz (1974:509), Munz and Keck (1959:538), Smith (1976:234).

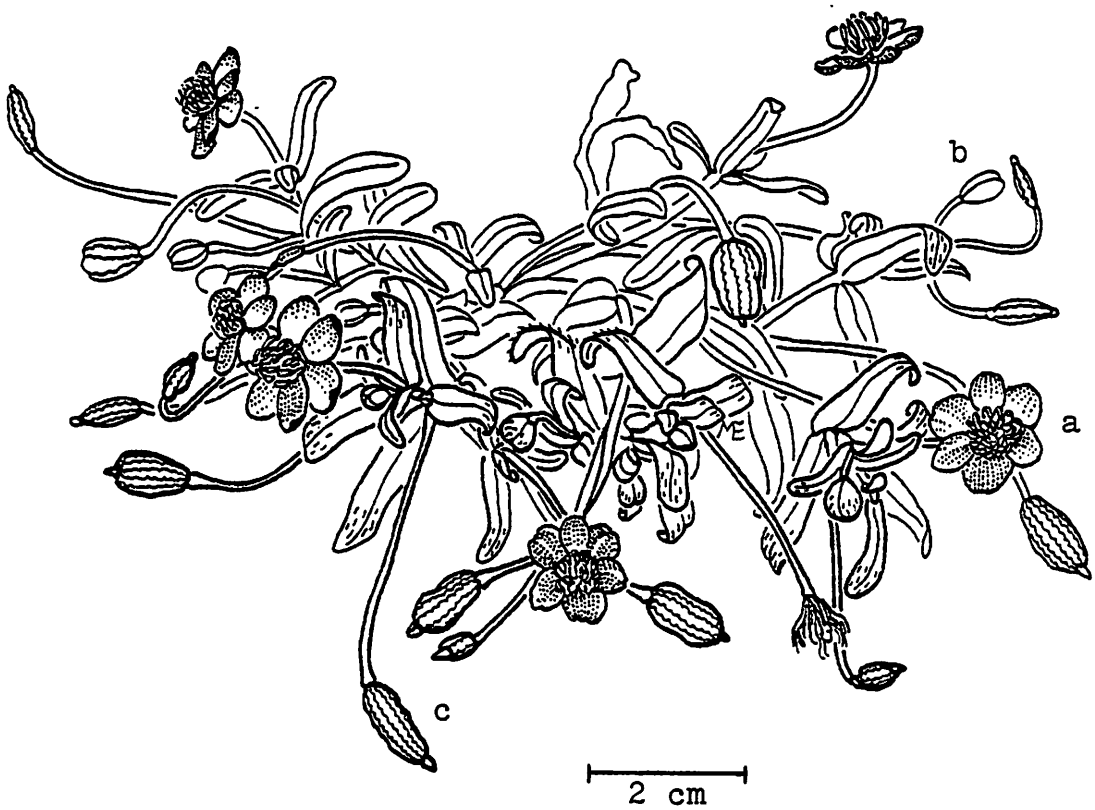

b
a
c
2 cm

Figure 52. CREAM CUPS

Platystemon californicus Benth. var. ornithopus (Greene) Munz Papaveraceae

DISTRIBUTION: SMI, SRO, SNI; apparently on the immediate coast of mainland northern California, and probably elsewhere.

ECOLOGY: locally abundant in colonies among sandy grasslands and coastal bluff vegetation. Probably wind pollinated; self-incompatible; blooms from late winter to early summer.

DESCRIPTION: prostrate annual, nearly glabrous, with pale green, fleshy leaves, becoming yellowish-tan; purple-tinged stems, and cream-colored flowers (a) which open in full sun; buds (b) purple; immature fruit (c) acid-green with yellow tip.

RELATIONSHIPS: a highly variable species without clearly marked segregates, including the present form. P. c. var. nutans Bdg. has fruits which droop in maturity; it is found in coastal habitats on all four islands and on the mainland in northern California, San Diego Co., and probably elsewhere. P. c. californicus is a widespread form which occurs in mainly interior locales on SRO, SCR, ANA?, SCA, (GUA?)?. P. c. ciliatus is endemic to SBA. The island populations have not been well studied. The various forms retain their characteristics in cultivation.

REFERENCES: Hannan (1980, 1981; pers. comm. 1981), Munz (1974: 631), Munz and Keck (1959:193), Smith (1976:142).

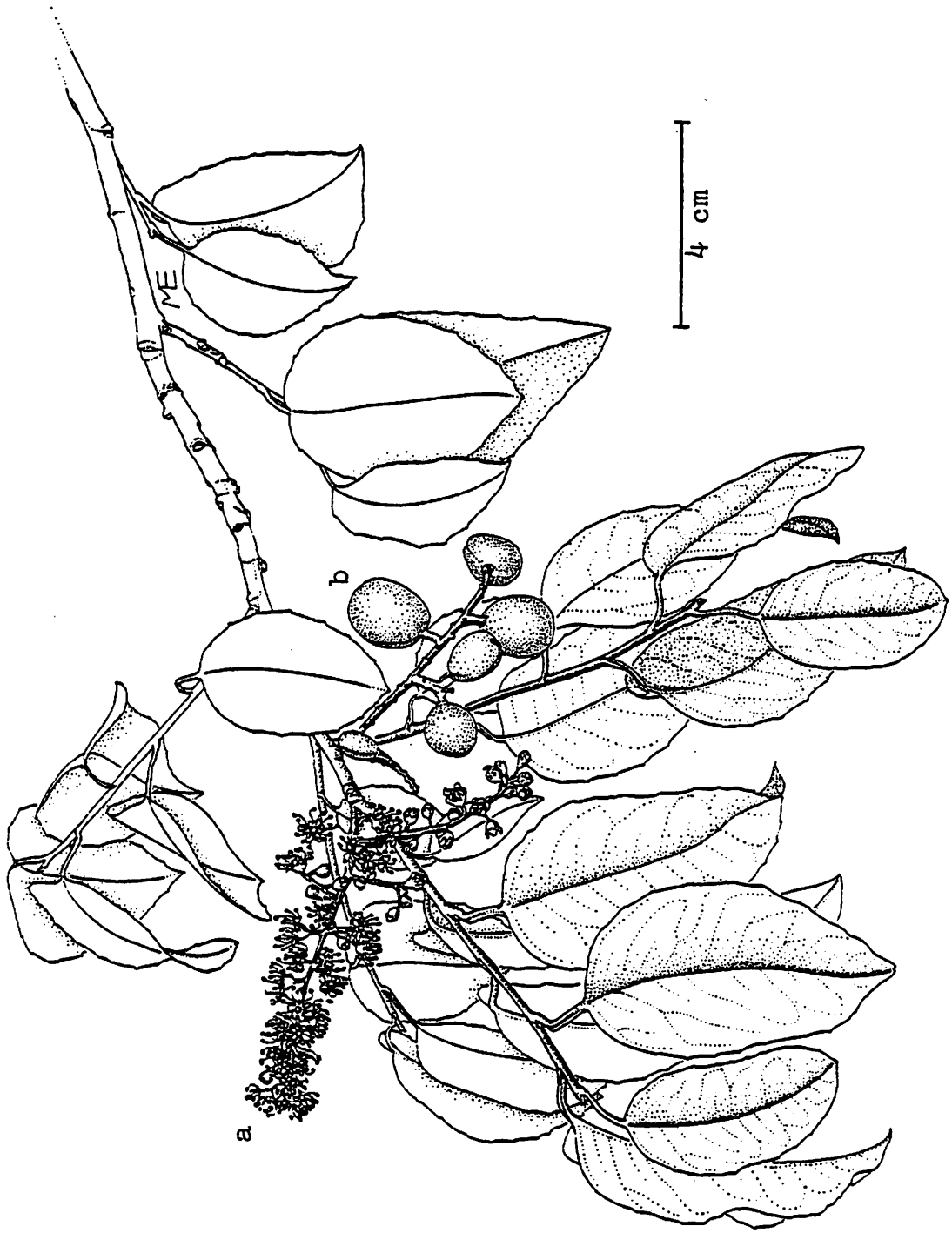

4 cm
a
b

Figure 53. ISLAND CHERRY, CATALINA CHERRY

Prunus [Laurocerasus] ilicifolia (Nutt.) Walp. ssp. lyonii (Eastw.) Raven

Rosaceae

DISTRIBUTION: SRO, SCR, West ANA, SCL, SCA; reported from the mainland in a few canyons of south-central Baja California, Mexico (e.g., San Julio Canyon). Widely cultivated and escaping on the adjacent mainland.

ECOLOGY: fairly common near streams in island woodland and coastal oak woodland; occasional in chaparral. Blooms from late winter to early summer; fruits in midsummer. Crown-sprouting after fires. Mainland plantings highly susceptible to a disfiguring virus (Emery, pers. comm. 1981).

DESCRIPTION: tree to fifty feet high, with a central trunk and fairly smooth, gray-brown bark. Leaves light acid-green to dull green turning yellow and orange-brown with age; evergreen, but wilting slightly in summer (opposite). Flowers (a) white, fragrant; fruit (b) light acid-green, becoming red-purple and almost black when ripe; edible and sweet on the best trees.

RELATIONSHIPS: Northern Channel Islands populations vary toward P. i. ilicifolia of the adjacent mainland in certain respects. Known from Tertiary fossils on the mainland.

REFERENCES: Abrams (1944:467, Fig. 2527), Hochberg (1980a, 1980b), Munz (1974:757), Munz and Keck (1959:791), Raven (1963), Smith (1976:164).

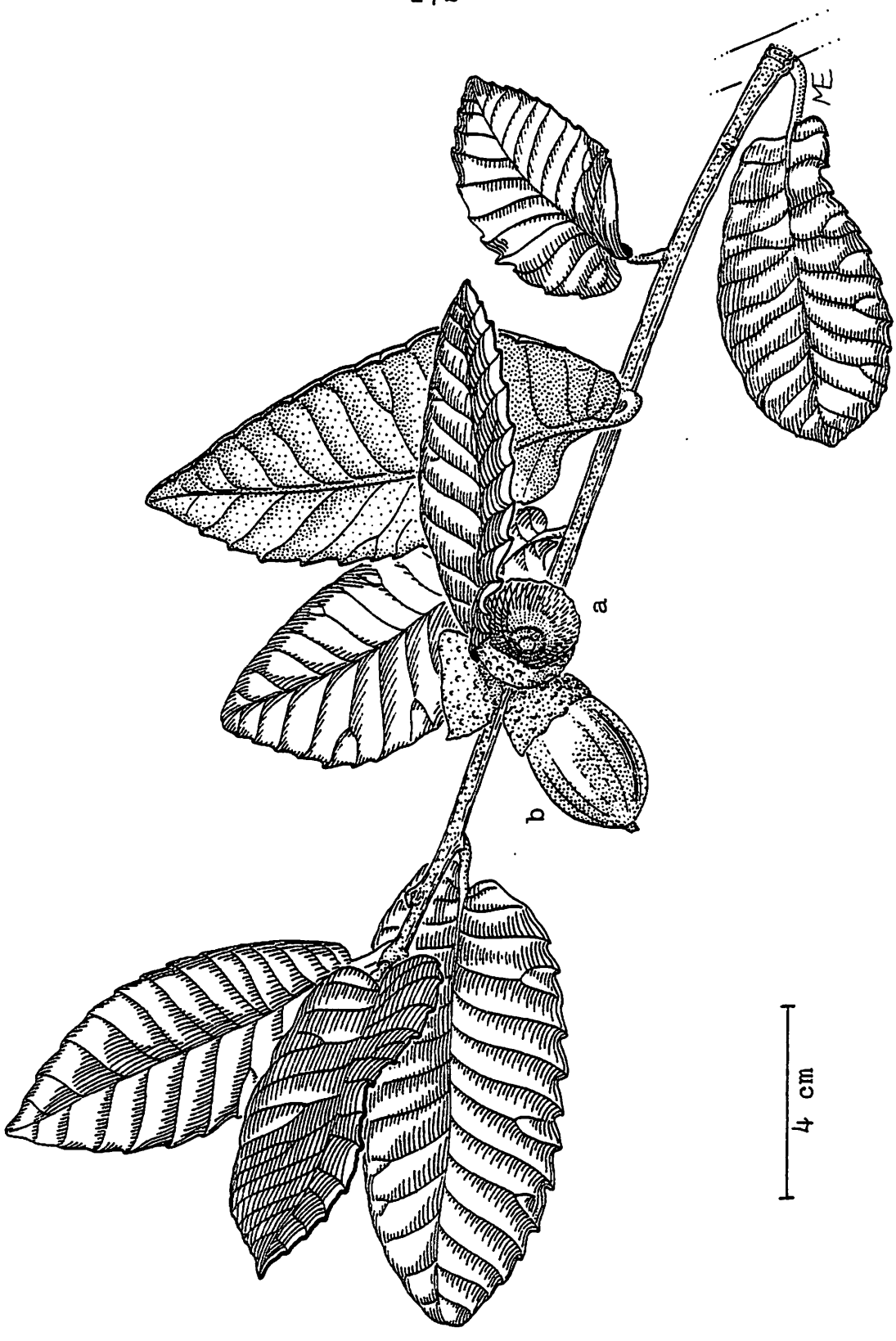

ME
a
b
4 cm

Figure 54. ISLAND OAK

Quercus tomentella Engelm.

Fagaceae

DISTRIBUTION: SRO, SCR, West ANA, SCL, SCA, GUA.

ECOLOGY: generally rare in canyons and on mountain slopes in island woodland and other woodland and chaparral communities. Blooms in spring, fruits in early winter. Seedlings rare (Dunkle 1950), perhaps due in part to allelopathy. Reproduces by succer shoots.

DESCRIPTION: rounded evergreen tree to 40 feet high with grayish or red-brown, scaly bark. Young twigs with gray pubescence, becoming brown; leaves stiff, medium to dark green, glossy above, with scattered hairs, paler and slightly pubescent below; staminate inflorescence a pendulous, inconspicuous catkin; acorn cup (a) gray-brown, downy outside, reddish-brown and gray inside; immature acorn (b) light to medium acid-green becoming brown.

RELATIONSHIPS: closely related to Q. crysolepis, with which it hybridizes on SCR, ANA, SCA, SCL, GUA. Known from Tertiary fossils on the mainland. Several other oaks occur on SCR, where they often dominate chaparral and woodland communities. Many of the species hybridize extensively on the islands, and some of the forms involved are near-endemics.

REFERENCES: Abrams (1940:521, Fig. 1265), Muller (1967), Munz (1974:481), Munz and Keck (1959:906), Smith (1976:113).

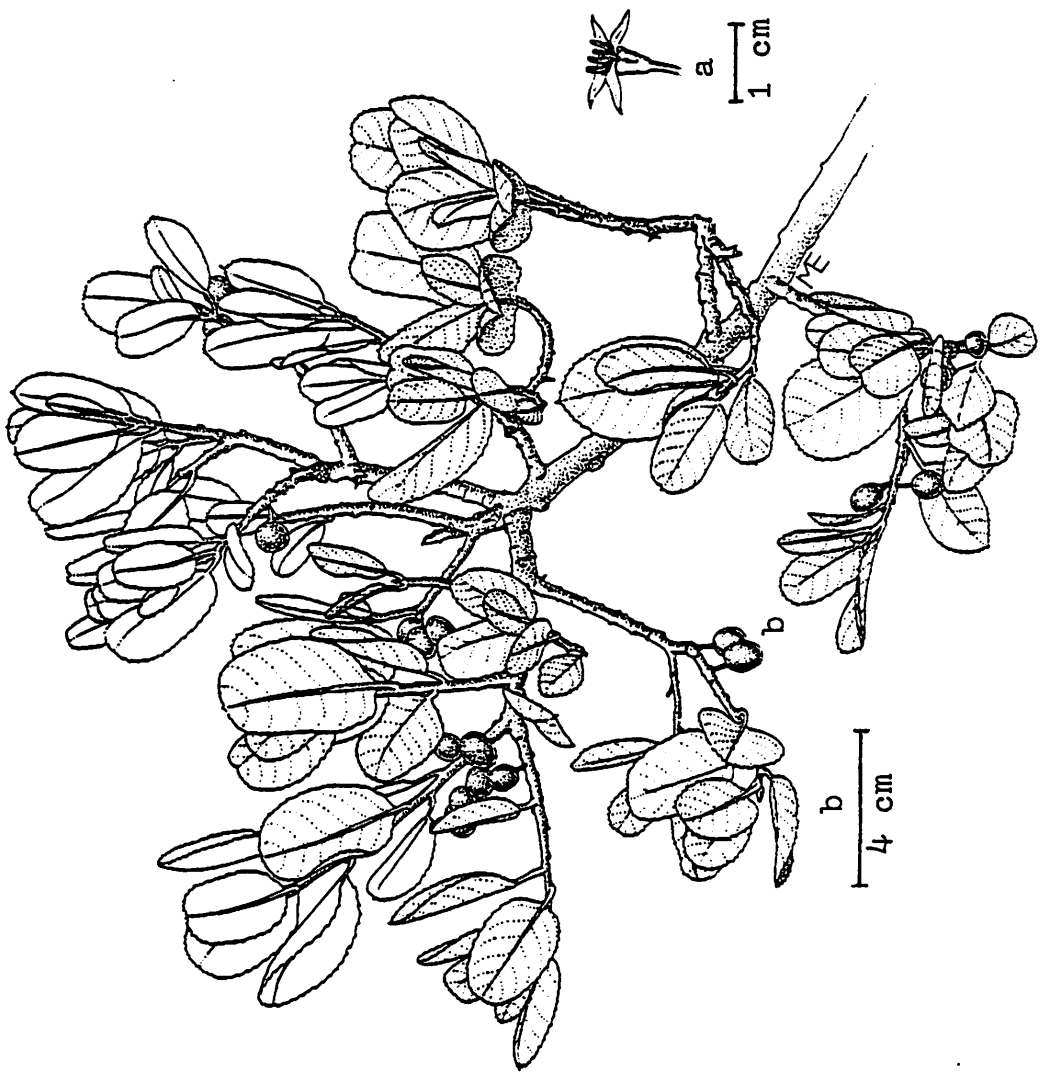

a
1 cm
b
b
4 cm

Figure 55. REDBERRY

Rhamnus pirifolia Greene

Rhamnaceae

DISTRIBUTION: (SMI?)?, SRO, SCR, SCL, SCA, GUA.

