Monterey Bay Area: Natural History and Cultural Imprints

Burton L. Gordon

Pacific Grove, California

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MOSS LANDING MARINE LABORATORIES

MONTEREY BAY AREA:

Natural History

and

Cultural Imprints

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FOREWORD

The Moss Landing Marine Laboratories are operated by a consortium of six of the California State University and Colleges. Dr. Gordon is a member of the faculty at San Francisco State University which is a member of the consortium. Since 1969 he has taught a course here at the Laboratories with a title about the same as this book. It is, in fact, this course that has stimulated the writing of the book.

Recognizing the controversy and confusion concerning management of the environment in this region, it is desirable to get the wealth of information represented by this course into the hands of those concerned with the environment. The aim is to put into better perspective the nature, history, and origins of that which we see about us.

To that end, we have sought and received funds from the Office of Sea Grant, NOAA, to support our research.

Robert J. Hurley
Moss Landing Marine Laboratories

Moss Landing, California
September 1974

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PREFACE

This study, which has grown from notes prepared for a field course, "Human Ecology of the Monterey Bay Area," benefitted greatly from my association with graduate students at Moss Landing Marine Laboratories—particularly Shane Anderson, Richard Avey, John Hansen, Robert Morey, and Larry Talent. (Specific factual contributions from class members, and others, are acknowledged in the text.) I am also much indebted to my colleagues at Moss Landing Marine Laboratories for encouragement—and especially to Dr. Victor Morejohn and Mary Jean Bilek, for editorial improvements in the manuscript, and Dr. Robert Hurley, Director, who implemented its publication.

Dr. Ralph Buchsbaum, formerly of the University of Pittsburgh, and Dr. James Griffin of Hastings Natural History Reservation generously contributed time to read the manuscript and make valuable suggestions. Jack Stirton, U.S. Army Corps of Engineers, made helpful comments on the section dealing with wave erosion and littoral drift. Allyn Smith and Barry Roth of the California Academy of Sciences kindly identified many of the mollusks discussed in the text. Professor Georg Treichel, Dr. John Westfall, Sharon Johnson, and Byron Wood of San Francisco State University gave liberal advice on bibliographic and map resources.

I wish to thank Stanley Clayton (Monterey County Agricultural Commissioner's Office), Howard Greenfield (Salinas Valley Mosquito Abatement Board), Tom Gould (Mount Madonna County Park Ranger), and Dave Steaffens (Toro Regional Park Ranger) for freely sharing their knowledge of the natural history of the Monterey Bay area.

I am especially grateful to Nat Bracco, Ronnie Chinn, Jack Dolan, George Flath, John Giannini, Bob Rubis, Hans Struve, and Harry Xanthus, long-time residents of the area, for their warm hospitality and for historical, and other, information heretofore not available in print.

And finally, my thanks to my wife, Myra, for contributing many careful observations of her own on plant and animal life, and for her patience and industry in typing several versions of the manuscript.

An alphabetical list of the common names of animals and plants discussed appears at the end of the book, along with their scientific names. The bracketed comments in quoted passages are mine.

Burton L. Gordon

Santa Cruz, California
August 1974

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Chapter 1

INTRODUCTION

THE PURPOSE of this study is twofold: (1) to investigate the character and extent of ecological changes produced by human action in the Monterey Bay area; and (2) to suggest applications of such information to land-use planning.

The clearing of the natural plant cover and physiographic alterations are emphasized because these are among the activities of humans which have had the greatest ecological consequences. Locally, species have been exterminated and habitats destroyed. Numerous domesticated and game species, and species commensal with mankind (such as insect and rodent pests), have been introduced. An even larger number of native species have been exposed to unplanned disruptive and selective action. Changes in animal habits and food sources have taken place. As a result of agricultural and industrial developments, natural hydrological patterns have been locally changed, and the chemical content of the air and waters altered. Thus, new habitats for plants and animals, including people themselves, are being created. (The theme is an old one, first dealt with in detail in 1863 by George P. Marsh in *The Earth As Modified by Human Action.)*

The strongly *historical emphasis* of the text allows the reader who knows the bay area as it *is* to review what it *has been* and see what it *is becoming.* Many contemporary problems are involved.

In *preserving nature* what, in fact, are the conditions we are trying to preserve—a landscape already molded by centuries of human occupancy? A beach is eroded by wave action. Was its disappearance a result of natural littoral processes alone, or the consequence of a jetty's having been built upcoast? A species becomes locally extinct. Was this a result of natural evolutionary processes, of fluctuations in climate, or of human modification of its habitat? Effluent materials are suspected of damaging aquatic life near a pipe outfall. But how can the fact be established with certainty when one is lacking knowledge of the biological conditions which existed when the pipe was laid? Many exotic plants and animals now inhabit the area. Has the introduction of certain of these species had detrimental effects? Clearly this question is important for regional planning purposes, but a useful answer can be given only if one knows which species were, in fact, introduced and the history of their effects.

Many questions remain unanswered for lack of adequate chronological detail. Without historical data it is almost impossible to distinguish biotic and environmental changes which are the result of natural processes from those actually produced by human industry—a circumstance which may be exploited by those seeking to avoid responsibility. On the following pages an attempt is made to sketch a number of what might be called *fiducial ecosystems* and to establish a chronological series of ecological reference points useful in interpreting future environmental change in the area.

Although the study is largely descriptive and meant to be without philosophical pretensions, it has been written with certain assumptions in mind. Most of these are readily apparent. Such assumptions do not, I trust, affect the accuracy of factual statements in the text, but some may be subject to question.

I have assumed, for example, that achievement of maximum ecological diversity should be something of an ideal in land-use planning; that a varied, species-rich biota, based upon multiple food chains is desirable; that an underlying biotic potential manifests itself in such features as the natural plant associations; that even where these associations have been altered or removed, regenerative forces continue to operate—because, for example, climatic and edaphic patterns persist; that the idea of a potential natural vegetation is a useful planning concept and that a knowledge of plant succession is essential in attaining optimum land use; that diversity will be partly ensured by maintaining and, where necessary, restoring tracts of the original plant associations—and further increased by keeping all successional phases of plant cover in existence somewhere within the area at all times; that only by control of the vegetation can terrestrial animal numbers, in certain species, be maintained above critically low values (though, admittedly, such values have not as yet been adequately determined); that further extinction of species in the Monterey Bay area, as elsewhere, should be prevented at all costs; and, that biotic enrichment can also be attained through judicious introduction and exclusion of exotic species.

A. DEFINITION OF TERMS

The Monterey Bay area as defined for this study extends along the coast from Monterey Peninsula, including Carmel, northward to Año Nuevo Island. This definition accords with an old usage. The northern extent of the embayment is not so sharply defined as is the southern, and in early accounts Año

Nuevo, then referred to as "Point Año Nuevo," was taken as the bay's north limit. For example, Father Pedro Font in his diary written in 1776, said, "... the bay formed by Cabo de Piños [Cape of Pines—i.e., Point Pinos] and Punto de Año Nuevo is very large." (Bolton, 1933, p. 308.) Later, in 1792, Captain George Vancouver described the limit of the Monterey Bay: "This famous bay is situated between Point Pinos and Point Año Nuevo.... This spacious but very open bay is formed by the coast falling back from the line of the two points, nearly four leagues." (Vancouver, 1933, p. 77.) On its seaward side, the area includes the littoral zone. Inland, it includes the water sheds of the rivers and streams draining into Monterey Bay, excepting the upper Salinas River which has its headwaters far to the south. Biogeographically the upper Salinas Valley is as strongly associated with southern California as it is with the shores of Monterey Bay. Hence, the southern limit of the area discussed here is placed arbitrarily across the Salinas Valley from Palo Escrito Peak in the Sierra de Salinas to Pinnacles National Monument in the Gabilan Mountains—that is, roughly at the old boundary between the Costanoan and Salinan Indians.