ECOLOGY: occasional in chaparral, mostly away from the immediate coast. Flowers in spring to early summer; fruits in summer. Crown-sprouting after fires.

DESCRIPTION: evergreen shrub or small tree to about 30 feet high with cracked, mottled gray bark. Twigs red-brown; leaves stiff, glossy, acid-green, becoming yellow or dull red with age; staminate flowers (a) light acid-green with brownish tinge, clustered; berries (b) greenish-yellow, becoming red-orange at maturity. Rather inconspicuous in the field, except for the berries.

RELATIONSHIPS: very similar to and perhaps conspecific with some specimens of R. ilicifolia from moist locales on the adjacent mainland. Known from Tertiary fossils on the mainland (Raven 1963)? A related form, R. insularis or R. insula, is found on CED and locally on the mainland of Baja California (Axelrod 1980). GUA specimens atypical (Eastwood 1929).

REFERENCES: Abrams (1951:64), Munz (1974:739), Munz and Keck (1959:972), Smith (1976:190), Wolf (1938).

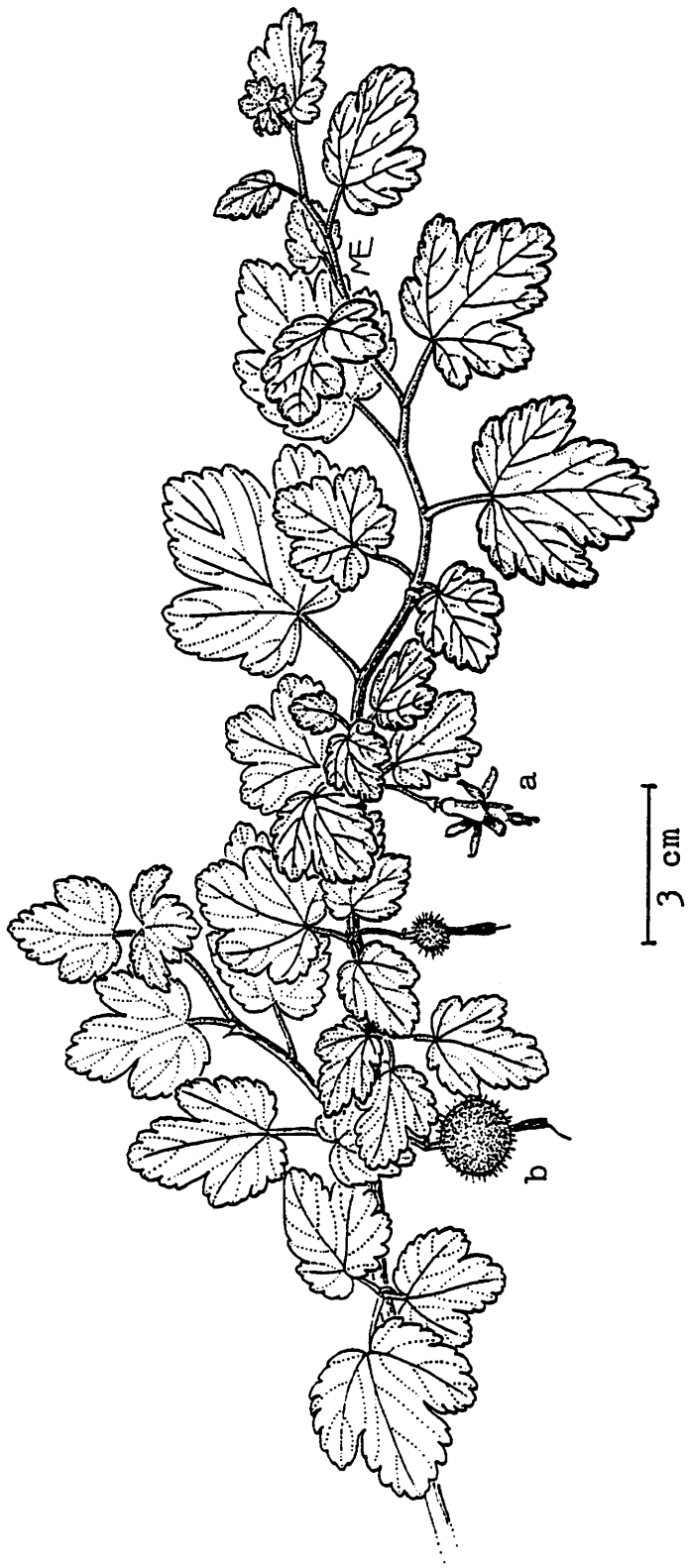

ME
a
b
3 cm

Figure 56. ISLAND CURRANT

Ribes thacherianum (Jeps.) Munz

Saxifragaceae

DISTRIBUTION: SCR.

ECOLOGY: occasional near streams in island woodland and especially in the western pine forest. Blooms mainly during the rainy season (winter) into early summer; fruits mainly in late spring.

DESCRIPTION: evergreen bush to 2.5 m high, with long, spreading branches and fine, brown bark. Leaves dull green above, paler and pubescent below; flowers (a) few, white and pinkish; fruit (b) acid-green, becoming dark red, edible.

RELATIONSHIPS: varying widely toward R. menziesii of the northern California coast and perhaps SCR (taxonomy unclear; Timbrook, pers. comm. 1981). Many closely-related and similar species on the mainland. Readily distinguished from R. malvaceum, a nonendemic of SRO, SCR, ANA.

REFERENCES: Munz (1974:788), Munz and Keck (1959:753), Smith (1976:158).

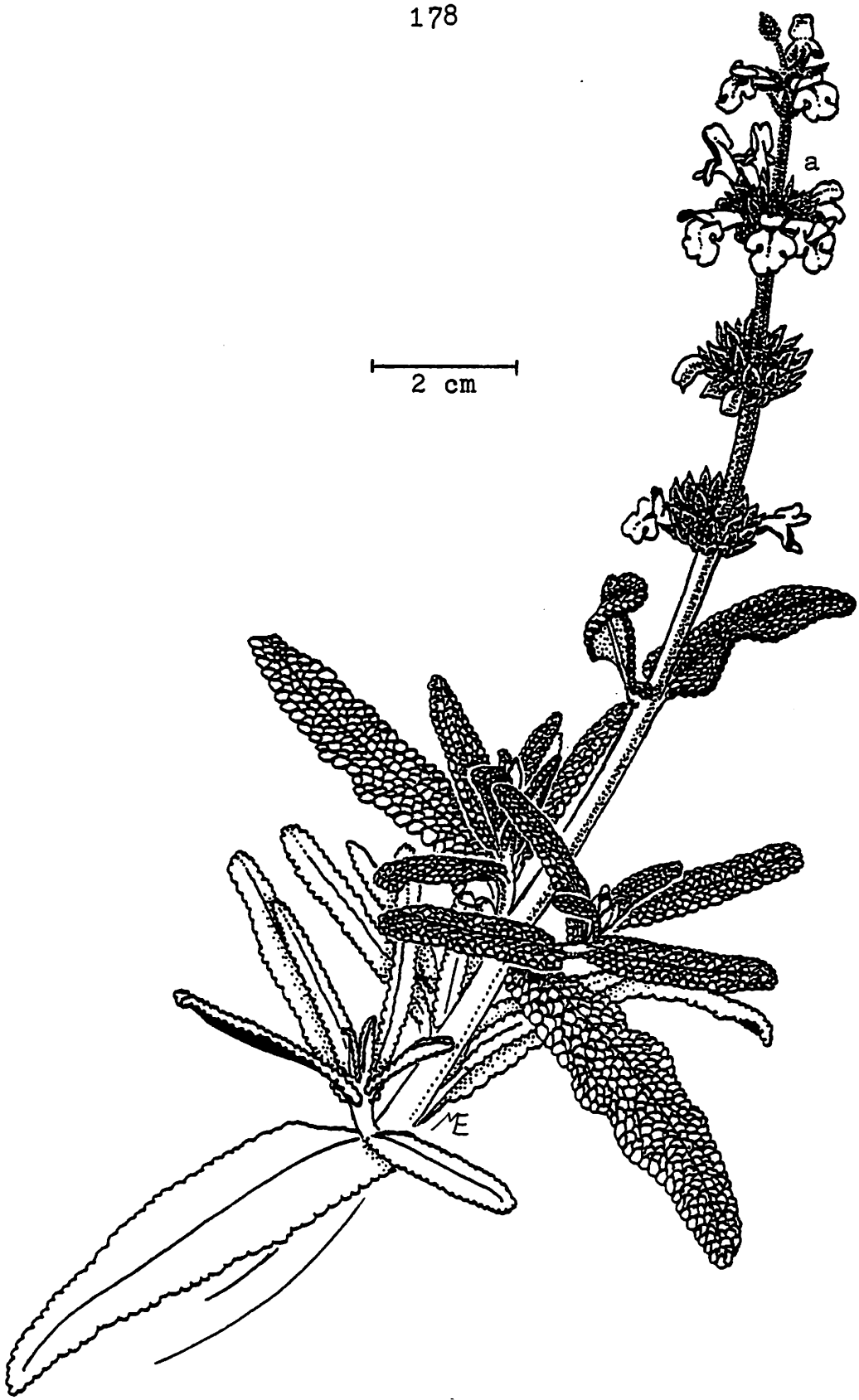

a
2 cm
ME

Figure 57. ISLAND BLACK SAGE

Salvia brandegei Munz [S. mellifera Greene var. revoluta Munz] Lamiaceae

DISTRIBUTION: SRO; mainland near Santo Tomas, Baja California, Mexico.

ECOLOGY: common in coastal sage scrub near streams; perhaps in chaparral and pine forests as well. Other species produce allelotoxins which prevent the growth of other plants nearly, as this form probably does. Blooms in spring and early summer.

DESCRIPTION: small bush to 2 m high, forming loosely-branched clumps. Leaves dark green, extremely wrinkled, with inrolled edges, downy-white below. Flowers lavender, in distinct heads (a).

RELATIONSHIPS: similar to S. mellifera of the mainland, SCR, ANA. The status of this species with regard to the hybridization complexes between S. mellifera and other species on the mainland (V. Grant 1971) might make an interesting study. Very different from chia (S. columbariae), which is native to SRO, SCR, some of the islands to the south, and the mainland.

REFERENCES Abrams (1951:641), Munz (1974:536), Munz and Keck (1959:705), Smith (1976:246).


a
b
2 cm

Figure 58. ISLAND ROCK CRESS

Sibara [*Arabis*] *filifolia* (Greene) Greene

Brassicaceae

DISTRIBUTION: (SCR, SCA)?

ECOLOGY: last collected on SCR in the early 1930's; possibly extinct. Apparently occurred on shady, north-facing slopes among chaparral, perhaps also in coastal bluff scrub and coastal sage scrub. Bloomed in spring.

DESCRIPTION: annual herb 2-3 dm high, glaucous, with ephemeral basal leaves; flowers (a) pink to purplish; fruit (b) slender, flattened.

RELATIONSHIPS: similar to two species of the Death Valley area and *S. pectinata* of CED and the adjacent mainland (Junak, pers. comm. 1982).

REFERENCES: Abrams (1944:304, Fig. 2097), Munz (1974:300), Munz and Keck (1959:266), Smith (1976:149).

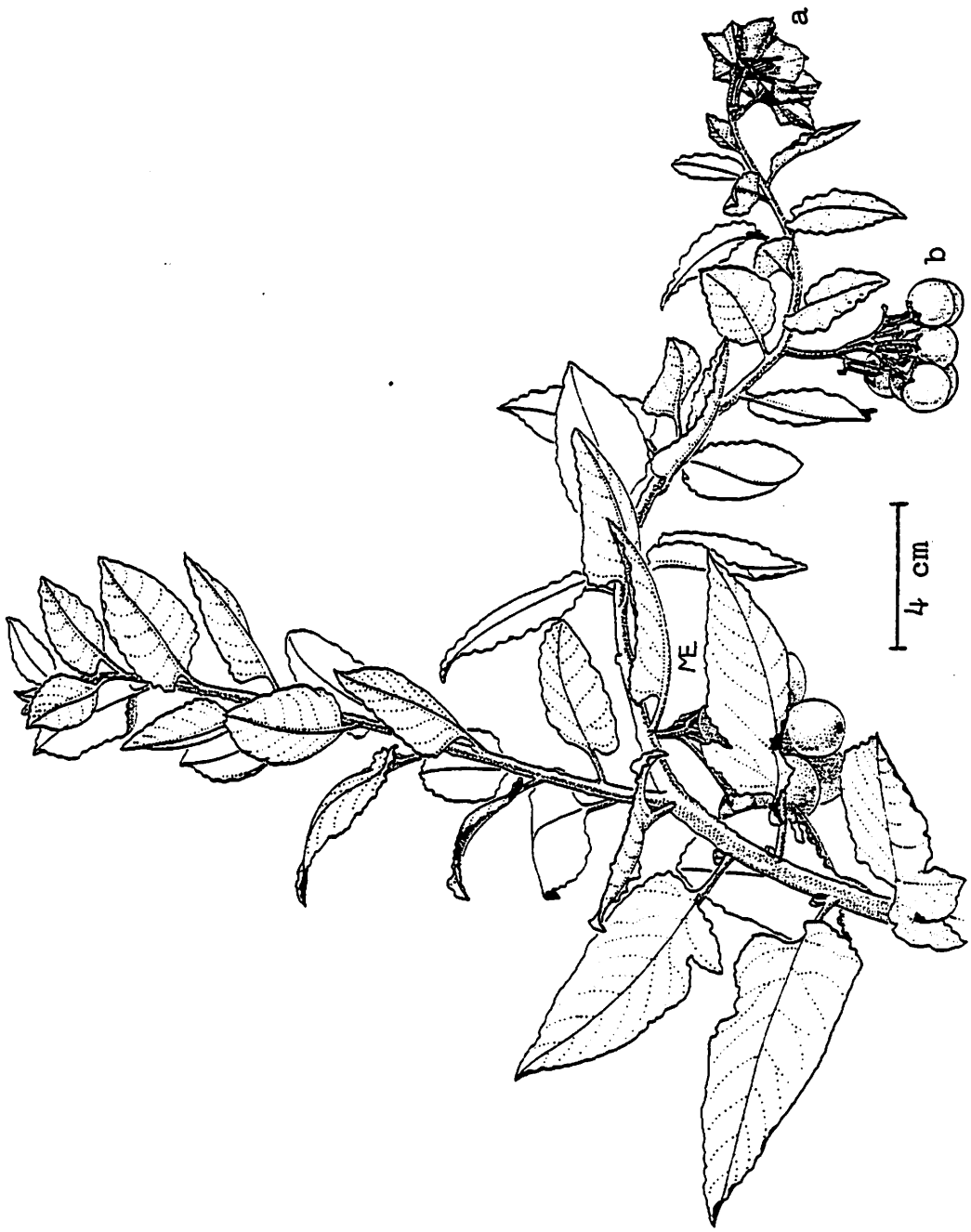

a
b
4 cm
ME

Figure 59. NIGHTSHADE

Solanum wallacei (A. Gray) Parish ssp. clockeyi (Munz) Thorne Solanaceae

DISTRIBUTION: SRO, SCR.

ECOLOGY: occasional in chaparral, coastal oak woodland, and other plant communities; often near streams. Blooms in late spring through summer; fruits in summer and early fall.

DESCRIPTION: small (evergreen?) bush 1-2 m high with a woody base. Leaves and stems dark green with a dust-like coating of tawny, glandular hairs; flowers (a) shaped like a five-pointed saucer, purple with two dark green spots circled with white at the base of each petal; yellow anthers; berries acid-green, becoming yellow and dropping when mature, probably poisonous.

RELATIONSHIPS: SRO specimens resemble S. xanti of the mainland, SRO, and SCR, with which they are apparently introgressed. The latter species approaches this form in San Luis Obispo County (Hoover 1970:254). Hybridization is common in the S. umbelliferum complex on the mainland. Other subspecies are endemic to SCA and GUA, where they are more distinctive. A few other (dissimilar and nonendemic) species occur on the islands.

REFERENCES: Abrams (1951:680), Munz (1974: 839), Munz and Keck (1959:598), Thorne (1967), Smith (1976:251).

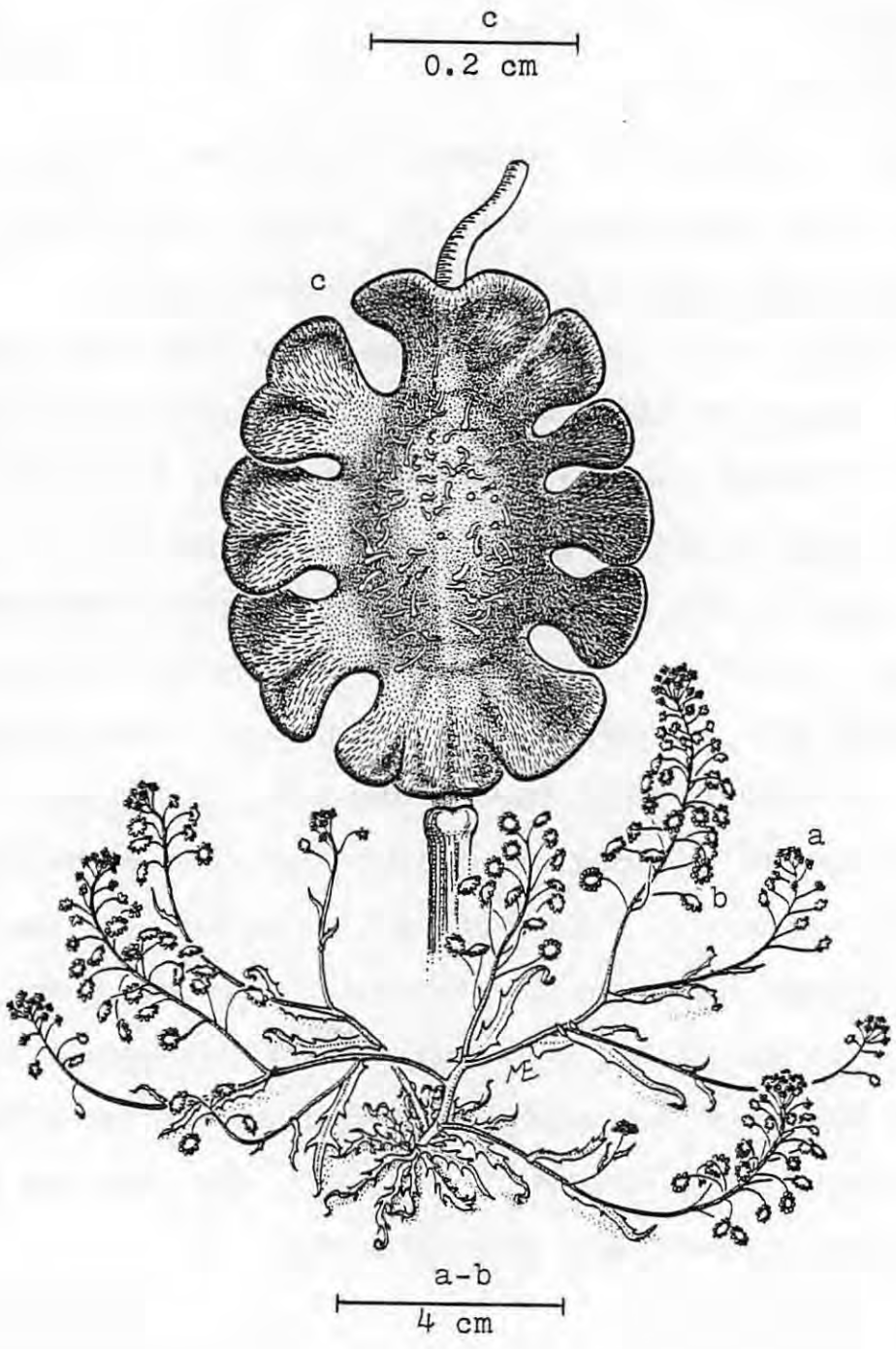

c
0.2 cm
c
a
b
ME
a-b
4 cm

Figure 60. LACE-POD

Thysanocarpus laciniatus Nutt. var. conchuliferus (Greene) Jeps.

Brassicaceae

DISTRIBUTION: SCR.

ECOLOGY: extremely rare due to reduction by grazing. Formerly occurred in grasslands, now restricted to a few rocky (mostly north-facing) slopes less accessible to sheep. Blooms from winter to early summer.

DESCRIPTION: an inconspicuous annual which is quite beautiful on close inspection. Stems and leaves glaucous, acid-green, becoming purplish-tan; flowers (a) tiny, lavender, becoming deeper purple with age; fruit (b,c) with folded, lobed wings (c, concave view), pale acid-green with purple hairs on wings.

RELATIONSHIPS: forming intergrading complexes with other varieties which occur on SRO and SCR, including the near-endemic or endemic T. l. ramosus (Greene) Munz and two nonendemic varieties. T. curvipes is also on SCR; and CED has an endemic species with purple flowers and pods (T. palmeri), as well as T. laciniatus and T. erectus. The species also occurs in some form on SCA and SCL. The diversity of forms suggests the initial stages of adaptive radiation, though the complex has not been closely studied.

REFERENCES: Abrams (1944:299, Fig. 2091), Munz (1974:307), Munz and Keck (1959:255), Smith (1976:152).

INVERTEBRATES

Since the taxonomy of the island invertebrates is still unknown for the most part, it is clear that there are numerous endemics which have not yet been described. The problem is compounded by the lack of information concerning the mainland representatives of most groups. Several new species of marine invertebrates of various phylla are being described from the waters surrounding the islands (Wicksten, pers. comm. 1979). Of the endemic crustaceans listed by Neushul et al. (1967), only one, Heptacarpus brachydactylus*, is still considered a strict endemic (Wicksten, pers. comm. 1979). Some of the other species listed may be considered near-endemics which are found on the rocky substrata which are more prevalent around the islands (Wicksten 1980). The status of a number of marine taxa originally described from the islands remains uncertain (Hewatt 1946).

Among the terrestrial invertebrates, two new species of scale insects, Phenacoccus sp. and Pseudococcus sp. (Homoptera: Pseudococcidae), are being described from Santa Cruz Island by Douglass Miller. A new subspecies of cicada, Okanagona* vanduzeii ssp. (Homoptera: Cicadidae), is being described from Santa Rosa and Santa Cruz Islands by Raymond Gill. Two new subspecies of a katydid, Neduba morsei sspp. (Orthoptera: Tettigoniidae), are also being described from the Northern Channel Islands by Rentz and Weissman (in press). None of these

have been illustrated in this thesis. A new subspecies of wood nymph butterfly, Cercyonis sthenele*, which is being described by Charles Remington from Santa Cruz Island, has been illustrated. At least eight other described and undescribed lepidopterans (Acrocercops insulariella, Coleotechnites sp., Feralia meadowsi, Halisidota indistincta, Ochlodes sylvanoides ssp., Rhodophaea cruza, Trichotaphe sp., and Zosteropoda clementei) are probably endemic on Santa Cruz and other islands (Powell, pers. comm. 1981-82), but were brought to my attention too late to be treated in detail. Specimens of two crane flies endemic to Santa Cruz Island, Tipula [Lunatipula] hastingsae diperona and T. [Trichotipula] santaecruzae (Diptera: Tipulidae), were not available for illustration. Also not included are various proposed endemics which are of questionable validity, including the Santa Cruz Island specimens of Sara orange-tip butterfly, which were previously described as Anthocaris sara gunderi (Lepidoptera: Pieridae; Langston 1981). Some of the earlier taxonomic workers on island insects described many of endemic species and subspecies which have since been synonomyzed with mainland taxa. T.D.A. Cockerell and D.W. Pierce were especially prolific splitters who were also overly enthusiastic in proclaiming the evolutionary significance of their findings.

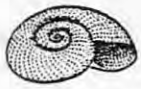
The compilation of information on terrestrial arthropods in this thesis is almost entirely the result of discussions with Scott E. Miller at the Santa Barbara Museum of Natural History,

who has generously shared his extensive knowledge of the island invertebrates. The majority of information presented here has been gleaned by him from a diversity of technical journals, though some of the distribution data taken from catalogued collections has not been published to date. The reader is strongly encouraged to consult the extensive bibliography by Miller and Menke (1981) for complete references concerning all of the terrestrial arthropods of the California Islands. Those publications dealing with invertebrates not covered in this bibliography are cited in the catalogue of endemics.

The important collections of terrestrial arthropods from the Northern Channel Islands are housed at the Santa Barbara Museum of Natural History, the Los Angeles County Museum, the University of California at Berkeley, and the Peabody Museum at Yale University.

a

b



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d

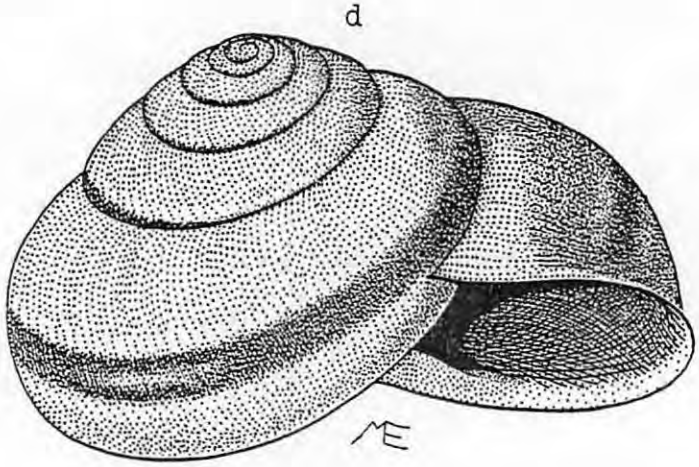


Figure 61. LAND SNAILS

Mollusca: Gastropoda: Pulmonata: Stylommatophora

All species in leaf litter and under surface objects; dormant in dry weather (Hochberg 1979).

(a) Vertigo californica longa Pilsbry; Pupillidae

SMI, SCR, ANA, SBA, SNI, SCL. Brownish. Locally abundant on south-facing slopes among coastal sage scrub, chaparral, oaks. Herbivorous. Variable: V. c. catalinaria (Strerki) on SBA, SCA, GUA. Pilsbry (1948:999, Figs. 533, 535-536).

(b) Pristiloma shepardae (Hemphill); Zonitide

SCR, West ANA, (SCA)? Transparent. Predatory as in Haplotrema*. Locally common among chaparral and island woodland. Pilsbry (1946:409, Fig. 220).

(c) Haplotrema duranti (Newcomb); Haplotrematidae

SCR, SBA, SNI. Brownish to pale gray. Feeds on Vertigo*, etc. Rare, but widespread in coastal oak woodlands on SCR; other habitats elsewhere. Pilsbry (1946:204-205, Fig. 97).

(d) Helminthoglypta ayresiana (Newcomb); Helminthoglyptidae

SMI, SRO, SCR, ANA. Brownish with darker stripe. Common West ANA, SMI; among coastal bluff and sage scrub, chaparral, and oaks. Herbivorous. Proposed subspecies uncertain: H. a. ayresiana (opposite) SMI, SRO?; H. a. sanctaecrucis Pilbry SCR, ANA; H. a. lesteri Cockerell SMI (subfossil); variability linked to climatic fluctuations? Johnson (1971), Pilsbry (1939:125-128, Figs. 63-64), Remington (1971).

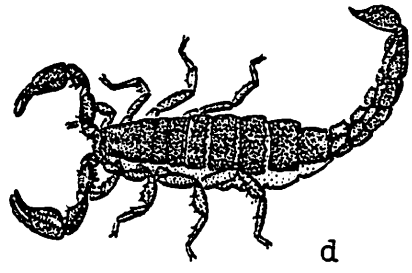
a

0.1 cm

ME

c

b



d

b-e

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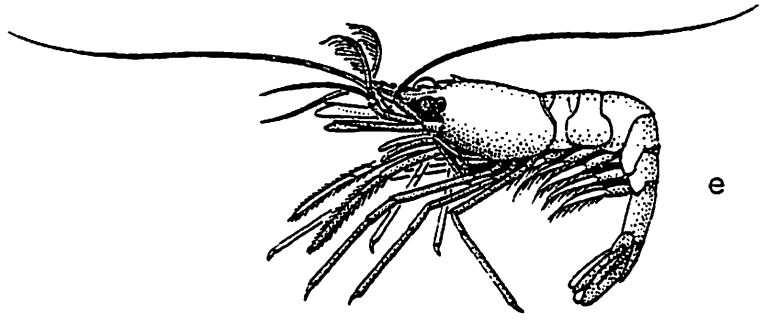


e

Fig. 62. MISCELLANEOUS ARTHROPODS (Arthropoda)

(a) Millipede (Diplopoda: Polyxenida: Polyxenidae)

Polyxenus anacapensis Pierce

West and Middle ANA. Probably rare; colonies under eucalyptus bark and on Astragalus miguelensis* pods. Yellowish to dark brown with dark bands on head and on sides; bristles silvery-white; legs tinged with reddish-brown. Probably invalid species.

(b) Tick (Arachnida: Acarina: Ixodidae)

Ixodes peromysci Augustson

ANA, SBA, SCL. Ectoparasite on rodents (especially Peromyscus*; Rattus) and lizards (Gerrhonotus). Gray with brown legs and markings above. Ventral view (opposite).

(c) Spider (Arachnida: Araneae: Zodariidae)

Lutica maculata Marx

SMI, SRO. Locally abundant in dunes; burrowing. Predatory on other arthropods. Olive-green above with brown markings.

(d) Scorpion (Arachnida: Scorpionida: Vejovidae)

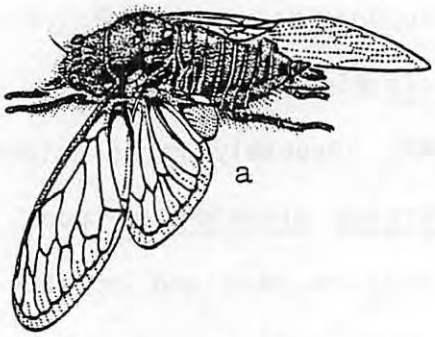
Vejovis minimus thompsoni Gertch and Soleglad

SRO, SCR, ANA. Uncommon under surface objects. Predatory; stings. Light brown.

(e) Shrimp (Crustacae: Decapoda: Hippolytidae)

Heptacarpus [Spironocaris] brachydacylus L.B. Holthuis

SRO, SCR, SCA. Four specimens from south sides of the islands (70-400 fathoms); probably among rocks. Coloration unknown. Schmitt (1921:72), Wicksten (pers. comm. 1979).



a

b

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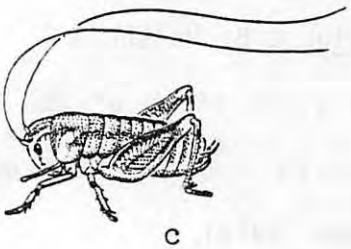
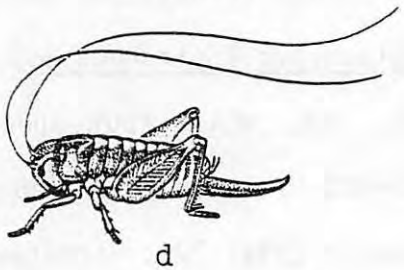
ME

a,c-d

2 cm



c



d

Figure 63. MISCELLANEOUS INSECTS (Arthropoda: Insecta)

(a) Cicada (Homoptera: Cicadidae)

Okanagona hirsuta Davis

SRO, SCR, ANA. Locally common and noisy in scrub. Sucks plant fluids. Dark brown with orange spots. Other species also occur on the islands, including an undescribed subspecies of O. vanduzeei on SRO, SCR.

(b) Leafhopper (Homoptera: Cicadellidae)

Tiaja insula Sawbridge

SMI, SCR, SBA. Farily common (?) but inconspicuous feeder on Sueda californica in coastal sage scrub. Speckled brownish. No other congeners on islands; females resemble T. californica.

(c,d) Silk-spinning sand crickets (Orthoptera: Stenopelmatidae) 5 species in genus, most insular. Resemble camel crickets.

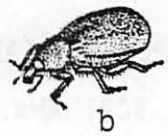
(c) Cnemotettix caudulus Rentz and Weissman

SMI, SRO, SCR. Locally common in dunes; rare on SCR and in chaparral (SRO). Female (opposite) with greatly reduced ovipositor probably adapted to fossilized dunes. Predominately gray; immatures pale.

(d) C. spinulus Rentz and Weissman

SRO, SCR, ANA, SNI. Locally common in coastal sage scrub (East ANA); rare in chaparral and eucalyptus (SCR), stable dune grassland (SNI). Female (opposite) with long ovipositor. Dark gray-brown stripes. SNI population apparently a distinct subspecies. Preyed upon by a wasp (Palmodes insularis*).

a



b

c

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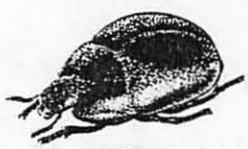
a-b,d-f

2 cm



d

e

ME

f

Fig. 64. BEETLES (Arthropoda: Insecta: Coleoptera)

(a,b) Weevils (Curculionidae)

(a) Sitona cockerelli Blaisdell

SMI. Not collected recently; very few specimens known. Light gray with faint brownish spots and streaks.

(b) Trigonoscuta miguelensis Pierce

SMI; many (questionable) species and subspecies described from the Channel Islands. Fairly common, burrowing in sand dunes. Silvery-gray.

(c) Ladybird beetle (Coccinellidae)

Scymnus [Pullus] falli Gordon

SRO, SCR. Probably carnivorus. Black and burnt orange.

(c,d,e) Darkling ground beetles (Tenebrionidae). All tenebrionids are probably herbivorous; many are flightless.

(c) Eustattus vanduzeei Blaisdell

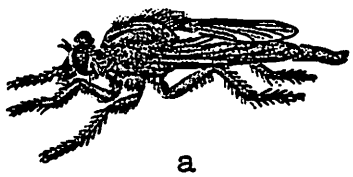
Prince Island (and SMI?), SRO. Dunes. black.

(d) Coniontis lata LeConte

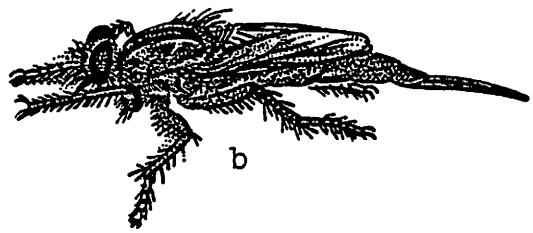
SMI, SRO?, SCR, Middle and East ANA, SBA, SNI, SCL. Common under rocks. Reddish black.