Much use of the terms *natural landscape* and *cultural landscape* has been made (cf. Krebs, 1923). The most obvious example of a natural landscape, as the term is used here, would be an area neither occupied nor affected by people. Virtually no such environment remains on earth; but even in long settled areas the concept of a natural versus a cultural landscape preserves an important and useful distinction. In defining the natural landscape, we picture the countryside as it would be if people and their works were removed leaving behind those environmental features which may exist independently of them; for example, mountains, unpolluted streams, and indigenous plant formations.

The term "cultural landscape" is applied to all features of the physical environment which are attributable to human presence—to roads, cities, orchards, deforested tracts, introduced species, and smog. In addition to a panorama of crops, pastures, towns, and the like, the effects of people on life and environment can be seen in a thousand details: birds aligned on telephone wires; gulls following a plough; swallow nests under the caves of a building; tree-rings around sawn stumps in a redwood forest; dust plumes rising from a cement plant (as at Davenport); a change in plant cover at the boundaries of an old Spanish land grant; the multicolored waters of salt ponds (Moss Landing); barnacles colonizing newly laid jetty rocks; clumps of mussels clinging to old pilings; a herd of sea lions hauled out on a breakwater (Monterey); mine scars on a mountain slope (as at

Natividad); the contour terrace paths made by cattle grazing a hillside; a skyline formed by groves of an Australian tree (*Eucalyptus*); jet trails overhead; and so on. Thus the cultural landscape is an environmental catalogue of human accomplishment in the area, for better or for worse.

In describing the development of the cultural landscape in the Monterey Bay area the implied reference date is the time, probably after the close of the Pleistocene period (late, by Old World standards), when people first appeared in this part of the western hemisphere. The reference condition, logical but necessarily hypothetical, is a scene lacking all human influence —the natural landscape, or fundament, upon which people have acted. Because this fundament has itself been subject to change by, among other forces, seasonal and long term climatic variations, the natural landscape is constantly being reposed with slight variations for cultural modification.

Related to the concept of natural landscape is that of a *potential natural vegetation*, this being the vegetation that would come into existence if people were suddenly removed from the scene and all of the ensuing stages of plant succession were concentrated into a single moment (Tüxen, 1956, p. 5).

An archaic and not especially euphonious term is revived because it expresses this idea of man as a uniquely different agent of change: *anthropurgic* (from the Greek for *man* plus *work*), defined as "influenced by the exercise of human power; operated upon by man," as distinguished from *physiurgic*, i.e., produced "in the course of nature, without the intervention of man." Hence the subtitle of this study could well be "An Anthropurgic Ecology of the Monterey Bay area."

B. CONTROLS FOR THE STUDY OF ECOLOGICAL CHANGE

When the Monterey Bay area was discovered by Europeans, the biota was not in an unaltered condition. Even then, the areas of natural plant cover—natural in the sense of being uninfluenced by people—had been reduced. Today such vegetation probably no longer exists.

> In very many parts of the world, Old and New, man has been on hand for so long and in such numbers that great deformation of the vegetation has resulted. We can then hardly speak of a natural balance without him, since man has been exerting sustained and selective pressures. Except at the climatic extremes, there may be no such thing as undisturbed or natural vegetation. (Sauer, 1952, p. 18.)

However, the circumstances in central coastal California were unusual. This land had not been subjected to those profound ecological changes which are associated with the evolution of agriculture, cities, and technology in many parts of the Americas and in the Old World. A lithic culture survived here into the nineteenth century. The aboriginal inhabitants of the Monterey Bay area were without agriculture or domesticated animals, other than dogs. Despite changes in plant cover and animal life made by the Indians, the biotic conditions observed here by the first Spaniards were probably closer to natural than those existing elsewhere in these latitudes, excepting in Australia.

Several general sources of information are available concerning the environmental conditions upon which man-made changes have been imposed. A number of prehistoric human-environment relationships can be glimpsed by inspecting the content of kitchen middens which mark the sites of old Indian settlements.

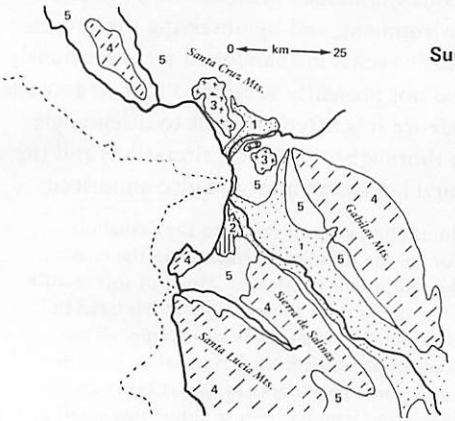
Dated descriptions and collections made by explorers and naturalists present views of environmental conditions in the Monterey Bay area at the time of its discovery and settlement by Europeans, before the most sweeping changes in the natural landscape had been made. Accounts by the explorers Lieutenant Pedro Fages and Father Juan Crespi are indispensable. Coulter, Douglas, Eschscholz, Haenke, Hartweg, Menzies, Nuttall, and von Chamisso are among the illustrious early naturalists who collected in the area.

Insight into early, more nearly natural, conditions also can be obtained from contemporary field studies of those parts of the landscape farthest removed from archaeological remains and human presence, and hence presumably vestiges of the natural environment, and by observing the successional and regenerative trend of biotic events in abandoned areas previously utilized by people in some way and not presently subject to human activities.

In the absence of historical evidence it is often difficult to disentangle the cultural and the natural. Even thoroughgoing biotic alterations and the presence of a well-developed cultural landscape may go quite unnoticed:

> ... man dominated landscapes do not betray their origin to the casual observer. Take the grasslands of California, the rolling hills back from the coast.... Here are stretches of what looks like indigenous vegetation. Much of this mantle is not obviously tended by man; it has the look of something that has been in California as long as the oaks it grows among, yet the bulk of it came, all uninvited.... Most of it had a long history of association with man when it made the trip.... Native plants are there, even some native grasses, but it takes a well-informed botanist going over the vegetation item by item to show how small a percentage is made up of indigenous California plants. (Anderson, 1956, p. 763.)

Monterey Bay Area and its borderlands, as shown on one of the first reasonably accurate topographical maps: *Topographical Map of Central California ... C. F. Hoffmann, Principal Topographer, State Geological Survey of California, 1873.* (Courtesy of Bancroft Library, University of California, Berkeley).



Surface-forming materials.