(e) Coelus pacificus Fall

SMI, SRO, SCR, ANA, SNI, SCL, SCA. Abundant, burrows in sand dunes throughout the year. Specimens from SNI, SCL tend to be larger. Black. Eaten by island foxes, which apparently avoid a nonendemic congener.



a



b

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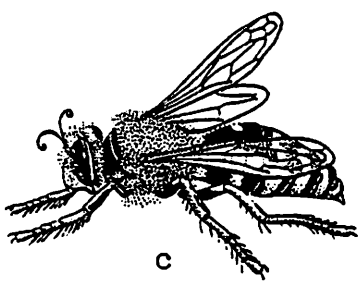
ME



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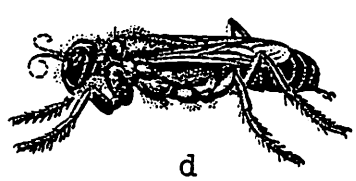


d

Fig. 65 ROBBER FLIES AND WASPS

(a,b) Robber flies (Arthropoda: Insecta: Diptera: Asilidae) Feed mainly on insects caught in flight.

(a) Stenopogon neojubatus Wilcox and Martin

SMI, SRO, SCR, SBA. Fairly common. Body olive-brown; legs dull reddish-brown; males slightly smaller. Closely related to several species, such as S. jubatus of the mainland.

(b) Efferia anacapai Wilcox and Martin

SRO, ANA, SBA. Rare. Body dark gray-brown to beige on thorax; legs dull reddish-brown, female (opposite) with long ovipositor. Resembles E. anomalus of the mainland; E. clementei of SCL not especially similar.

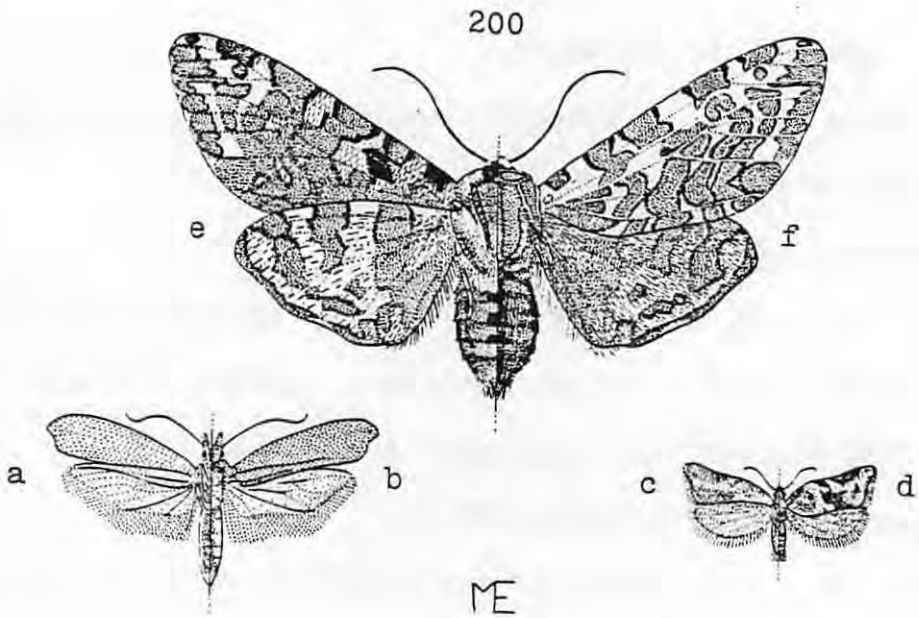
(c,d) Digger wasps (Arthropoda: Insecta: Hymenoptera: Sphecidae). Stock nests dug in sand with insects. Sting.

(c) Bembix americana hamata C. Fox

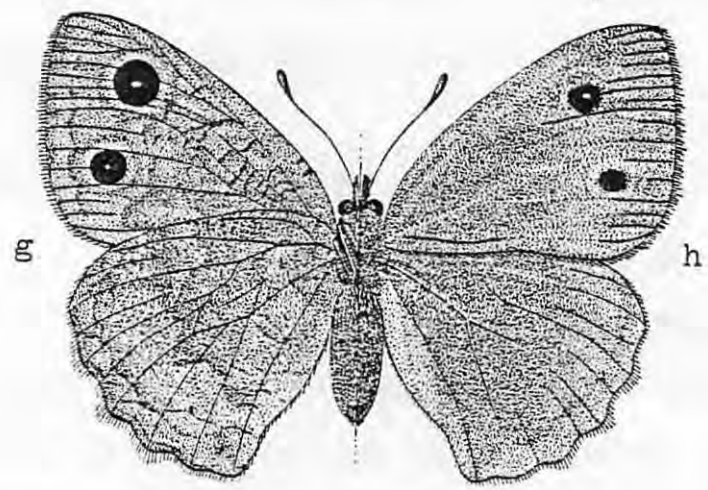
SMI, SRO, SCR. Uncommon but conspicuous in sand dunes. Catches flies? Head and abdomen dull greenish-yellow and black; thorax mostly olive-drab; legs deep yellow and black. Intermediate in size and color between B. a. comata of the adjacent mainland and B. a. nicolai of SNI.

(d) Palmodes insularis Bohart and Menke

SMI, SRO, ANA, SCL. Fairly common in sand dunes. Eats Orthoptera. Shiny black. Similar to P. pacificus of coastal California.



ME



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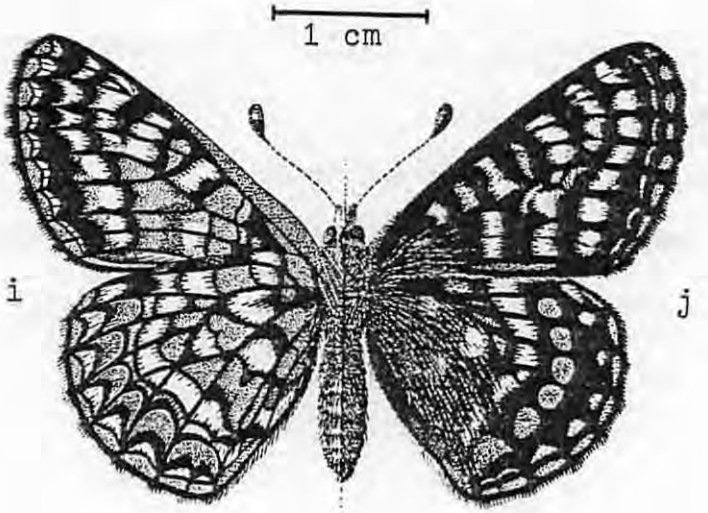


Figure 66. MOTHS AND BUTTERFLIES (Arthropoda: Insecta: Lepidoptera). Left side ventral, right side dorsal.

(a,b) Cerostoma lyonothamnae Powell; Plutellidae

SCR, SCL (Powell, pers. comm. 1981). Inconspicuous, probably rare. Larvae mine leaves of Lyonothamnus floribundus asplenifolius*. Brownish-gray with whitish markings above (b); abdomen and underside of wings (a) shiny, pale gray.

(c,d) Argyrotaenia franciscana insulana Powell; Tortricidae

SMI, SRO, SCR, ANA, SNI. Common in coastal sage scrub, etc.; throughout the year? Forewing brownish-gray with brown markings dorsally (d), hindwings silvery beige. Highly variable, most typical on ANA (Powell, pers. comm. 1981).

(e,f) Painted tiger moth

Arachnis picta insularis Clarke; Arctiidae

SRO, SCR?, ANA. Not common; in scrub vegetation? Above (f) white with tan spots outlined in black, hindwing pink; forewing tinged with yellow beneath (e).

(g,h) Brown wood nymph

Cercyonis sthenele (sylvestris) ssp. nov. Remington; Satyridae

SCR. Locally common in several canyons. Dull brown with dark brown spots, some silver underneath hindwing (g).

(i,j) Checkerspot

Euphydryas editha insularis Emmel and Emmel; Nymphalidae

SRO. Locally common in early spring in grasslands. Dark brown, orange, and pale yellow.

VERTEBRATES

(Chordata: Vertebrata)

The vertebrates, especially birds, of the Northern Channel Islands are the most thoroughly studied element of the biota in many respects. A wealth of data concerning the distribution, taxonomy, morphology, ecology, and behavior of the endemic vertebrates makes them an especially valuable scientific resource.

NEAR-ENDEMICS

Two species of marine fish (Alloclinus holderi and Ulvicola sanctae-rosae) may be more abundant and widespread on the islands, but they are also found along the mainland, and are not included here. A rare, deepwater angler fish from near Santa Cruz Island, Monocertias acanthias, is so poorly known that it can not be said to be an endemic with any certainty. A nearshore, endemic topsmelt (Atherinops affinis insularum) is probably found around the Northern Channel Islands (Barnhart 1936:35, Gilbert 1892, Hewatt 1946, Roedel 1953:77), but specimens for illustration were unavailable. Two birds Selasphorus sasin sedentarius* and Vermivora celata sordida*, appear to have recolonized small parts of coastal, mainland southern California from the adjacent islands. Specimens resembling two other endemic subspecies of birds, Eremophila alpestris insularis* and Lanius

ludovicianus anthonyi*, are occasionally found among mainland populations of the coastal region. The former may represent gene flow from the islands, and the latter may be due to convergent evolution in the coastal habitat (Johnson 1972).

Haldorson (1980) has reported minor genetic and phenotypic differences between populations of surfperches (Embiotocidae*) around Santa Cruz Island and along the mainland. The House Finches of the Northern Channel Islands are included in the mainland race (Carpodacus mexicanus frontalis*) but the San Miguel and Santa Rosa Island specimens resemble the endemic C. m. clementae of the islands to the south. Because this species has been studied extensively on the northern islands (Power 1980c), and because it provides an interesting example of a species which has differentiated more extensively on the southern islands, it has been included in this thesis. There is considerable disagreement among ornithologists concerning the status of Western Flycatchers (Empidonax difficilis insulicola) on the Channel Islands (Johnson 1972). I have followed the example of the American Ornithological Union checklist (1957 and supplements) and do not treat this subspecies in detail. Some of the other endemic races of birds (e.g., Thryomanes bewickii nesophilus*) are only weakly differentiated at best. Finally, the individual island races of some vertebrate species (Melospiza melodia*, Peromyscus maniculatus* and Urocyon littoralis*) are lumped into one discussion.

Although many of the sea birds (Hunt et al. 1980) and pinnipeds (Le Boeuf and Bonnell 1980) which breed in abundance on the Northern Channel Islands do not breed on the mainland, these creatures are not usually considered insular endemics. Endemic subspecies of sea birds have been described for Guadalupe Island (A.O.U. 1957). Deriving most or all of their nutrition from a wide expanse of ocean, including the mainland coast, the sea birds and mammals are not limited by the island environment, except for the availability of suitable breeding space. It seems apparent, however, that many of the characteristics of these vertebrates, parallel similar adaptations in the strictly terrestrial endemics.

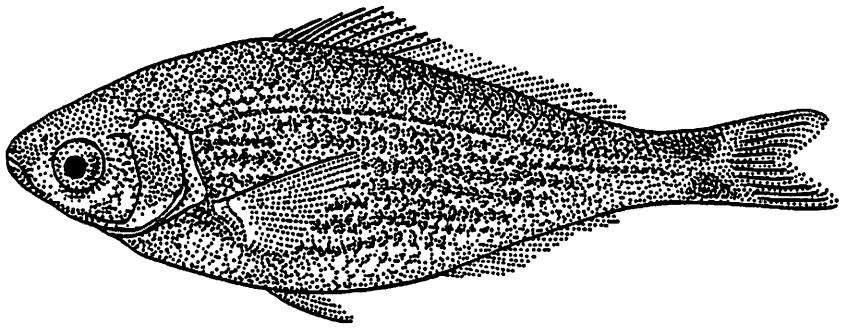
EXTINCT ENDEMICS

Of the extinct vertebrates known from fossil deposits on the Northern Channel Islands, three are believed to be true endemics. Two others, Chendytes milleri and C. lawii, were apparently flightless, diving geese falling into the category of sea birds which ranged widely but probably bred only on the islands. The genus Chendytes is presently being revised by S. Warter at California State University, Long Beach. The mouse, Peromyscus* anyapahensis is known only from the late Pleistocene of West Anacapa, and the large P. nesodytes is known from deposits on San Miguel and Santa Rosa Islands (Wilson 1936, White 1966, Walker

1980). Both of these species belong to the same subgenus as P. eremicus, which has an endemic race on Cedros Island. The endemic races of P. maniculatus* belong to another subgenus, and could not have been derived from the extinct species. The most famous of the extinct, endemic vertebrates of the islands is the dwarf mammoth (Mammuthus exilis) which is found in extensive deposits on San Miguel and Santa Rosa islands. Elephant remains have also been found on Santa Cruz Island, but these are too few and fragmentary to exclude the possibility that they were left there by early man. The taxonomy of the dwarf mammoth is uncertain due to the mixture of dwarfed and normal specimens in the same place (Wenner and Johnson 1980). There is a strong possibility that more than one eposide of colonization by mammoths occurred on the Northern Channel Islands (Madden 1981). M. exilis stood about four to six feet at the shoulder, compared to eleven feet for M. columbi of the mainland. Even more extreme cases of dwarfing occurred among the Pleistocene elephants of the Mediterranean islands, Japan, and the East Indies. The mammoth is believed to have had a severe environmental impact in its home range (Johnson 1980), just as modern elephants do in Africa game reserves. It probably was eaten by the earliest humans to inhabit the islands, which may have hastened its extinction. The extinct endemics are not illustrated in this thesis.

INTRODUCED SPECIES

The establishment of vertebrate pests and domesticates by man has not been as disruptive to the ecology of the Northern Channel Islands as it has been on many other islands. Black rats are presently established on Anacapa and San Miguel islands (Collins 1979b), where they may threaten endemic snails (Hochberg 1979), birds, and mice (Collins et al. 1979). European rabbits on East Anacapa Island and burros on San Miguel Island caused damage to native vegetation until they were eradicated in past decades (Collins, pers. comm. 1980). The most destructive herbivore, sheep, has been eliminated from all of the islands except Santa Cruz, where it has almost denuded parts of the island. Cattle graze and trample the vegetation of Santa Rosa and Santa Cruz islands, where feral pigs disturb extensive plots of ground by rooting (which favors the establishment of weeds at the expense of native vegetation). Horses do not seem to present any problems where they are herded on the two largest islands, but deer and elk have an undetermined impact on Santa Rosa Island. The European Starling is the only bird pest which has become established on the islands, though it does not yet appear to be a problem; House Sparrows formerly bred on Santa Rosa Island. A few game birds, such as quail have been introduced to Santa Rosa and Santa Cruz islands, and turkeys and peafowl occur in small numbers on Santa Cruz Island.



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ME

Figure 67. ISLAND PERCH

Cymatogaster gracilis Tarp

Pisces: Teleostomi: Perciformes: Embiotocidae

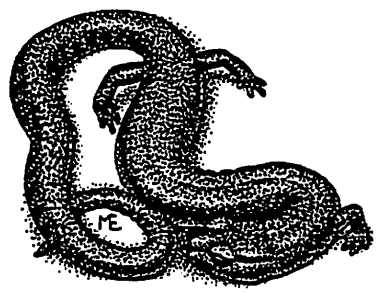
DISTRIBUTION: SRO, SCR, SCA.

ECOLOGY: dense schools roam the canopy of kelp forests. This species is apparently a specialized planktivore. Reproduction in surfperches is very unusual in fish, exhibiting internal fertilization and viviparity; males small, precocious breeders (thoughout the year?).

DESCRIPTION: small, slender; silvery coloration (lacking the yellow '7-11' marking of C. aggregata?); males (opposite) with an external copulatory organ (lacking horizontal black stripes on the side in the breeding season?).

RELATIONSHIPS: specialized derivative of the widespread, coastal generalist C. aggregata; the endemic differs in its smaller size and more slender form. Other members of this family show incipient divergence around Santa Cruz Island. Surfperches have radiated extensively along the California coast.

REFERENCES: Ebeling (pers. comm. 1980), Haldorson (1980), Hewatt (1946), Tarp (1952).



2 cm

Figure 68. PACIFIC SLENDER SALAMANDER

Batrachoceps pacificus (Cope) pacificus

Amphibia: Urodela: Plethodontidae

DISTRIBUTION: SMI, SRO, SCR, ANA.

ECOLOGY: occasional and solitary under logs and rocks in winter and spring, mainly near streams in woodlands, etc.; retreats underground during the dry season. Extremely sedentary, possibly territorial (competition for burrows on SCR should be studied). Eggs probably brooded terrestrially in winter. Preys mainly on small arthropods. Fairly tolerant of salt. Highly sensitive to habitat disturbance.

DESCRIPTION: comparatively large and robust, with large legs and readily discernable toes. Gray to coppery above, sides black, belly light gray with tiny black dots.

RELATIONSHIPS: most primitive subspecies, other races non-endemic(?) on SCA, LCO, TSA, and on mainland California, Baja California, and apparently southern Mexico. Resembles some other primitive species of this specialized genus. B. nigriventris, the only other salamander on the Northern Channel Islands, is found in the same habitats on SCR; similar but smaller, wormlike, and gregarious.

REFERENCES: Brame and Murray (1968), Stebbins (1954:65-67, 81; 1966:46-47, Pl. 7), Yanev (1980).

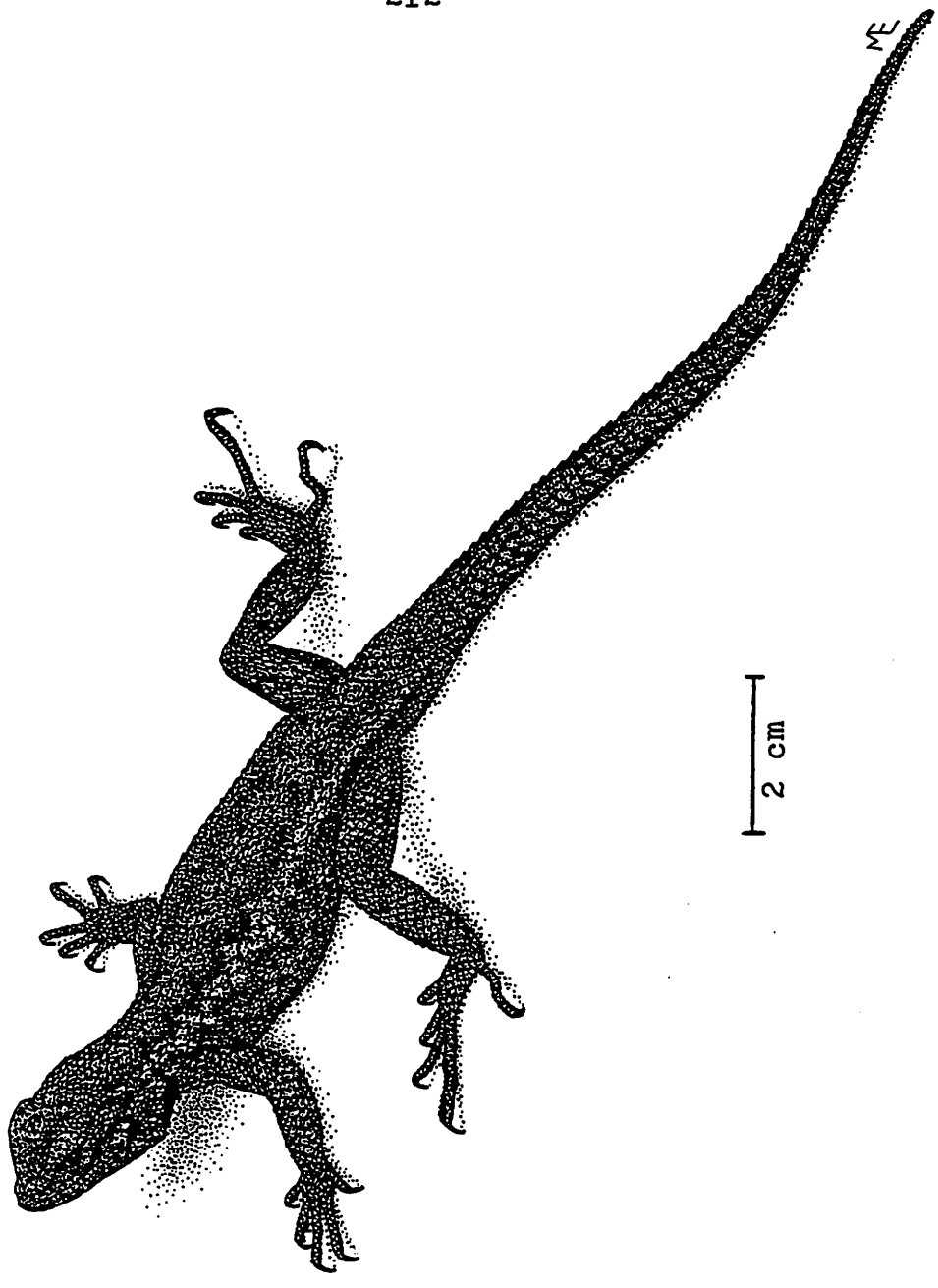

ME
2 cm

Figure 69. WESTERN FENCE LIZARD

Sceloporus occidentalis beckii Van Denburgh

Reptilia: Squamata: Lacertilia: Iguanidae

DISTRIBUTION: SMI, SRO, SCR.

ECOLOGY: locally common in rocky places among coastal sage scrub and chaparral, occasionally in grassland. Insectivorous; undoubtedly preyed upon by snakes, birds, skunks, and foxes. Territorial; oviparous; little studied.

DESCRIPTION: male (opposite) light brown above with darker markings and light blue spots; bright blue patches on belly and throat are displayed by doing pushups (often called "blue-belly). Females duller.

RELATIONSHIPS: similar to S. o. biseriatus of the adjacent mainland, but minor differences in scalation and throat pattern. Superficially resembles the nonendemic Uta stansburiana (SCR, ANA, etc.), which is smaller, paler, smoother, and more numerous.

REFERENCES: Stebbins (1954:240-243, 316; 1966:107), Van Denburgh (1922:318-321, Fig. 25).

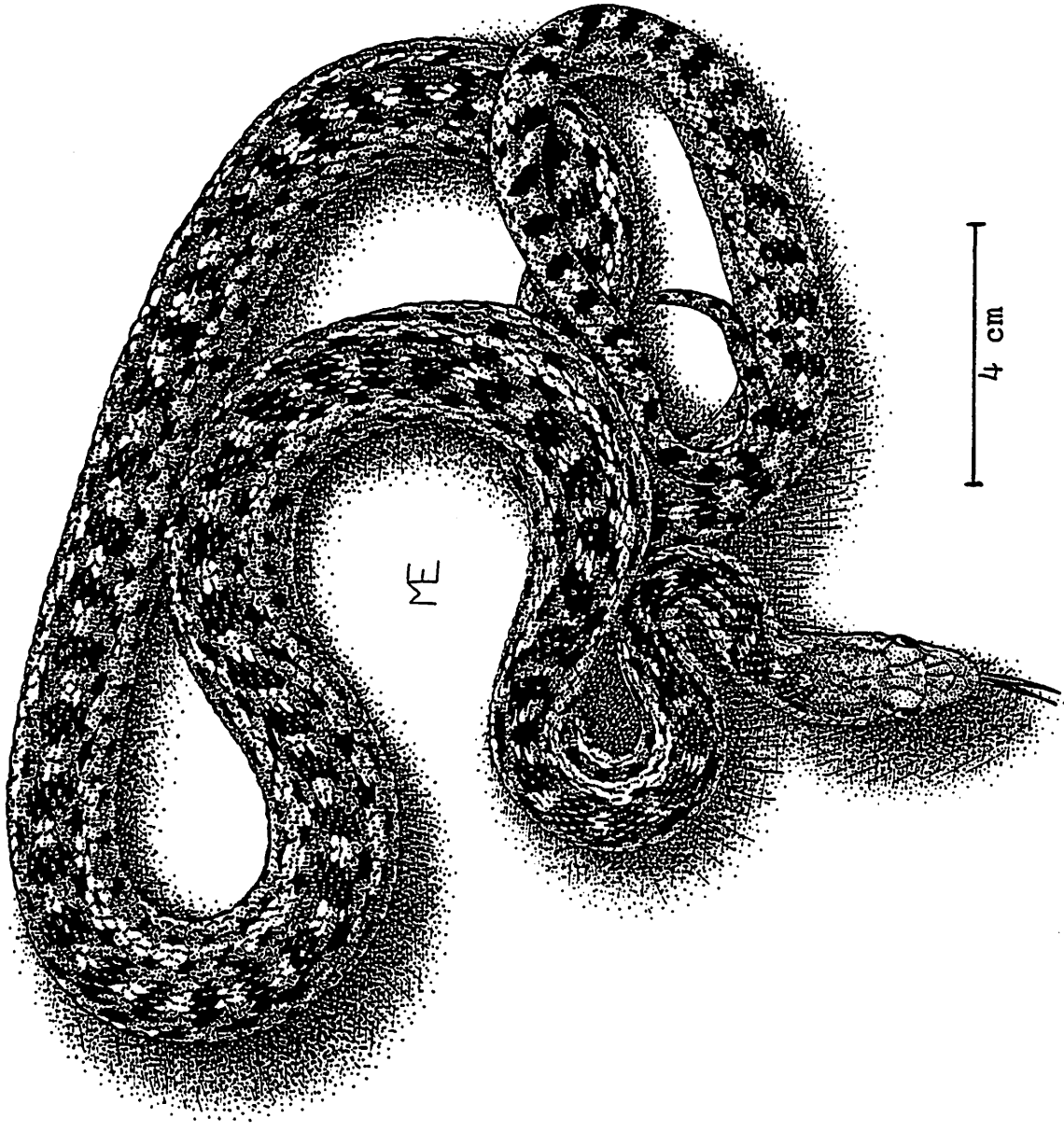

4 cm
ME

Figure 70. GOPHER SNAKE

Pituophis melanoleucus pumilis Klauber

Reptilia: Squamata: Serpentes: Colubridae

DISTRIBUTION: SRO, SCR.

ECOLOGY: occasional in chaparral and other plant communities (SCR), rare in grasslands (SRO). Sometimes gregarious; I found three males and one female entwined under a sheet of tin at Christi Ranch (SCR), June 13, 1979. Preys mainly on small mammals and birds; constricts. Commonly eaten by Red-tailed Hawks. Nonvenomous and inoffensive. Active during the night (hot weather) or day. Oviparous. Little studied.

DESCRIPTION: to about four feet long; tan with dark blotches and a pale lateral streak and belly. Scales on upper back weakly keeled.

RELATIONSHIPS: apparently the smallest subspecies. Similar to P. m. annectens of the adjacent mainland and SCA; apparently derived from P. m. catenifer of the mainland north of Point Conception. Other races endemic to LCO, SMA, CED. The species is widespread and variable in North America. Young individuals superficially resemble small specimens of the two other (non-endemic, nonvenomous) snakes found on SCR.

REFERENCES: Collins (pers. comm. 1980-81; m.s. in prep), Klauber (1946, 1947), Stebbins (1954:391-394, 497-500; 1966:157).

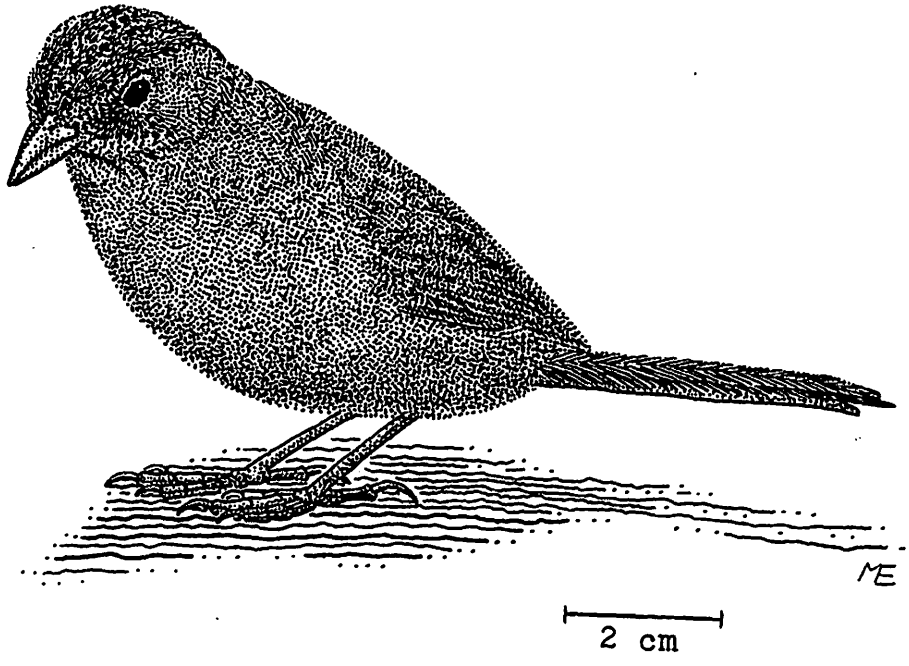

ME
2 cm

Figure 71. RUFOUS-CROWNED SPARROW

Aimophila ruficeps obscura Dickey and Van Rossem

Aves: Passeriformes: Fringillidae

DISTRIBUTION: SCR, ANA, (SCA?).

ECOLOGY: fairly common but inconspicuous resident of coastal sage scrub on SCR; may have recolonized ANA during this century, following recovery of brush from overgrazing. Ground-dwelling and secretive. Adults granivorous, young are fed insects. Apparently competes with Melospiza melodia clementae* on SCR, where it may prevent ecological expansion by the latter.

DESCRIPTION: sexes alike; slightly brownish gray, paler below, darker on wings and tail, some dull red-brown on crown and shoulders, facial streaks dark gray; legs yellow-brown; beak dark gray above, beige below.

RELATIONSHIPS: weakly differentiated from A. r. canescens of the adjacent mainland (including a slight difference in song?). A. r. sanctorum is endemic to TSA.

REFERENCES: Cogswell (1968), Diamond and Jones (1980), Johnson (1972), Miller (1951).

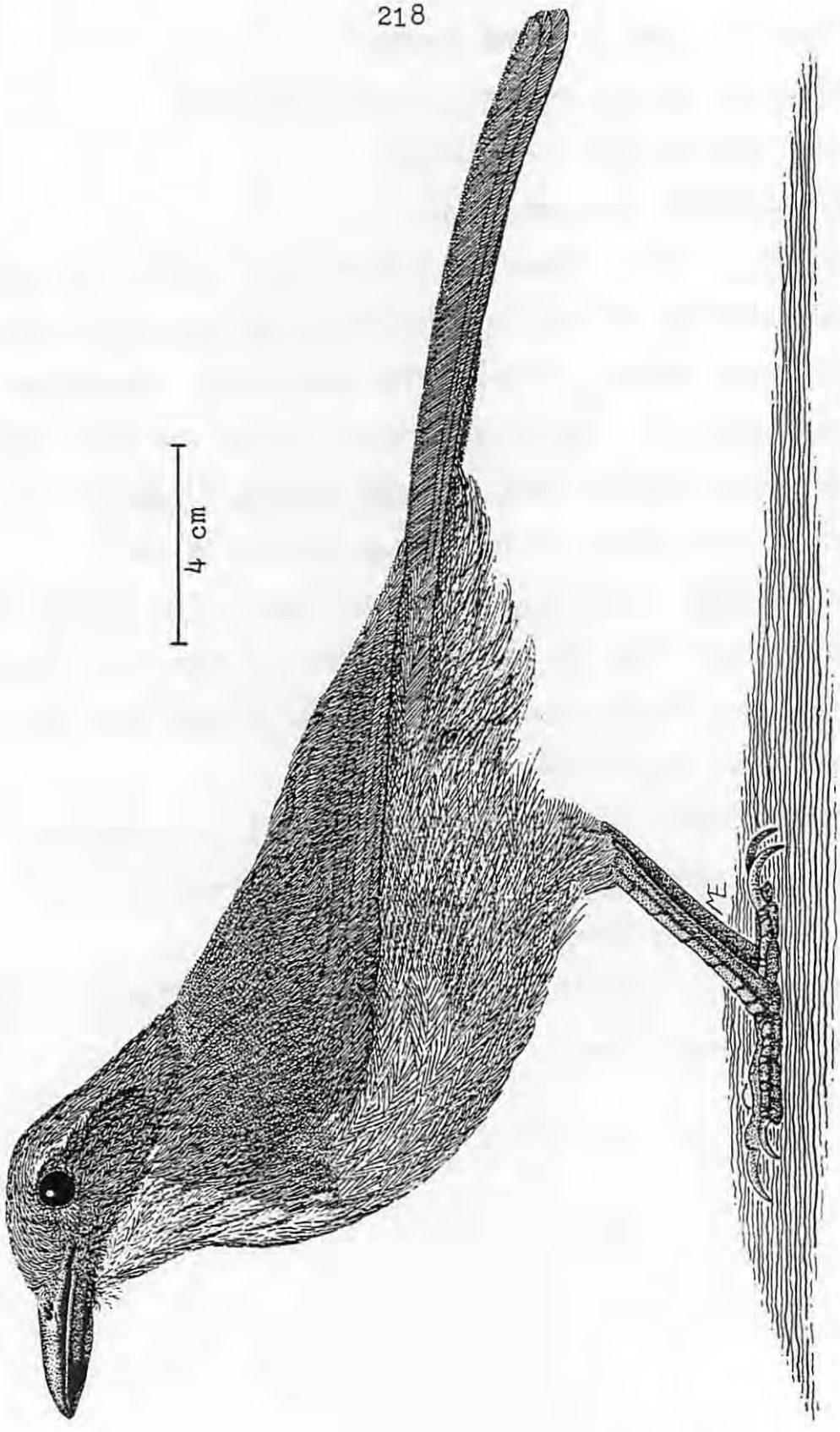

4 cm

Figure 72. SCRUB JAY

Aphelocoma coerulescens insularis Henshaw

Aves: Passeriformes: Corvidae

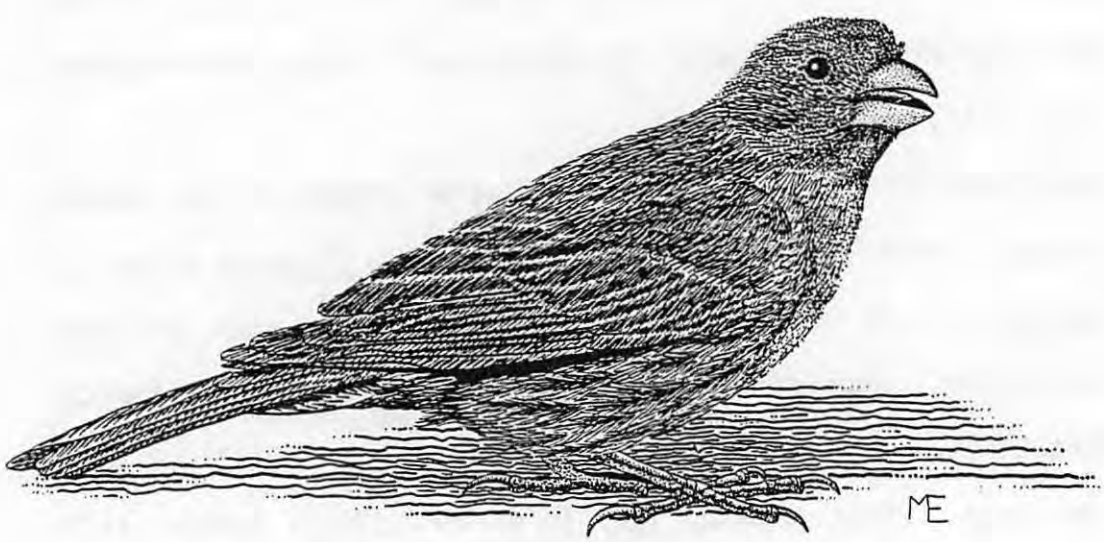
DISTRIBUTION: SCR.