1. Alluvium
2. Old and recent dunes
3. Aromas red sands
4. Igneous rocks
5. Undifferentiated sedimentary rocks

Chapter 2

THE NATURAL LANDSCAPE

THE PHYSICAL ENVIRONMENT

A FEW principal characteristics of the inanimate physical environment require review to show the effects of human occupancy within a framework of nature.

(1) Physiographic Features and Surface-forming Materials

An unobservable, yet dominant and controlling factor in the geomorphic history of the Monterey Bay area, is the great submarine canyon which extends out of the bay into the Pacific. Drainage throughout the area converges toward this canyon, the head of which approaches shoreline of the bay at Moss Landing. The courses of the principal streams, the San Lorenzo, Pajaro, and Salinas Rivers, are directed toward the canyon, and offshore contours show that beneath the sea this converging pattern continues—a vestige of an older and similar drainage pattern existing when the Pleistocene Pacific stood several hundred feet below its present level. Despite considerable depths in the canyon (more than 1½ kilometer, 8 or 9 km west of Moss Landing) the larger part of the bay, lying on the continental shelf is less than 30 meters deep.

A notable feature of the Monterey Bay is its symmetrical outline with the canyon midway between Santa Cruz and Point Pinos. Approaching the bay from the open sea and looking eastward the observer's skyline is formed by the crests of the Santa Cruz Mountains toward the left and center of his horizon, and by the Gabilan and Santa Lucia Mountains to his right, the latter two ranges being separated by the Salinas Valley. Loma Prieta in the Santa Cruz Mountains and Fremont Peak in the Gabilans stand out as landmarks.

Between the coast and the mountain crests in the northern half of the bay area lies an expanse of low hills while in the southern half alluvial plains are extensive: thus the San Lorenzo River is almost without an alluvial plain, the plain of the Pajaro is much broader, and the Salinas River has produced by far the greatest expanse of alluvium in the area.

Igneous and metamorphic rocks are exposed along parts of the mountain crests both in the Santa Cruz and Santa Lucia Mountains but the predominant rocks are of sedimentary origin.

Differences in surface-forming materials account for several contrasts between the southern and northern ends of the bay: The rough, boulder-strewn headlands of Point Pinos are made of granitic rock. Sedimentary rocks, especially shales, form both the slopes of the Salinas Valley and the flat coastal shelf at the north end of the bay, between Santa Cruz and Davenport. Around Point Pinos, quartz and feldspar derived from the weathering and granite have supplied the sands in the white dunes and beaches of Pacific Grove and Carmel. The clear offshore water there with good subsurface visibility is appreciated by scuba divers. Within the bay and northward, finer deposits coming from the Salinas River, or eroded from shoreline cliffs, yield gray and tan beach silts and sands, and make for turbid offshore waters.

Not all recent changes hereabouts have been initiated by people. Coastal physiography is characterized by especially rapid natural change. Año Nuevo Island is itself a recent feature. All early accounts refer to *Point* Año Nuevo, not to Año Nuevo *Island.* Captain Vancouver appears to have approached the Point and inspected it closely: "Near *Point* Año Nuevo are some small rocks detached from the coast a very little distance...." (Vancouver, 1798, p. 78.) Seen from the sea the island might simply have been indistinguishable from the headland, but Father Crespi's party approached Año Nuevo by land and camped nearby in 1770. His account refers to "... the *point* of Año Nuevo, which is low with rocky reefs." (Bolton, 1927, p. 251.) And a description from the diary of Palou upon his reaching the beach near Waddell Creek in 1776 after travelling overland reads:

> The Punta de Año Nuevo, which we have so close at hand, is a tongue of low land, rocks, and reefs of very low elevation but it extends a long way into the sea, and to sailors doubtless it would look very high because of the range of hills and sierras which it has very near by. (Bolton, 1930, p. 443.)

Studies of cliff erosion along this coast indicate that in places wave action is displacing the shoreline inland at an average of over 15 cm per year. Año Nuevo Point, subjected to strongly refracted and focused waves approaching from both sides, has been breached. Such wave action over the 200 years since Spanish settlement began has left an island of resistant materials offshore. The idea that Año Nuevo was a peninsula rather than an island in early historical times is discounted in one study (Orr and Poulter, 1962, p. 14). However, a permanently separate island has existed only a short time. As early as 1798, the promontory probably appeared either as

an island or as a peninsula, depending upon whether it was viewed at low or high tide, in winter or summer. As late as 1857, one official and detailed map shows no Año Nuevo Island, only Año Nuevo Point; the seaward tract of higher land which now forms the island was then connected to the mainland by a sandbar (Plat of the Rancho Punta Año Nuevo, surveyed under orders of the U.S. Surveyor General, by J. Kellenberger, June 1857). Water depths have changed within living memory. Old residents in the neighborhood say that building materials for the now abandoned Coast Guard houses were hauled to the island by wagon at low tide.

(2) Climate and Season

In the Monterey Bay area seasons are weakly developed. Certainly the most conspicuous influence of season on landscape here arises from variations in rainfall. Grass covered hills, green under winter rains, are parched to yellows and tans in summer. January and February are usually the wettest months, while July and August are virtually without rainfall.

Rainfall increases from south to north along the coast. At Monterey it averages about 38 cm a year while at Santa Cruz, it measures some 69 cm per year. Rainfall also generally increases with elevation. For example, at Boulder Creek, some 183 m higher than Santa Cruz, the average rainfall is about 137 cm per year.

During the winter season—when rain-bearing air masses arrive from a westerly direction, there is a marked rainshadow in the Salinas Valley and on the western slopes of the Gabilans, which are on the lee side of the Santa Lucia Range. Thus, annual rainfall values in the Salinas Valley are reduced as compared to coastal sites like Monterey and Santa Cruz. Soledad, in the valley, receives only a little over 23 cm. Stations along the crest of the Santa Lucia Range average as much as 152 cm per year, while those at about the same elevations along the crest of the Gabilans average only around 50 cm per year.

It should be noted that the averaging of the annual rainfall values obscures a climatic factor of great importance to the biota, namely, the considerable variation in rainfall from year to year. For example, at King City the average annual rainfall for the period 1888-1954, was 26.4 cm, the maximum 64.0 cm, and the minimum only 10.08 cm.

Except at higher elevations snow cover is rarely a part of the area's scenery. From Santa Cruz, patches of snow can be seen for a week or two in most winters—atop El Toro Peak. And from Monterey, snow can occasionally be seen on Fremont Peak in the Gabilan Mountains, across the Salinas Valley to the east.

Winter weather is likely to be alternately cloudy, rainy, and fair. In the summer, more stable air and recurrent summer fog are characteristic. Under these stable summer conditions, strong convection and associated thunder and lightning are rare. Fires started from natural causes cannot have been a significant ecological factor in the Monterey Bay area as they are, for example, in Sierran California. Lightning flashes are seen mainly in the winter when the danger of forest fire is minimal. Farther inland, around Pinnacles National Monument, lightning-caused fires do occur—but even there only a small fraction of the recorded forest fires have been started this way.

Summer fog is usually associated with a temperature inversion. As early as 1861, a traveller in the Monterey Bay area remarked: "There is a very curious meteorological fact connected with these hills. It is cooler in the large valleys and hotter on the hills." (Brewer, 1949, p. 124.) This temperature inversion is associated with the summer pattern of regional air circulation which produces an upwelling of cold ocean water along the California coast. Those who have driven along Highway 17, from Los Gatos to Santa Cruz, may recognize this description of an August view from the crest of the Santa Cruz Mountains, written over a century ago:

> To the south lie the whole Bay of Monterey and a vast expanse of ocean .... Monterey is obscured by fog, but the mountains rise above it in the clear air. Fog forms at the head of the bay and rolls up the Salinas Valley ... [which] seems like a great arm of the sea. (Brewer, 1949, p. 155.)

Summer fog is especially heavy in the mornings and near the coast, usually clearing with rising surface temperatures in the afternoons. Fog cover is often dense in the middle of the bay, and around Moss Landing, perhaps because of colder surface water upwelling from the submarine canyon. Ranges in both annual and diurnal temperatures are remarkably small because of the proximity of the whole area to the coast and because of the upwelling of cold water offshore in summer. The moderating influence on temperature of the nearby ocean results in a long growing season which decreases inland. Near the coast at Monterey (Del Monte) the growing season is 296 days; about 8 km (5 miles) inland at Watsonville, 245 days; and up the Salinas Valley, at King City, 211 days.

Along the coast summer winds are generally northwesterly and in the winter, variable, often westerly or southwesterly. Over much of the area the strongest winds are felt in winter. However, this is not so in the Salinas Valley:

> In the Salinas Valley summer winds are stronger than winter winds—entering the Salinas Valley from Monterey Bay, they sweep up the valley with increasing regularity and force as the valley narrows and the heated interior is approached. The movement generally begins in the forenoon, reaches a maximum in the early afternoon, and gradually subsides as evening approaches. Heated as they move inland, they increase transpiration and evaporation. (Carpenter and Cosby, 1929, p. 5.)

In the Salinas Valley one can observe an east-west alignment of eucalyptus windbreaks, with the trees leaning southward toward the upper valley.

In accordance with the season of rainfall, river and creek flow is mainly in the winter; in summer most stream courses are dry.

Autumn is not a colorful season by eastern standards. The leaves of poison oak supply a little red, sycamore trees growing along the upper river courses turn yellow, and in the salt marshes around Elkhorn Slough pickleweed marks out broad patches of pink and salmon.

The height of the waves varies seasonally. Summer waves build broad, gently-sloping beaches, while the higher winter waves transport sand to the offshore zone, removing the beaches completely or leaving them narrow, steep, and usually with a pronounced berm. Moss-like green algae, *Enteromorpha*, covering rocks and ledges which are well within the splash zone in winter, wither and disappear when summer beaches reform and displace the shoreline seaward.

There is also a seasonal sequence in the offshore plants cast up on beaches. Thus, piles of *Macrocystis*, torn from beds in shallow water, appear in the summer and fall while *Nereocystis* and even the deepwater *Pterogophora* become more plentiful after winter storms.

Occasionally, on bright summer days, dinoflagellates become so numerous offshore that they discolor the bay, producing the so-called "red tides."

Seasonal changes in animal life may reflect climatic extremes experienced elsewhere rather than within the Monterey Bay area itself. The appearance of migratory birds is an example. In June and again late in the summer sooty shearwater appear in huge flocks offshore; in the winter, snow geese visit Elkhorn Slough and cedar waxwing arrive to feed on pyracantha berries in city gardens.

The Monterey Bay area is uncommonly rich in endemic plant species (Stebbins, G. L. and J. Major, 1965, p. 23) and is also known for the large number of species which find either their northern or southern limits there (Thomas, 1961, p. 30).

The area has a varied plant cover within which at least a dozen major plant associations can be distinguished; these are named below.

NATURAL PLANT ASSOCIATIONS

(Adapted from Munz, 1959; Jensen, 1947; and Smith, 1959)

Natural Plant Formations or Groupings	Dominant or Conspicuous Species	Location of Examples
(1) Offshore kelp beds	Proceeding from deep water shoreward, a succession of beds: whip-strap kelp, sea otter cabbage (bull whip kelp), giant kelp, and woody chain bladder.	The beds are found in the shallow offshore zone, mainly at depths of less than 18 m, particularly around Monterey Peninsula, at Soquel Point and Soquel Cove, and elsewhere within the bay. Their distribution is controlled mainly by the availability of hard bottom for kelp holdfasts, by the depth of the water, and by the wave refraction pattern within the bay. Giant kelp and sea otter cabbage are widely distributed and form most of the kelp beds in the area; there is a large stand of woody chain bladder off Cannery Row.
(2) Intertidal and splash-zone	Eel grass, surf grass (or narrow-leaved eel grass), and such algae as ribbon kelp, sea palm, and *Enteromorpha intestinalis.*	In this narrow strip numerous marine algae grow in a marked vertical zonation, the zonal limits being determined by lighting, wave exposure, and tidal action; particularly abundant where rocky ledges, boulder and cobble form the shoreline, e.g., between Natural Bridges Beach and Pt. Santa Cruz, at Opal Cliffs, and around Point Pinos. Surf grass is found in the surf-zone of rocky shorelines where there is a certain amount of sand; it is common at Año Nuevo, Natural Bridges Beach State Park, along West Cliff Drive and on Monterey Peninsula. Eel grass is estuarine; it is found only in Elkhorn Slough, where there are several stands a little south of the small craft harbor. *E. intestinalis* is a bright yellowish-green alga which grows between plus 1 m and mean low tide; it is particularly common on the mudflats of Elkhorn Slough.
(3) Strand vegetation; herbs and shrubs	Lizard tail, beach bur, beach sagewort, common and yellow sand verbena, sea rocket.	(a) Dune and beach vegetation—young dunes and inner beach margins; especially between Sunset Beach and the mouth of the Salinas River.
	Mock heather, coast Eriogonum, California sage, blue beach lupine, bluff lettuce.	(b) Coastal scrub—old dunes, coastal cliffs and hills; esp. between Moss Landing and Mulligan Hill and between Año Nuevo and Santa Cruz.

Natural Plant Formations or Groupings	Dominant or Conspicuous Species	Location of Examples
(4) Coastal salt marsh	Pickleweed, salt grass, salt rush.	Elkhorn Slough.
(5) Riparian vegetation	California tule, common cattail, sedges.	(a) Freshwater marsh—areas of sluggish drainage along the lower courses of the major streams; e.g., the lower Pajaro River and Salinas River floodplains, and around lakes and (now) irrigation ponds.
	Willows, cottonwoods, box elder, sycamore.	(b) Riparian woodland—recent alluvium on floodplains of the larger streams, the Salinas River, Pajaro River, Branciforte Creek, Aptos Creek, etc.
(6) Closed-cone pine and cypress forests	Monterey pine, knobcone pine, bishop pine, Monterey cypress, Gowen cypress.	Monterey pine and knobcone pine near Año Nuevo; Monterey pine, Monterey cypress, bishop pine, and Gowen cypress on the Monterey Peninsula.
(7) Redwood and mixed redwood Douglas fir forests	Coast redwood, Douglas fir, redwood sorrel, sword fern.	Redwood forests at middle elevations on slopes of Santa Cruz Mountains; at its margins, redwood forest intermixed with Douglas fir. Although not found at shoreline, redwoods extend downslope to within a few hundred meters of the sea on some leeward slopes, e.g., along Aptos Creek.
(8) Broadleaf evergreen forest	Madrone, tanbark oak, coast and interior live oak, California laurel, blue blossom.	On higher hills and slopes of the Santa Cruz Mountains, intermixed with tracts of redwood and Douglas fir forest; e.g., Nisene Marks State Park and Mount Madonna County Park.
(9) Coast live oak woodland	Coast live oak intermixed with poison oak, coffee berry, *Ceanothus*, etc.	Fort Ord area, where the dunes have weathered to a normal soil profile; the Aromas Red Sands area, including the Prunedale district and Royal Oaks County Park; a large uninterrupted stand lies between Aptos and Watsonville along Highway 1.
(10) Foothill woodland	Blue oak, maul oak, black oak, digger pine, coulter pine.	On the slopes of the Gabilan Mountains and the Sierra de Salinas. In the Monterey Bay area, as defined here, Coulter pine grows only in the northern Gabilans —on Fremont Peak and southward to Gloria Pass.