ECOLOGY: common and conspicuous resident of chaparral, woodland, and pine forests; spilling over into grasslands, etc. (especially immatures). Omnivorous feeder on seeds, fruits, invertebrates, small vertebrates, and carrion. Apparently specialized for foraging in lower levels of habitat (a niche occupied on the mainland by the California Thrasher), but in a wider range of plant communities than mainland forms. Acorns are a major food item; may be instrumental as an 'up-hill planter' of oaks. Highly monogamous, territorial, and sedentary. Foxes prey heavily on eggs and young, Sharp-shinned Hawks eat adults.

DESCRIPTION: sexes similar, males slightly larger. Deep blue above, suffused with olive-brown on back and wing tips; whitish with gray streaks on throat and chest; belly light brownish-gray; legs, bill, and face black.

RELATIONSHIPS: the most distinctive avian endemic of the Channel Islands; readily distinguished from A. c. californica and A. c. obscura of the adjacent mainland by its large size and deep coloration. Superficially resembles A. ultramarina of Mexico.

REFERENCES: Atwood (1978, 1980), Bent (1964a:114-118), Diamond and Jones (1980), Johnson (1972), Miller (1951), Yeaton (1972, 1974).



2 cm

Figure 73. HOUSE FINCH, LINNET

Carpodacus mexicanus (Müller)

Aves: Passeriformes: Fringillidae

DISTRIBUTION: SMI, SRO, SCR, ANA, (SBA), SNI, SCL, SCA, LCO, TSA, SMA, CED, (SBE), GUA; widespread in western North America.

ECOLOGY: generally common around buildings and in rocky places among coastal sage scrub and other habitats. Granivorous; often feels on cactus and other fruit. Nests in cactus patches and other vegetation and on cliffs.

DESCRIPTION: males (opposite) dull brown (lighter at edges of feathers) becoming reddish on back and scarlet on head and breast (rarely replaced by yellow or orange); dirty white with darker streaks below; legs, beak brown. Female dull, slightly greenish, no red, more streaking.

RELATIONSHIPS: northern island populations included in C. m. frontalis of the adjacent mainland, but tending toward C. m. clementis Mearns of the Southern Channel Islands and LCO, especially on SMI, SRO. Clinal variation seems mainly correlated with isolation, the most extreme populations endemic to SCL, SBE, GUA. Archaeological evidence suggests that the species may have colonized SMI within the past 500 years (Guthrie 1980).

REFERENCES: Bent (1968:316-317), Diamond and Jones (1980), Grinnell and Miller (1944:453-454), Johnson (1972), Miller (1951), Power (1971, 1980c).

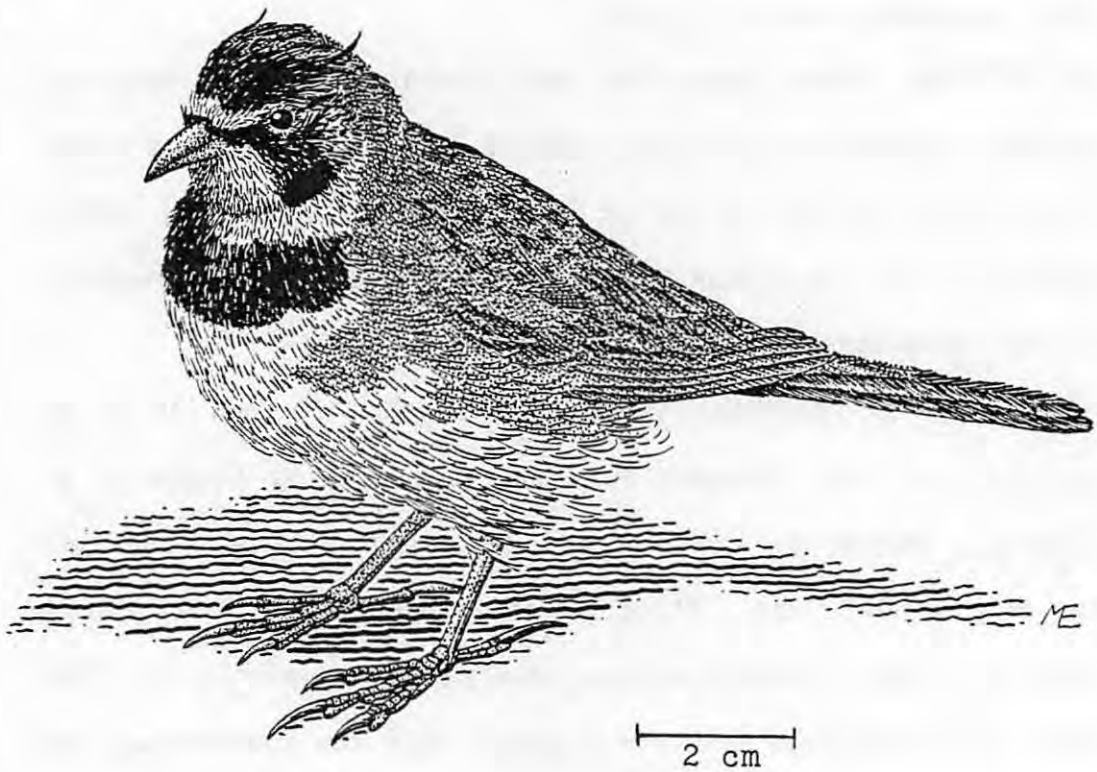

ME
2 cm

Figure 74. HORNED LARK

Eremophila [Otocoris] alpestris insularis Townsend

Aves: Passeriformes: Alaudidae

DISTRIBUTION: SMI, SRO, SCR, (ANA)?, SBA, SNI, SCL, SCA; occasionally wanders to the adjacent mainland.

ECOLOGY: abundant resident in exposed areas with low growth, especially grassy marine terraces; recent decline and possible extinction on ANA probably due to recovery of brush from overgrazing. Vaults readily into strong winds; wide distribution. Feeds mainly on seeds, some insects. Ground nesting.

DESCRIPTION: male (opposite) chestnut-brown above, duller on wings and back, darker on tail, white below, face and chest pale yellow and black. Female similar but duller and lacks 'horns.'

RELATIONSHIPS: well differentiated from E. a. actia of the adjacent mainland coast, but resembles E. a. strigata of the Pacific Northwest and E. a. sierra of the Sierra Nevada. Tends toward E. a. actia on the Southern Channel Islands (especially SCA) and ANA; populations on SMA, NAT, CED, SBE (Bostic 1975) nonendemic. (A.O.U. 1957).

REFERENCES: Behle (1942), Bent (1963a:361-364), Diamond and Jones (1980), Johnson (1972).

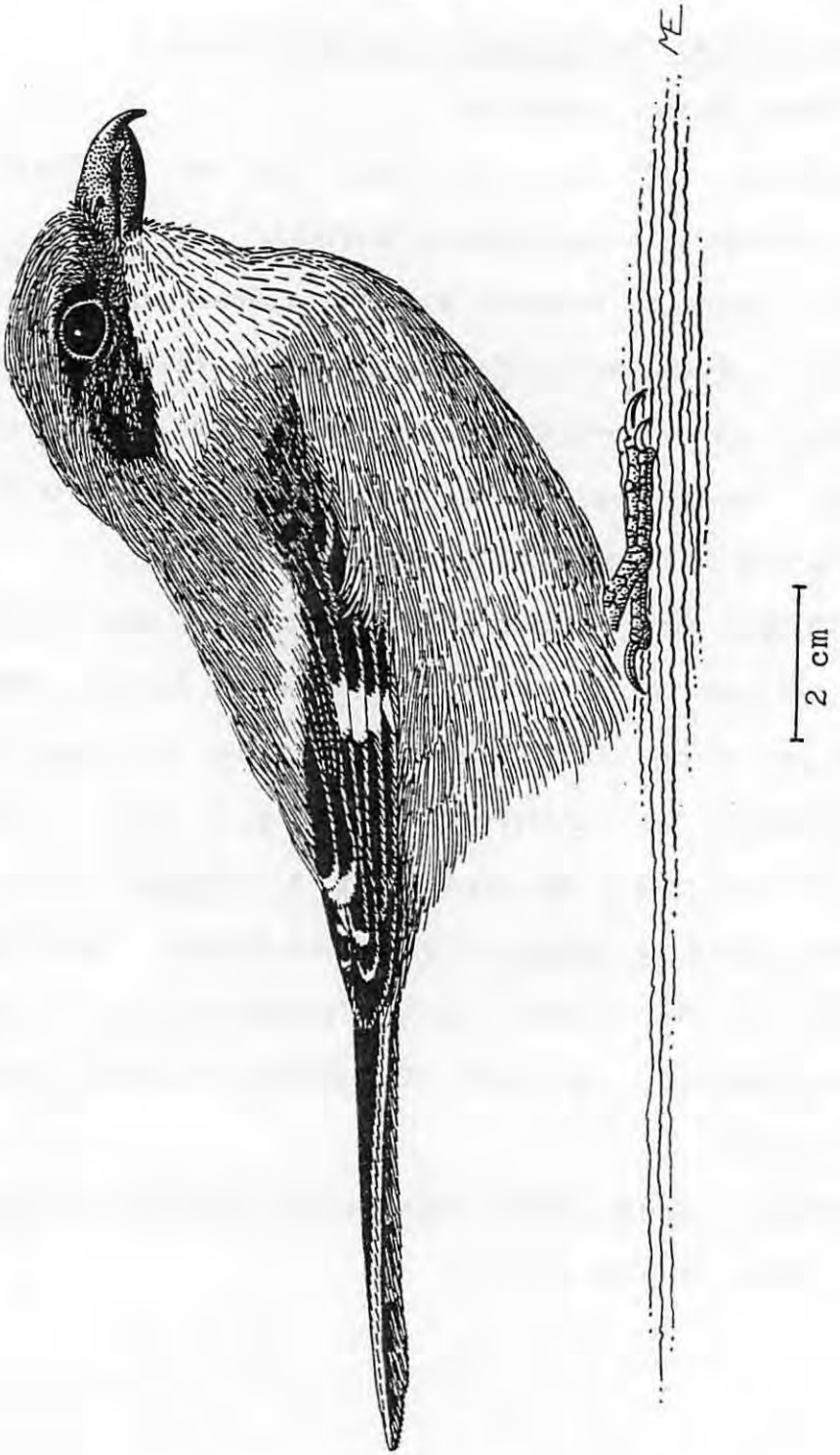

ME
2 cm

Figure 75. LOGGERHEAD SHRIKE

Lanius ludovicianus anthonyi Mearns

Aves: Passeriformes: Laniidae

DISTRIBUTION: (SMI)?, SRO, SCR, (ANA)?, (SBA?)?, SCA; some specimens from the adjacent mainland coast show signs of convergence with this subspecies.

ECOLOGY: common on SRO and western SCR, sometimes breeding on SMI, ANA. Mainly in grasslands, but does not avoid steep hillsides with coastal sage scrub and chaparral. Preys on invertebrates and small vertebrates, sometimes impaling larger prey on thorns, etc. Hunts from high perches. Strong pair bonds? Highly territorial; nests in trees and shrubs.

DESCRIPTION: resembles a stocky mockingbird with a mask. Sexes alike; black, white, and various shades of gray.

RELATIONSHIPS: fairly strongly differentiated from *L. l. gambeli* of the adjacent mainland; SCA specimens are somewhat intermediate. Another endemic subspecies (*L. l. mearnsi*) is rare on SCL.

REFERENCES: Bent (1965:180-182), Diamond and Jones (1980), Grinnell and Miller (1944:382), Johnson (1972), Miller (1931, 1951).

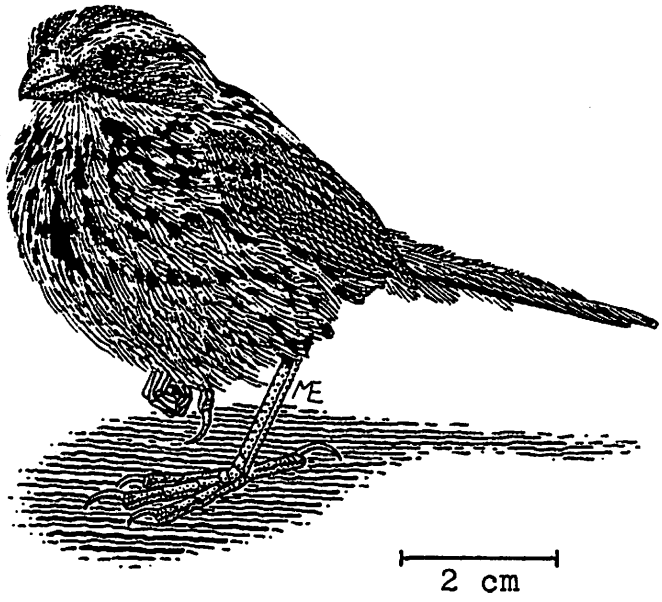

ME
2 cm

Figure 76. SONG SPARROW

Melospiza melodia clementae Townsend

M. m. micronyx Grinnell (opposite)

Aves: Passeriformes: Fringillidae

DISTRIBUTION: M. m. micronyx SMI; M. m. clementae SRO, SCR, (SCL); occasionally sighted on ANA, but not breeding there.

ECOLOGY: locally abundant but secretive and inconspicuous in coastal sage scrub, especially in canyons near streams. Uncommon and more restricted to stream courses on SCR, where it apparently competes with Aimophila ruficeps obscura*; may be excluding the latter from favorable habitats on SRO. Adults mainly granivorous, feed young insects; nests in brush near ground. May drink condensed fog in dry areas.

DESCRIPTION: an accomplished songster; sexes alike. M. m. micronyx gray-brown above, off-white below with dark brown streaks. M. m. clementae larger, more brownish.

RELATIONSHIPS: compared to M. m. cooperi of the adjacent mainland, M. m. clementae is larger, M. m. micronyx is smaller; both are more gray, M. m. micronyx being the grayest of the many, widespread races. The latter resembles M. m. graminea of (SBA), now extinct; M. m. clementae is similar to M. m. coronatorum of LCO.

REFERENCES: Collins (1979), Diamond and Jones (1980), Grinnell and Miller (1944: frontispiece), Johnson (1972), Miller (1951), Nolan (1968), Yeaton and Cody (1974).

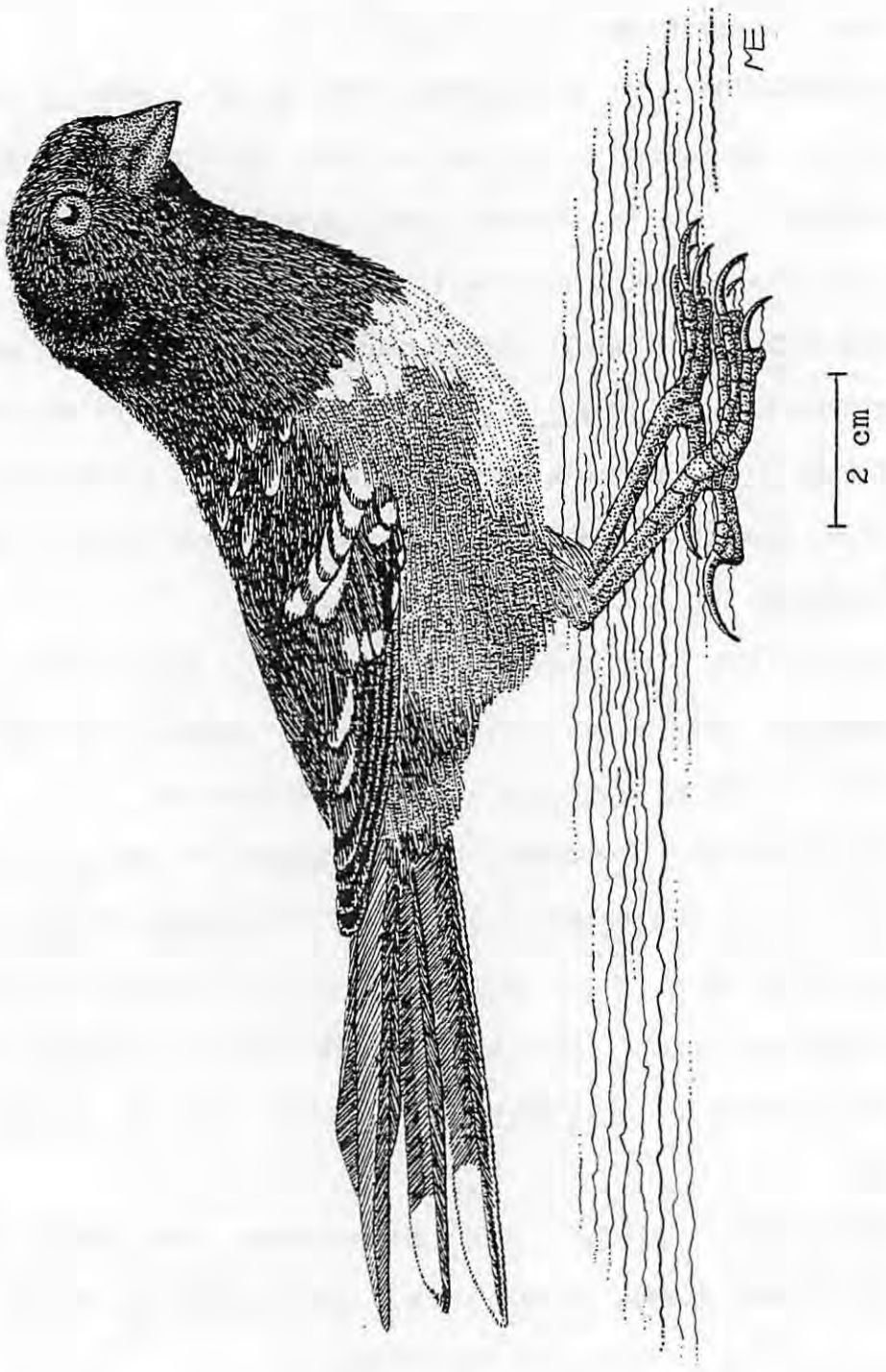

ME
2 cm

Figure 77. RUFOUS-SIDED TOWHEE

Pipilio erythrophthalmus [maculatus] clementae Grinnell

Aves: Passeriformes: Fringillidae

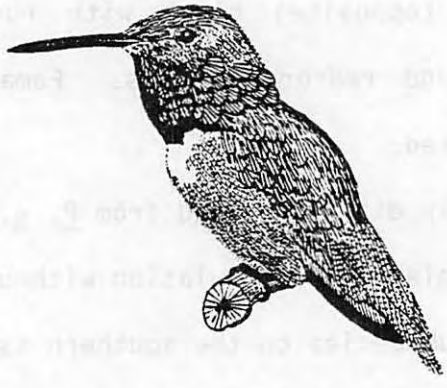
DISTRIBUTION: SRO, (SCL), SCA.