Natural Plant Formations or Groupings	Dominant or Conspicuous Species	Location of Examples
(11) Chaparral	Chamise, manzanitas, and *Ceanothus.*	Slopes and ridges of the Santa Cruz and Gabilan Mountains, and the Sierra de Salinas.
(12) Grassland	Perennial bunch grasses, e.g., *Stipa.*	No sizeable tracts of this plant cover remain. The largest area was probably located in the lower Salinas Valley. It was largely converted to annual grassland soon after European settlement; and then, in part, to cropland.

Chapter 3

THE CULTURAL LANDSCAPE AND ITS DEVELOPMENT

THE MONTEREY BAY area has been occupied successively by three major cultural groups: American Indians of the Costanoan group; Spanish-Mexicans; and "Americans." The last-named is plainly a very general grouping; it includes diverse elements, each of which has made contributions to the area's development, e.g., Americans from the eastern seaboard, Chinese, Italians, Japanese, Portuguese, Yugoslavians, etc. A cumulative effect of occupancy of the area by these several groups has been the production of the existing cultural landscape.

A. INDIAN OCCUPANCY

The Monterey Bay area is within the former territory of the Costanoan Indians. Although Costanoan territory included all of the land draining into Monterey Bay (excepting the upper Salinas Valley) and extended inland into the Santa Clara Valley, the typical Costanoan habitat was coastal. Indeed, the name Costanoan itself is derived from the Spanish word meaning "Coast People."

(1) Costanoan Village Sites and Population Centers

Archaeological evidence, including radiocarbon dating, suggests that the earliest human occupance of coastal California began some 10,000 or more years ago with immigrants who were primarily hunters, and that strong dependence upon shoreline resources and seed gathering developed some time later, around 7500 years ago (Meighan, 1965, p. 712). The Costanoan economy was a continuation of this tradition.

The Costanoans practised no agriculture and raised no domesticated plants or animals, except the dog. Their subsistence was based upon gathering and hunting, and their economy was predominantly biotechnic. The littoral zone appears to have supplied most of the gathered part of their diet. Old habitation sites can be located today by kitchen midden deposits (now commonly called shellmounds because they consist largely of mollusk shells) which accumulated in their villages.

Along the shore, Indian food sources were concentrated in the intertidal zone where shellfish and associated organisms are abundant—near rocky ledges, reefs, and tide pools—found especially on Monterey Peninsula

and Año Nuevo Point. Rocky shoreline is not extensive between Santa Cruz and Monterey Peninsula but shellmounds are common too in the mid-coastal part of the bay, around the mouth of the Pajaro River and in the vicinity of Elkhorn Slough, an area which is also rich in bivalves.

On the coast itself kitchen midden sites are commonly on dunes. The only large accumulation of midden at shoreline between Santa Cruz and Año Nuevo is near the mouth of Laguna Creek, on the only large patch of dune in this stretch. The largest accumulation of midden north of Monterey Peninsula is on the dunes of Año Nuevo Point. (This midden area extends on northward to Gazos Creek, as far as the dunes themselves.) No obvious reasons come to mind for this shoreline congregation of the Indians on dunes. Perhaps good drainage made their surface more attractive in winter than most of the flat coastal terrace, because the dunes were less muddy.

Since this part of California has little rain for about six months of the year, proximity to a permanent water supply was an important factor in the selection of habitation sites. The Indians seldom lived far from streams or springs. Some of the larger villages such as those on Año Nuevo and Laguna Creeks were back a little way from shoreline, in spots protected from coastal winds by the surrounding terrain.

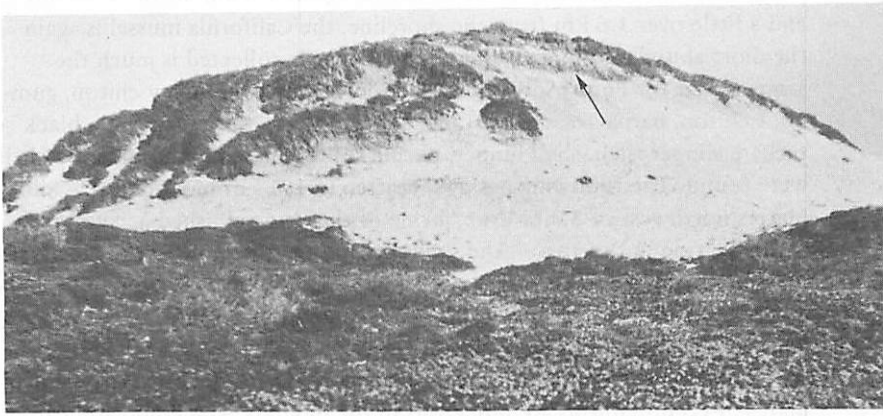
Although the Spanish remark on fighting among coastal tribes, well-organized intertribal warfare was uncommon, and considerations of defense were probably of slight importance in the selection of village sites.

(2) Costanoan Middens, Subsistence and Environmental Effects

The contents of Costanoan middens is the principal source of information on relationships here between aboriginal man and his environment.

Costanoans made no pottery. They cooked in large, water-tight baskets by an extremely laborious, fuel-consuming process called stone boiling. Stones were heated, dropped into baskets filled with water, and, when cooled, replaced with freshly heated ones. Little by little the water was brought to the boiling point. Food materials were added and the heating process continued. Gathering large quantities of fuel broken limbs and twigs must have been a major chore as the Costanoans lacked cutting tools before the arrival of Europeans.

The shore was an important source of food for Indians well back from the coast. Middens rich in shells are to be found miles from shoreline (e.g., on the University of California campus at Santa Cruz). For the area as a whole, the California mussel is the most abundant shell in the mounds, although locally other shells predominate.



Above, **Laguna Creek and Sand Hill Bluff,** south of Davenport, showing two favored Indian habitation sites: sand dunes at shoreline and lee positions at streamsides. Note Laguna Creek in left foreground. The dunes on Sand Hill Bluff, in the background, are covered by a thick deposit of midden. The rock ledges at the base of the bluff, shown here exposed at low tide, were rich sources of marine foods, as were nearby offshore kelp beds. Laguna Creek, seasonally impounded by beach sand, forms a small lake which attracts edible waterfowl. Oak groves and buckeyes grow a short distance inland. *Center,* **Dunes on Sand Hill Bluff.** The slope is covered with shell which has fallen from the thick midden deposit, shown as a dark layer, *arrow,* at the top of the mound. *Left,* **Midden materials,** predominantly mollusk shells. Note the rounded rocks used in stone-boiling; lead pencil, *arrow,* for scale. (Photo, B. Gordon)

More than a dozen shellmounds are located on the dunes at Año Nuevo Point. As wind winnows the sand, shells and artifacts are exposed from time to time. We found remains of the following animals on the surface at one site: shells of California mussel (which predominate), black turban, shell limpet, littleneck clam, purple-hinged scallop, olivella, red abalone, barnacles, and some large sea snails, e.g., red turban; gumboot chiton plates, purple sea urchin tests, and crab claws; fish, mammal, and bird bones. Intermixed with the animal remains are great quantities of chipped chert and flint, many flat, rounded stones, a little larger than the fist (used in stone boiling), and a few pieces of obsidian.

At a site on a tributary of Scott Creek, about 1.6 km north of Swanton and a little over 1.6 km from the shoreline, the California mussel is again the most abundant mollusk and the list of shells collected is much the same as that for Point Año Nuevo: Besides the mussel, mossy chiton, gumboot chiton, barnacles, red abalone, black abalone, littleneck clam, black turban, slipper shell, shell limpet, purple sea urchin tests, and blue top shell were found. The following passage, written in 1914 of mounds a few kilometers northwest of Santa Cruz, is one of the first published accounts of an excavation in the area: "The shells composing the mounds are mostly mussel, though there are many other kinds, and quite a few bones of birds, crabs, and seals, which are in a very good state of preservation." (Dodge, 1914, p. 120.)

The Costanoans fed omnivorously on shorelife. White, butterfly-shaped plates of cryptochitons are numerous in the mounds. The Pomo still eat these chitons although some of the least finicky and convention-bound modern inhabitants have found the cryptochiton unsuitable fare: "After one experiment we decided to reserve the animals for times of famine." (Ricketts and Calvin, 1968, p. 91.)

The Indians gathered all shellfish regardless of size. Shells of many limpets, turbans and other sea snails found in the mounds are so small that they seem hardly worth collecting. Some may have been carried in with clumps of mussels, but they are too numerous to have all been brought in accidentally. Since these shells are usually unbroken, they may have been boiled, whole, for soups.

Gathering mollusks seems to have been women's work: A Scot naturalist visiting the missionized Indians at Carmel in 1792 noted, "Their food at this time was chiefly shellfish which the women collected along the shore, while the men lounged about the country with their bows and arrows, killing rabbits and quails...." (Menzies, 1924, p. 293-294.)

The middens suggest very closely-clustered people. Perhaps cooking was communal as there is hardly space for both dwellings and individual family fires on the mound surfaces.

The Costanoans did not make canoes (Fages, 1937, p. 65), but instead used reed rafts or *balsas*, as the Spanish called them (Costanso, 1910, p. 65-67). Accounts by the explorer Pedro Fages written in 1769-70 are among the most valuable of the historical materials on Costanoan life. The Spaniard describes the Indians at Año Nuevo as being:

> ... very clever at *going out to fish embarked on rafts of reeds*, and they succeed, during good weather, in getting their provisions from the sea ... the land also provides them with an abundance of seeds and fruits. (Fages, 1937, p. 70.)

The reefs and rocky shoreline favored by mussels and abalones are absent in the mudflats of Elkhorn Slough and their shells rarely appear in midden thereabouts. According to one source, Indian shellmounds on Elkhorn Slough contain more of the bent-nosed clams than any other shell (Ricketts and Calvin, 1968, p. 305). But this is not generally the case—although it is true that bent-nosed clams are now among the most common mollusks living in the slough. Three sites are located on the slopes of the low hills which stand above the lower end of the slough on its north side.

The first site, farthest up the slough, is located on the big bend where it turns from a southerly course westward into the bay. The most plentiful shells there are those of the Washington clam (moneyshell clam) and fragments of the native Olympia oyster are also present. At the second site Olympia oyster shells were almost the only ones to be seen. On the third site, not far from the salt ponds at the lower end of the slough, shells of the basket cockle and the white sand clam, rather than the bent-nosed clam, were found.

Abalones and mussels are the most common shells in the midden on Monterey Peninsula. Two species of the former, the red abalone and the black abalone, were especially important to the Indians as food. *Haliotis* "... *rufescens* and *cracherodii* [i.e., the red abalone and the black abalone] are found by the thousands in all stages of decomposition." (Keen, 1896.)

Marine invertebrate remains are present in the midden in great variety on Monterey Peninsula, as at Año Nuevo. The species present are for the most part the same in the two areas. A surface collection of invertebrates made at Fan Shell Beach included sea urchin tests, snails, crabs, and barnacles "... chiton plates are indeed numerous." (Fisher, 1935.) Another

site yielded abalone, mussel, snail, limpet, and barnacles. Midden excavated at the Monterey Custom House Flagpole contained shells of abalones, mussels, clams, limpets, oysters, and landsnails (Beardsley, 1946, p. 22).

Water fowl, including migrant species, were hunted. In November 1770, travelling from Monterey toward the Santa Clara Valley, Fages described the country near the head of Elkhorn Slough. He mentioned passing through

> ... many reed patches crossed by *numerous bear trails.* At one place where they end there was a very large pond, and at the head of this a village of heathen, in which we saw about fifty souls. Two of these heathen went about with two *little rafts hunting ducks on the pool* ... two of them hastened off across the plain to inform two very large villages of our passing; these villages were in sight, midway of our march .... They were very much surprised to see a soldier *kill in passing nine geese at three shots.* (Fages, 1911, p. 140.)

Another characteristic of Costanoan subsistence is suggested by the fact that baskets and arrowpoints were among their principal artifacts. Año Nuevo Point was the chief Costanoan quarry and stone working center. At the seaward end of the point there is an outcrop of banded gray, white, and brown chert. Great quantities of chert fragments, purposely chipped, are present in shellmounds scattered through the neighboring dunes. Complete arrowpoints are, however, very scarce. The probable explanation for the absence of completed points is that only "blanks," i.e., preliminary flakes, were prepared here and these were then carried away for completion elsewhere (Heizer and Treganza, 1944, p. 314). Another large arrowsmith site was located in the dunes near the mouth of Laguna Creek. Banded chert, probably from Año Nuevo or Laguna Creek, is also found in shellmounds northward at Half Moon Bay and southward around Elkhorn Slough.

Large land mammals such as deer and antelopes were important sources of food. In crossing the lower Salinas Valley in 1769, near the present site of Chualar, Spanish explorers noted:

> *Many antelope were seen* going by, and the place was named Real de los Cazadores [Place of the Hunters], for there were then round about it some Indians who were so absorbed and occupied in hunting game that they did not notice us.... (Fages, 1911, p. 61.)

A surprising fact not recorded in the historical sources but made clear from archaeological finds is that sea mammals were also a major source of Indian food. In a collection of bones from the surfaces of two sites on Monterey Peninsula the following were counted (cf. manuscript by Edna Fisher).