ECOLOGY: fairly common but secretive on SRO in chaparral (including the prostrate form which grows in windy areas), woodlands, and pine forests, especially near streams; perhaps in coastal sage scrub. Ground dwelling and nesting. Forages for seeds and fruit among leaf litter; young are fed insects.

DESCRIPTION: male (opposite) black with rusty sides, white breast and spots, and red-orange iris. Female and immatures gray-brown and streaked.

RELATIONSHIPS: weakly differentiated from P. e. megalonyx of SCR and the adjacent mainland; SRO population without the distinctive call notes of this subspecies on the southern islands; coloration resembles that of interior races (Swarth 1913). P. m. consobrinus (GUA) now extinct.

REFERENCES: Johnston (1968), Diamond and Jones (1980), Johnson (1972), Miller (1951), Power (1980c).



2 cm

ME

Figure 78. ALLEN'S HUMMINGBIRD

Selasphorus sasin sedentarius Grinnell

Aves: Apodiformes: Trochilidae

DISTRIBUTION: SMI, SRO, SCR, ANA, SCL, SCA; reinvasion of mainland near San Pedro, Orange County. Many have colonized SMI only recently.

ECOLOGY: fairly common in chaparral, and oak woodlands, also in coastal sage scrub and riparian woodlands. Successfully excludes the nonendemic Anna's Hummingbird (Calypte anna) from favorable habitats on SCR. Feeds on nectar and small insects around a variety of flowers, especially Eucalyptus spp. (winter), Mimulus* spp. (sect. Diplacus; summer), and Zauschneria spp. (fall). Does not migrate, as does the mainland race. Nests in bushes and trees. Distinctive swinging and diving courtship display?

DESCRIPTION: male (opposite) metallic green above, dull purple-black on wings, white and rusty below, throat dark, flashing coppery-red in light. Female without red throat, mostly white below.

RELATIONSHIPS: similar to S. s. sasin of the adjacent mainland (but more common farther north); ANA specimens somewhat intermediate.

REFERENCES: Diamond and Jones (1980), Johnson (1972), Yeaton and Laughrin (1976).

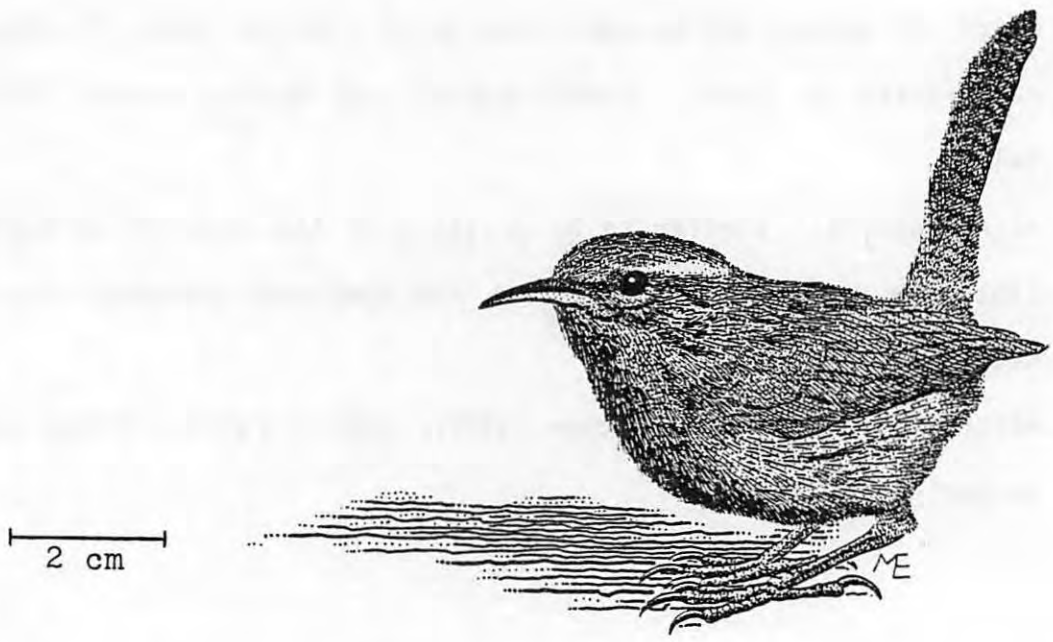

2 cm

Figure 79. BEWICK'S WREN

Thryomanes bewickii nesophilus Oberholser

Aves: Passeriformes: Trogoldytidae

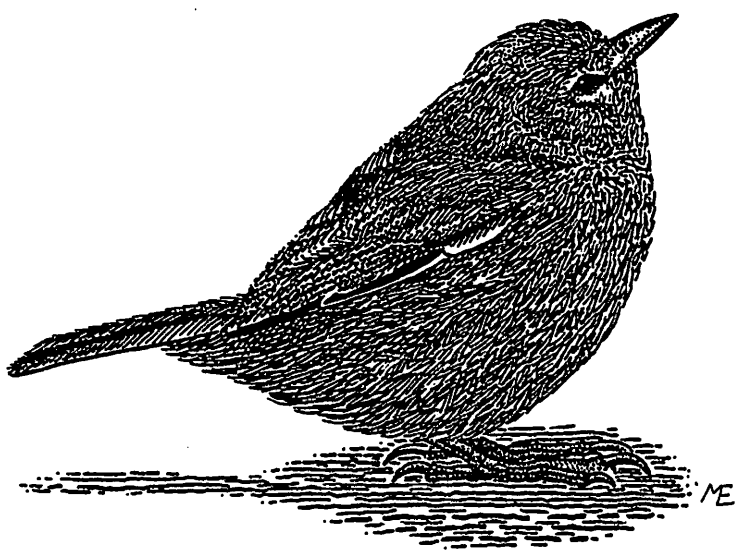
DISTRIBUTION: SRO, SCR, ANA.

ECOLOGY: common in chaparral and woodlands. Specializes in feeding in lower levels of habitat occupied on the mainland by the Wrentit (Chamaea fasciata); eats insects and their larvae.

DESCRIPTION: an accomplished songster; song less variable on SCR than on mainland. Sexes alike; gray-brown above to light gray below.

RELATIONSHIPS: very weakly differentiated from T. b. correctus of the adjacent mainland; intermediate between that form and T. b. spilurus of the San Francisco Bay region. T. b. catalinae of SCA, T. b. leucophrys (SCL), and T. b. brevicauda (GUA) more clearly distinct. Another race is a near-endemic of CED and the adjacent mainland. Slight differences between the populations of SRO and SCR. Widespread and diversified over much of North America.

REFERENCES: Bent (1964b:199), Diamond and Jones (1980), Johnson (1972), Kroodsma (1977), Miller (1951), Power (1980), Yeaton (1972, 1974).



2 cm

Figure 80. ORANGE-CROWNED WARBLER

Vermivora celata sordida Townsend

Aves: Passeriformes: Parulidae [Compsothlydidae]

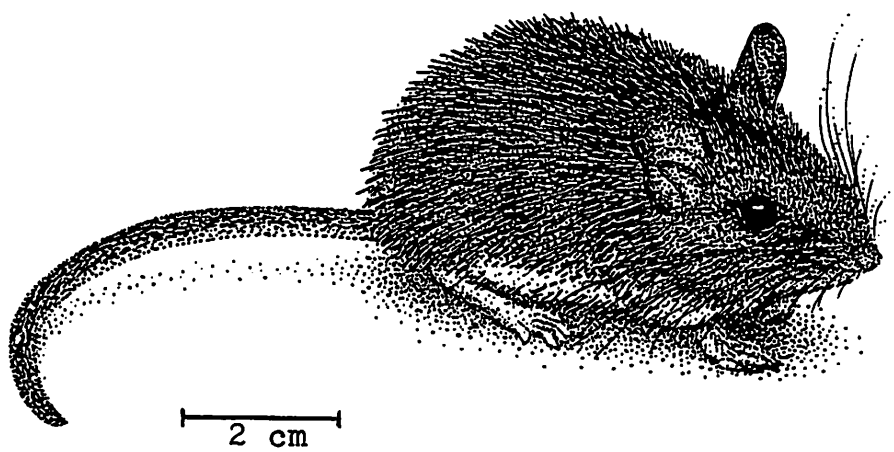
DISTRIBUTION: SMI, SRO, SCR, ANA, (SBA)?, SNI, SCL, SCA, LCO, TSA; scattered colonies on mainland from Los Angeles to San Diego counties (and northwestern Baja California, Mexico?).

ECOLOGY: abundant in coastal bluff vegetation, coastal sage scrub, chaparral, and woodlands in the spring. Although much less vagile than mainland races, the majority disperse to the mainland from mid-July to March, where they scatter mostly northward along the coast; some apparently remain on the mainland. Unlike mainland races, usually nests off the ground in shrubs. Forages for small insects (and some fruit and seeds) at tips of branches, among grasses, and on the ground.

DESCRIPTION: sexes similar; greenish-yellow with darker streaks below to olive-green above and grayish-brown on wings; inconspicuous orange spot on the top of the head; legs brown. Trilling song may be more elaborate in this race (Howell 1917).

RELATIONSHIPS: rather strongly differentiated from V. c. lutescens of the adjacent mainland mountains, but resembles V. c. orestera of forested habitats of the interior mountains and the northern coast.

REFERENCES: Bent (1963b:103-105, Pl. 15), Diamond and Jones (1980), Grinnell and Miller (1944:393-395), Johnson (1972), Yeaton (1972, 1974).



ME

Figure 81. DEER MOUSE

Peromyscus maniculatus anacapae Von Bloeker

P. m. sanctarosae Von Bloeker

P. m. santacruzae Nelson and Goldman (opposite)

P. m. streatori Nelson and Goldman

Mammalia: Rodentia: Cricetidae

DISTRIBUTION: P. m. streatori SMI and Prince Island; P. m. sanctarosae SRO; P. m. santacruzae SCR; P. m. anacapae ANA.

ECOLOGY: abundant where sheltered from predation by owls and foxes (buildings and rocks outcroppings); all habitats except grasslands, especially coastal bluff community and Prisoners Harbor marsh, SCR. Nocturnal; omnivorous. Prolific, breeding mainly in spring and summer. Supports endemic ticks (Ixodes peromysci*). May be threatened by introduced black rats on SMI and ANA.

DESCRIPTION: gray-brown above (sometimes light brown), white below.

RELATIONSHIPS: other subpsecies endemic on southern islands; island races similar, but distinct; superficially similar races endemic to islands of Puget Sound area. Two extinct, endemic species of late and post-Pleistocene not closely related. Species and genus widespread and diversified in North America.

REFERENCES: Bills (1969), Collins et al. (1979), Gill (1976, 1980), Hall and Kelson (1959:613-624), von Bloeker (1967), Walker (1980), White (1966), Wilson (1936).

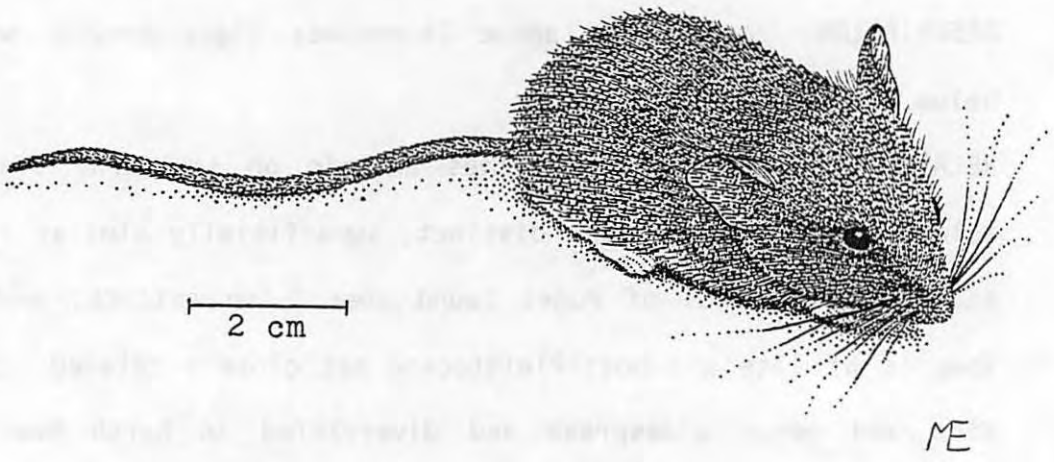

2 cm
ME

Figure 82. WESTERN HARVEST MOUSE

Reithrodontomys megalotis santacruzae Pearson

Mammalia: Rodentia: Cricetidae

DISTRIBUTION: SCR.

ECOLOGY: extremely rare and apparently diminishing in the coastal marsh at Prisoners Harbor (Laughrin, pers. comm. 1979), one specimen collected in coastal sage scrub of Central Valley; well-represented in Barn Owl castings from Christi Ranch at west end, suggesting local population. Probably feeds mainly on seeds, plants, and some insects; nocturnal. Presumably breeds in spring and summer; probably builds a spherical nest of grasses in rushes. May be in the process off being displaced by the expansion of deer mice into marshy habitats. Little studied.

DESCRIPTION: grayish-brown above, whitish below.

RELATIONSHIPS: R. m. catalinae of SCA more distinct from R. m. longicaudus (opposite) of the adjacent mainland and SCL (introduced). Superficially similar to Peromyscus*, but smaller, more delicate, proportionally longer tail, and with grooves on the anterior face of the upper incisors. Genus and species widespread and diverse, but no others on islands?

REFERENCES: Bills (1969), Hall and Kelson (1959:588), Von Bloeker (1967).

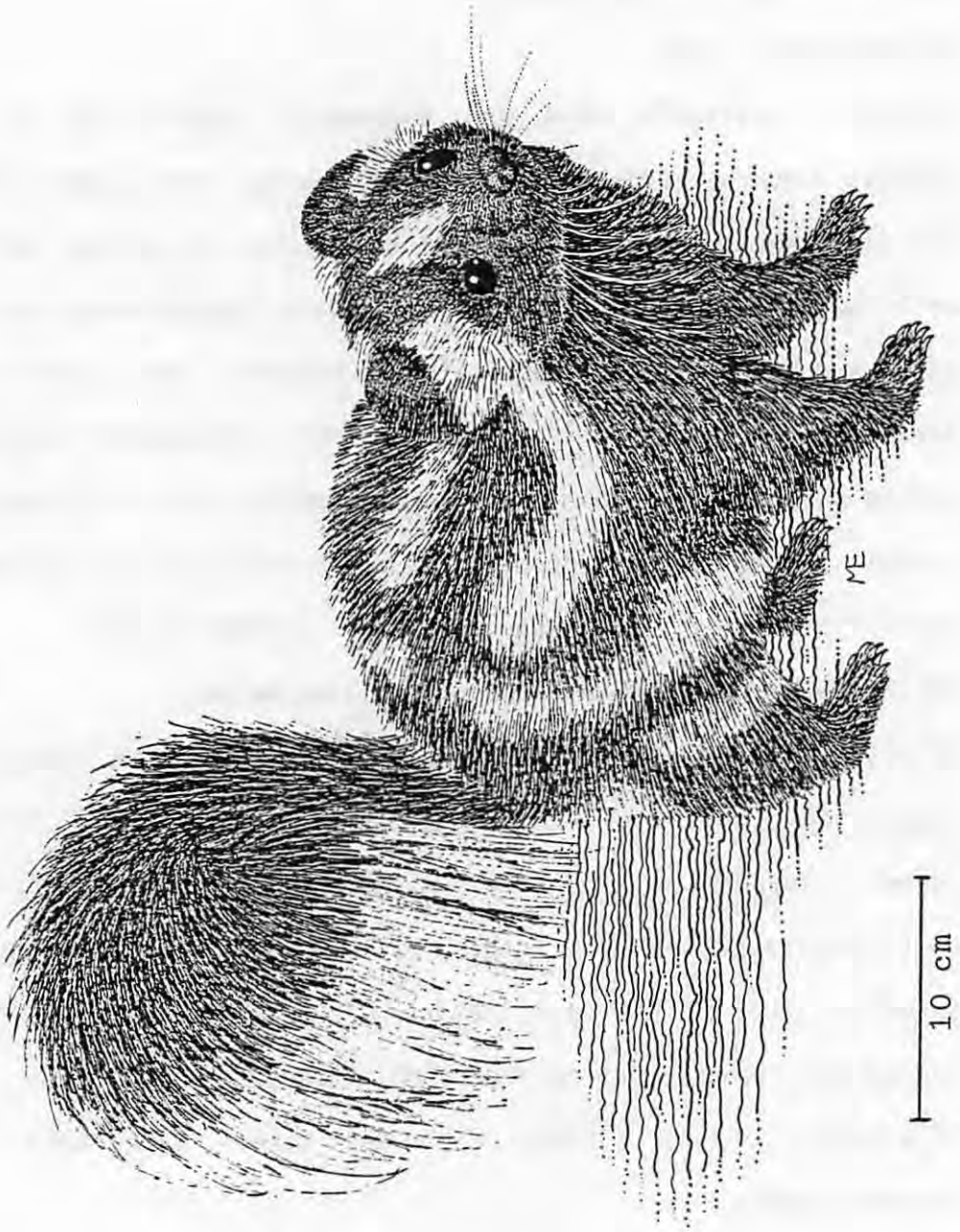

ME
10 cm

Figure 83. SPOTTED SKUNK

Spilogale gracilis [putoris] amphialus Dickey

Mammalia: Carnivora: Mustelidae

DISTRIBUTION: SRO, SCR.

ECOLOGY: formerly common on both islands (Laughrin, pers. comm. 1978), now rare on SCR; in a variety of habitats. Climbs well; nocturnal. Opportunistic and omnivorous, eating fruits, insects, small vertebrates, and probably carrion. Probably not preyed upon by any other animals on the islands (except possibly large raptors), but may have been eaten by the Canaliños. Heavily parasitized by a nematode worm (Skyjabingylus chitwoodorum), which riddles the skull and probably hastens death. This parasite probably uses the land snail Helminthoglypta ayresiana* as an intermediate host (Hochberg 1979).

DESCRIPTION: size of a small house cat. Black and off-white.

RELATIONSHIPS: weakly differentiated from S. g. microrhina of the adjacent mainland; resembles S. g. latifrons of the Pacific Northwest. Sex-linked differences between island populations slight. Although widespread as a species, this is the only insular population (poor swimmer); apparently evolves slowly. Recent subfossils and early historic accounts suggest that the spotted skunk (perhaps of another subspecies) occurred on SMI until recently.

REFERENCES: Hall and Kelson (1959:931), van Gelder (1965), Von Bloeker (1967), Walker (1980), Wenner and Johnson (1980).

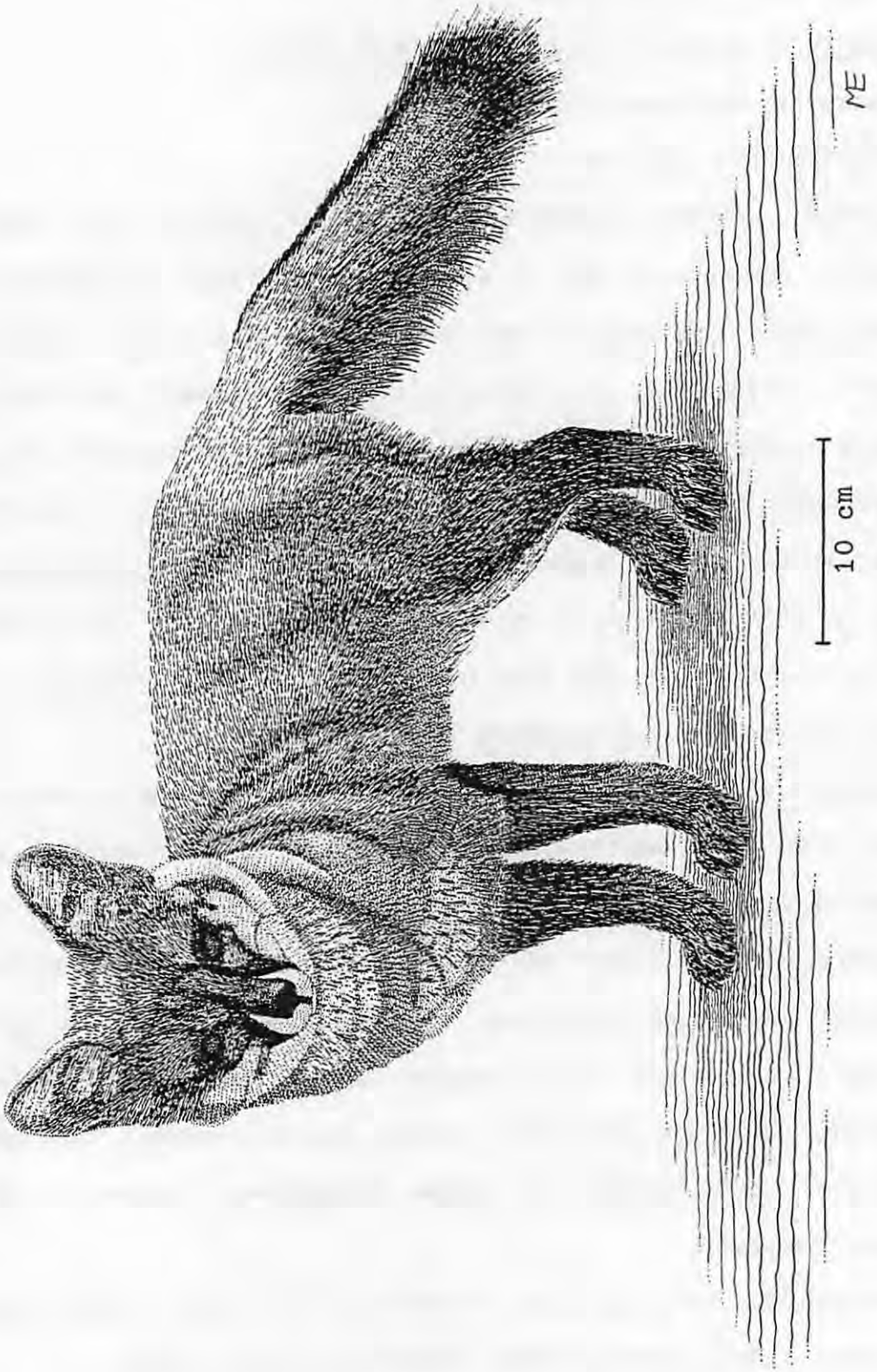

ME
10 cm

Figure 84. ISLAND FOX

Urocyon [Vulpes] littoralis (Baird) littoralis

U. l. santacruzae Merriam (opposite)

U. l. santarosae Grinnell and Lindsdale

Mammalia: Carnivora: Canidae

DISTRIBUTION: U. l. littoralis SMI; U. l. santarosae SRO; U. l. santacruzae SCR. Other subspecies on SNI, SCL, SCA.

ECOLOGY: presently most common in chaparral and woodlands on SCR. Omnivorous. Weakly territorial. Young black, born in makeshift dens in spring. Abroad at all hours. Often shows no fear of man; perhaps kept by the Canalinos, who may have been responsible for its wide distribution among the Channel Islands.

DESCRIPTION: about the size of an average house cat. Grizzled gray above, rusty below with some black and white.

RELATIONSHIPS: similar to and perhaps conspecific with the widespread mainland gray fox (U. cinereoargenteus), which is dwarfed on Tiburon Island, Gulf of California, Mexico (as is the coyote there; Collins, pers. comm. 1981). The individual subspecies are of questionable validity. Known from late Pleistocene deposits on SRO (loc. cit.). Superficially similar species occur in Central America and southern Mexico.

REFERENCES: Collins and Laughrin (1979), Doyen (1974), L. Fausett (pers. comm., 1978-1979), Hall and Kelson (1959:864), Laughrin (1976, 1980), Von Bloeker (1967), Wenner and Johnson (1980).

APPENDIX

Materials and Methods of Illustration

The drawing materials used in executing the figures in this thesis were fairly uniform throughout. Except for Figs. 2 and 3, which were photographically reduced from large prints, all of the drawings were done on 11 x 14", 2-ply Strathmore Bristol Board (400 series, mainly plate finish). The drawings were inked using a set of seven Koh-i-noor Rapidograph pens with points ranging in size from 000 to 3, after being sketched with an HB pencil (excepts Figs. 9 (m,n) and 70). Pencil lines were elininated with a kneaded eraser and inked errors and blemishes were whited out with goache. The drawings were done life size or slightly larger (except Figs. 70, 83, and 84) and then reproduced on a Xerox 9400 copier. Except for the invertebrate series (which was mainly drawn 2.75 X life size, then reduced to 74%), the amount of reduction needed to conform to the thesis format was not, unfortunately, taken into consideration. Some of the larger drawings had to be photostatically reduced twice, since reproduction are limited to 102, 98, 74, and 65% of the original size. Once the desired size was reached, page numbers, the scale, and reference letters were typed on and the result was run off with the text. All of the final copies of the illustrations are second or third generation reproductions, and the greater the reducton and number of generations, the greater the random scatter in the

image. This accounts for the blurred quality of some of the illustrations, a problem more noticeable when 100% rag paper is used.

The source materials used for the figures are listed below. Unless otherwise stated, all specimens were drawn from life. Many were drawn in the field during several trips to the islands. Field work totaled two days on East Anacapa Island in May of 1978 and 1978, one week each on San Miguel and Santa Rosa Islands in April of 1979, and several weeks on Santa Cruz Island from May, 1978 to August, 1979. The only other California Island I have visited was Guadalupe, for two days in May, 1981. No drawings were executed on Anacapa or Guadalupe islands. Several plants were drawn from cultivated specimens, mainly at the Santa Barbara Botanic Garden; such specimens tend to be somewhat more lush than field-grown examples (e.g., Fig. 20). Pressed herbarium specimens were used only for those species which are so rare that I was unable to find living specimens. The invertebrates were drawn mainly from pinned specimens (which may have shriveled slightly in some cases) and alcoholic specimens. The vertebrates were drawn from various combinations of living, preserved, and photographed specimens. In general, photographs were used only for achieving a life-like pose, though slides of island subspecies provided more detail. The plumage, bills, and feet of birds were drawn from museum skins. Alteration in the body size of museum skins may have resulted in inaccurate proportions

between the body and bill and legs (e.g., Fig. 77). I have experimented with varous graphic techniques in an attempt to create life-like renderings. The acute observer will note variations in the use of line, shadowing, and composition. The only real graphic innovation I have employed is the simultaneous depiction of the dorsal and ventral surfaces of the Lepidoptera (Fig. 66). Although many of the plants have been illustrated previously in some form, the invertegrate and vertebrate drawings are largely the first done for these taxa, to the best of my knowledge. The emphasis is on the overall aspect of the species as it is encountered in the field, rather than on microscopic characters (which are necessary for accurate identification in some cases). Many of the drawings are somewhat idealized in that I looked for representative examples and I usually combined features of more than one specimen and eliminated certain defects. For this reason (and the diversity of material used) I have not cited specific voucher specimens. The length of time spent drawing indivdiual specimens varied from about one hour for the smaller plants and invertebrates to two days for the largest butterflies and vertebrates; the average was about four hours. The year in which each figure was done follows the specimens drawn.

The following is a list of the abbreviations used here:

ANA - Anacapa Island

LACMNH - Los Angeles County Museum of Natural History

SBA - Santa Barbara Island

SBBG - Santa Barbara Botanic Garden

SBMNH - Santa Barbara Museum of Natural History

SCA - Santa Catalina Island

SCR - Santa Cruz Island

SMI - San Miguel Island

SRO - Santa Rosa Island

UCB - University of California at Berkeley

UCSB - University of California at Santa Barbara

USC - University of Southern California

USGS - United States Geological Survey

Fig. 1. Modified from Power (1972: Fig. 1), 1981.

Fig. 2. Modified from USGS, 1981.

Fig. 3. Loc. cit., 1981.

Fig. 4. Modified from Power (1979), contour from USGS 1:500,000 State of California, South Half (1970), 1981.

Fig. 5. Modified from USGS 1:500,000 State of Calif. South Half (1970), 1981.

Fig. 6. Loc. cit., 1981.

Fig. 7. Modified from Power (1979), 1981.

Fig. 8. SBMNH herbarium, 1981.

Fig. 9. (a,b) SRO, (c-1) SCR, 1979; (m,n) SBBG (SCR, "A. subcordata"), 1978.

Fig. 10. SCR, 1978.

Fig. 11. SBBG, 1981.

Fig. 12. SCR, 1979.

Fig. 13. SBBG, 1978.

Fig. 14. SBBG, 1978.

Fig. 15. (a,b) SBBG, 1978; (c) SCR, 1979.

Fig. 16. SBBG, 1978.

Fig. 17. Transplanted (SRO), 1979.

Fig. 18. Transplanted (SCR), 1980.

Fig. 19. SBBG (SCR), 1978.

Fig. 20. Cultivated (SCR), 1979.

Fig. 21. SCR, 1979.

Fig. 22. SBBG, 1978.

Fig. 23. SCR, 1979.

Fig. 24. (a-d) SMI, (e,f) SRO, 1979.

Fig. 25. SBBG herbarium (cultivated from SCR), (a) SBBG slide of E. minutiflora, 1981.

Fig. 26. SCR, 1979.

Fig. 27. (a-c) SMI, (d) SCR, 1979.

Fig. 28. (a) SMI, 1979; (b) SMI, 1979 (hairs from same specimen pressed 1981).

Fig. 29. SBBG (SCR), 1979.

Fig. 30. SBBG (SCR), 1979.

Fig. 31. SBBG herbarium (ANA), with reference to V. Grant (1966: Fig. 3), 1981.

Fig. 32. SRO, 1979.

Fig. 33. Cultivated at SCR field station, 1978.

Fig. 34. SCR, 1979.

Fig. 35. SBBG (SBA), 1978.

Fig. 36. SBBG, 1979.

Fig. 37. SBBG, 1980.

Fig. 38. SRO, 1979.

Fig. 39. (a,b) SBBG herbarium (SCR) and slide (SCA), 1981; (b,c) SCR, 1979.

Fig. 40. SBBG (SMI), 1979 (1981).

Fig. 41. SCR, 1979.

Fig. 42. SCR, 1978.

Fig. 43. SBBG, 1978.

Fig. 44. SBBG, 1979.

Fig. 45. SCR, 1979.

Fig. 46. (a-c,h) SBBG semi-fresh specimen (East ANA) with reference to SBBG cultivated M. sp. (SBA), (d,e) SBBG herbarium (Middle ANA), (f,g) SBBG cultivated M. sp. (SBA), (i) SBBG herbarium (SCR), 1979.

Fig. 47. SCR, 1978.

Fig. 48. SBMNH herbarium (SCR) with reference to Abrams (1951: Fig. 4626), 1980.

Fig. 49. SCR, 1979.

Fig. 50. SCR, 1978.

Fig. 51. SBBG herbarium (SMI), 1979.

Fig. 52. SMI, 1979 (1981).

Fig. 53. SCR, 1978.

Fig. 54. SBBG, 1981.

Fig. 55. SCR, 1979.

Fig. 56. SBBG (SCR), 1980.

Fig. 57. SBBG (SRO), 1978.

Fig. 58. SBMNH herbarium (SCR) with reference to Abrams (1944: Fig. 2097), 1980.

Fig. 59. SCR, 1979.

Fig. 60. SCR field station herbarium, 1979.

Fig. 61. (a) SBMNH (East ANA), (b) SBMNH (West ANA), (c) SBMNH (SBA), (d) SMI, 1981.

Fig. 62. (a) LACMNH in resin (ANA), 1980; (b) SBMNH in alcohol (SBA), 1981; (c,d) SBMNH in alcohol, (e) USC Allan Hancock Foundation in alcohol, 1980.

Fig. 63. (a) SBMNH pinned, 1980; (b) SBMNH pinned, (c) Rentz and Weissman (1973) and Fig. 63d, 1981; (d) SBMNH in alcohol, 1980.

Fig. 64. (a) SBMNH (UCB) pinned (SMI); (b) SBMNH pinned (SMI), 1980; (c) SBMNH pinned, 1981; (d,e) SBMNH pinned, 1980.

Fig. 65. (a,b) SBMNH pinned, (c,d) LACMNH pinned, 1980.

Fig. 66. (a,b) SBMNH (UCB) reared from SCR, 1981; (c-j) SBMNH pinned, 1980.

Fig. 67. UCSB in alcohol (SCR) with reference to Tarp (1952), 1981.

Fig. 68. SCR, 1979.

Fig. 69. SCR, 1979.

Fig. 70. Slide by P. Collins (SCR), 1979.

Fig. 71. Photograph of mainland ssp. (Udvardy 1977: Fig. 591) and UCSB skin (SCR), 1980.

Fig. 72. SBMNH slide of mainland ssp. and UCSB skin (SCR), 1980.

Fig. 73. SBMNH slide of mainland ssp. and SBMNH skin (SRO), 1979.

Fig. 74. Loc. cit., 1979.

Fig. 75. SBMNH slide of mainland ssp. and LACMNH skin (SRO), 1981.

Fig. 76. Slide by J. Greaves (SMI) and SBMNH skin (SMI), 1979.

Fig. 77. SBMNH slide of mainland ssp. and SBMNH skin (SRO), 1979.

Fig. 78. Loc. cit., 1979.

Fig. 79. Loc. cit., 1979.

Fig. 80. Slide by J. Greaves (SMI) and UCSB skin, 1980.

Fig. 81. SCR, 1978.

Fig. 82. Goleta, Calif. freshly killed specimen, with reference to Fig. 81, 1979.

Fig. 83. SBMNH slide of mainland ssp. and SBMNH skin (SRO), 1979.

Fig. 84. Slide by M.E. (SCR) and German shepherd feet, 1979.

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