Seal and sea lion	116 bones
Fish	190 "
Sea otter	250 "
Deer and elk	157 "
Birds	352 "
Coyotes	8 "
Rodents (gophers, mice, and rabbits)	23 "
Unidentified carnivores	6 "

Although such counts are difficult to interpret they do provide an idea of the relative importance of various food items for purposes of reconstructing a typical Indian diet. The list shows that the Indians had the same unprejudiced taste for vertebrates as for invertebrates—all kinds were eaten, including carnivores. Among the large carnivores, pinnipeds were especially important. More sea otter bones were found than deer and elk, probably because the site is near shoreline. The abundance of sea otter bones suggests that the otters may have been captured on land as well as in the kelpbeds and this conclusion is confirmed by an early historical account. The French explorer Le Perouse who arrived in Monterey Bay September 15, 1786, commented on the Indian methods of otter hunting:

> The Indians ... whose boats at Monterey are only made of reeds, catch them on the land with snares, or by knocking them down with large sticks when they find them at a distance from the shore; for this purpose, they keep themselves concealed among the rocks, for this animal is frightened at the least noise, and immediately plunges into the water. (Le Perouse, 1799, II, p. 208.)

The Southern sea otter has changed its habits. Nowadays, it rarely comes out on shore.

Local differences in predominant species in the middens can usually be explained by variations in neighboring marine habitats. However, there are few abalone shells in the midden at Año Nuevo Point, despite the fact that the point is now known as an excellent abalone fishing ground. Abalone (and *Olivella)* shells are known to have been traded out of the Monterey Bay area in aboriginal times, but it seems unlikely that this can account for their scarcity in the Año Nuevo mounds.

Like other coastal tribes the Costanoans probably dried the meat of mollusks both for their own use and for trade: "... throughout prehistoric time the coast natives exported large amounts of shellfish to the interior ... both shells and dried meat." (Cook, 1946, p. 51.) In the absence of any ethnographic description of these drying operations, an old account of middens west of Santa Cruz, written in 1914, contains an interesting note on the caves in the shale and limestone hills nearby:

> That the Indians carried mussels back to the hills is proved by the abundance of shells in the ground, and *every little cave has its complement, as if they used them for ovens. Shell fragments in the caves seem to have been burned, and the cave walls are discolored by fires.* (Dodge, 1914, p. 120.)

The kitchen middens are the best sources for information on animals used by the Costanoans. For information on the plants they used, historical and ethnographic accounts are the principal sources.

Quantities of acorns and buckeyes were collected for food. Both contain a bitter material which was removed by crushing and leaching the fruit. The leaching was done either in specially made baskets or in sand pits dug for the purpose. After leaching, the meal was dried and stored.

Acorns were the main staple of the north and central California Indians as a whole (Baumhoff, 1963, p. 176), and even coastal Indians depended heavily upon them. The protein content of shellfish is high, but acorns added a needed supply of carbohydrates and fats (Cook, 1946, p. 51). In an old history of Monterey County, it is noted that "Large quantities of acorns were stored in baskets made of willow, and placed in trees fifteen to twenty feet from the ground, and secured from rain, and kept for winter use." (Elliott and Moss, 1881, p. 96.) Whether this account refers to Costanoans or Salinans is uncertain. California Indian population densities were generally at their highest in oak covered areas.

Tanbark acorns were by far the most important acorn in the norther half of the Monterey Bay area. In only a few parts of California were tanbark oaks more common than in the Santa Cruz Mountains. The tree is a heavy and regular producer, and its acorns are preferred over others. The large acorns grow in clusters and, in October, are easily plucked. Those that cannot be reached can be collected from the ground a month or so later. No doubt regular seasonal visits to tanbark groves were customary for the coastal Indians. (Strictly speaking, the tanbark is not a true oak, belonging as it does in the genus *Lithocarpus*, rather than *Quercus.)*

Of the common oak species, the acorns of the coast live oak, the most abundant oak in coastal parts of the Monterey Bay area, were the least important as food for the Indians (Baumhoff, 1963, p. 165). The yield is small, variable, and of inferior quality.

In addition to the rich acorn source in tanbark groves of the Santa Cruz Mountains, there must have been something of a concentration of the area's diversified acorn resource in the Sierra de Salinas and northern Santa Lucia Mountains where blue oak, valley oak, interior live oak, and black oak—all major acorn producers—along with some tanbark oak, are all found.

Sources of acorns in both of these areas were denied to the newly converted Indians on Monterey Peninsula according to one of the earliest accounts of mission days:

> The hill Indians also of the Sierra de Santa Lucia who live between this mission [Carmel] and that of San Antonio de las Robles [Paso Robles], persecute indiscriminately the New Christians of this region [that is, the Indian converts of Monterey Peninsula] whenever they enter the range to search for acorns, which the hill Indians guard and desire to keep for their own. These unhappy people encounter the same resistance when they go along the beach above Monterey [that is, northward to the tanbark groves of the Santa Cruz Mountains] on the same quest.... (Fages, 1937, p. 64.)

Acorns were scarce in the coast live oak-Monterey pine country around Carmel and elsewhere on Monterey Peninsula. Use of what is clearly the buckeye was noted there by the Spanish sources:

> Those who are in this mission and nearby obtain few acorns, the lack of which they supply in part with blackberries and strawberries, which abound around the point of the Monte de Pinos; there are many *boletes* or mushrooms, and *another wild fruit about the size of an ordinary pear which is eaten roasted and boiled though it is somewhat bitter. The tree which bears it is rather whitish, like a fig tree, but not very tall. When it bears fruit it sheds its leaves entirely.* (Fages, 1937, p. 68.)

Early accounts of burning are especially numerous from Santa Cruz northward to Año Nuevo and beyond. Grass seed which may have been particularly important as food there was gathered elsewhere, also. Between the Pajaro and Salinas Rivers, and about 4.2 km from the latter, Spanish explorers noted, "... we saw near a lake some women who were gathering grass seeds...." (Bolton, 1930, p. 452.) (This must have been in the vicinity of Lake Espinosa; an archaeological site exists on one of the nearby Vierra Lakes.)

A variety of fiber plants were used. The following account is of Indians south of Monterey.

> There are two plants from which the natives obtain thread sufficiently strong for their needs. One of them grows on a moist soil and is very like true hemp, at least I take it to be so, and the other grows on dry ground and has leaves like a walnut, ashy colored and downy, with a white flower.... Neither of these plants grows to a height of more than three or four spans. (Fages, 1937, p. 80.)

These are good descriptions of two widely used aboriginal fiber plants, Indian hemp and milkweed. The Indian hemp, though rarer now than formerly is still found in some abundance around a few old Indian sites throughout central California.

The crafts of nearby tribes have been thoroughly studied. The beautiful basketry of the Pomo to the north and the Salinan to the south is well known, but few specimens of Costanoan basketry are in existence. Probably Costanoan baskets were similar to those made by their neighbors. Good quality basketry is essential to the practise of stone-boiling.

The Costanoans must have used a large part of their energy in canvassing the country to gather food. Although the annual range in temperature in the area is not great, the inland supply of wild foods varies greatly due to seasonal rainfall. This was probably an important reason for the concentration of Indian populations along the coast. Being seasonally less variable, the intertidal zone offers gatherers a more dependable food-source than does the inland. Although shoreline foods were the mainstay, Costanoan life was probably at its best in the fall when inland acorns, buckeyes, islay prune, and blackberries ripened, grass seeds matured, and migrant flocks of ducks and geese arrived.

(3) Disappearance of the Costanoans

The Indians, first concentrated in the missions during the Spanish period, were dispersed when the missions were secularized during the Mexican period. The naturalist Menzies, visiting Mission Carmel in 1792 during the Spanish administration wrote "Close by, we saw a large village of huts containing about seven hundred Indians converted to the Christian religion...." (Menzies, 1924, p. 284.)

An American who visited San Juan Bautista in 1833, immediately before secularization, found it "... containing from six to seven hundred inhabitants —all of whom are Indians, with the exception of the priests and fifteen or twenty people who are occupied in teaching and instructing these heathens." (Leonard, 1934, p. 161.)

When he visited Monterey in 1836, a few years after secularization, Dana the author of *Two Years Before The Mast,* commented on:

> ... the pure Indian, who runs about with nothing upon him but a small piece of cloth, kept up by a wide leather strap drawn around his waist.... The Indians, as I have said before do all the hard work, two or three being attached to each [Spanish] house; and the poorest persons are able to keep one, at least, for they have only to feed them. (Dana, 1911, p. 82 and 86.)

Dana also states (1911, p. 74) that there were about a hundred houses in Monterey, so several hundred Indians must have been working as servants for the Spanish in Monterey at that time.

The Costanoan way of life was greatly altered during the Spanish-Mexican period. Within a short time they learned something of agriculture. An American traveller in 1833 who described his position as being about forty miles south of San Francisco and sixty or seventy miles north of Monterey (i.e., somewhere near Point Año Nuevo), remarked that "In some parts the natives raise a small quantity of corn, pumpkins, melons, etc." (Leonard, 1934, p. 91.) At a point farther south, closer to Monterey, he observed, "Some of the natives live well, as they cultivate pumpkins, beans and some of them Indian corn ... they also raise an abundance of melons...." (Leonard, 1934, p. 95.) All of these agricultural plants were introduced here by the Spanish.

During the early Spanish Period the Indians had been mainly transferred to the missions at San Juan Bautista, Soledad, and Carmel from the Pajaro Valley. After secularization some drifted back to the valley as laborers. An American settler in the valley recorded that in 1852 "We had a great many Indians in the valley. They made good hands to dig potatoes and bind grain. The squaws gathered wheat after the crops were harvested." (Kitchen, 1952, unpaginated.) Kitchen probably means "a great many" relative to the total population, which was very small at the time. Costanoan culture did not last long in the American period of occupancy. The note above is one of the last published references to Indians living in the Pajaro Valley.

Introduced European diseases, particularly whooping cough and measles, are known to have decimated other California Indian groups, but few records exist of their effects upon the Costanoans. Nonetheless, the Costanoans are now virtually extinct. Today a few people of partly Costanoan descent reside near San Jose and around the old mission San Juan Bautista. But their mission Costanoan forebears had abandoned most all tribal customs more than a century ago.

The total Costanoan population has been estimated at 11,000 at the time the first Europeans arrived. Probably at least a third of them lived in the Monterey Bay area. In 1920, there were 56 survivors (Cook, 1943, p. 40).

Probably the destructive effects of European settlement, both Spanish and American, upon Costanoan culture bore most heavily upon the Indians' food sources: They were taken or driven away from their food supply, or the food resource itself was destroyed in place (Cook, 1943, p. 26).

A few Indians may have survived in the hills northwest of Santa Cruz until around the middle of the last century practising, to some extent, their traditional livelihood. The following note written in 1914 refers to a large shellmound about five miles upcoast from Santa Cruz: "Old timers tell me

that the Indians used to come from the hills to this place, gather and cook shell fish, and throw the shells on the heap." (Dodge, 1914, p. 120.)

The content of Costanoan shellmounds shows that the central Californian littoral had been subjected to a thoroughgoing human influence long before the coming of Europeans.

The total volume of shells in California middens is so great that later it was sometimes mined by Americans. For example, in the San Francisco Bay area it was used as road surfacing material. Midden from a site described as being about five miles upcoast from Santa cruz (near Laguna Creek ?) was also used: "... on the coast is a large shell mound about 270 feet long and 90 feet wide. How high it formerly was cannot be told *as most of it has been removed by poultry men who used to haul it away by the wagon loads;* at this time the mound was about 20 feet high." (Dodge, 1914, p. 120.) The quantity of shell in the mounds and the presence of both mature and immature specimens of most of the common species suggest that parts of the shoreline were nearly stripped of mollusks at times. It seems likely that the Costanoans were a principal control of animal population numbers in the littoral zone, particularly of mollusk and pinniped numbers, and that this control was sustained for centuries. On the other hand, the Indians' subsistence-demands were spread over virtually the entire biotic spectrum. This is in contrast to later inhabitants whose special and limited preferences (e.g., for the red abalone and sea otter) may have generated imbalances by making heavy demands on only a few species.

(4) Plant Cover and Indian Burning Before European Settlement

The first European to see Monterey Bay was Juan Rodriguez Cabrillo, in November 1542. Unable to land because of high seas, he skirted the shores of the bay and finally anchored near the shore in approximately 80 m. He named the bay "Bahia de los Pinos." Although the name was probably suggested by the pine forests on Monterey Peninsula and Point Año Nuevo, coniferous trees may have grown on other parts of the Monterey Bay coastland as well. Cabrillo stated that he sighted pine trees (or at least trees with a similar outline—redwood? Douglas fir?) from his anchorage: "... the depth of water in which Cabrillo's ship was anchored close to the coast can only be found off Moss Landing in the submarine canyon." (Wagner, 1937, II, p. 398.) Thus, the country within sight of Moss Landing, now almost treeless, may have supported some coniferous growth at that time.

Sebastian Vizcaíno, the first European explorer to enter and describe the Monterey Bay, landed in the vicinity of what is now Monterey Harbor in December, 1602. He found pines and oaks near shoreline there, in an area now partly covered by the city of Monterey (Mathes, 1965, I, p. 375 and 603). In 1770, Father Junipero Serra took possession of California for Spain, standing beneath an oak which grew at the site of the Mission San Carlos in Monterey.

At the time when European settlement began, the vegetation in parts of the Monterey Bay area had been considerably altered by fires set by the Costanoan Indians, who found an increased supply of food plants and game in country opened by burning. The amount of burning done by the Indians is generally underestimated. Fire was their principal tool of land management. Historical and ethnographic evidence suggests that their burning was done with considerable skill and foresight, that the successional consequences of burning were well known to them, and that when they were forced to discontinue the practise some of their main food sources were cut off.

In parts of the area, the seed of grasses or other herbaceous plants was a food staple. Exactly which plants these were is uncertain. It is unlikely that grass seeds were the only ones collected as the yield of the native grasses was small. One plant which comes immediately to mind here, because of its common use by California Indians is the chia.

The Indians continued the practise of burning for a time after the beginnings of Spanish settlement. A Spanish captain, writing at the presidio in Monterey on October 3, 1774, spoke of a "... bad habit of the heathens. *Having harvested their seeds, they set fires ... so that new 'yerbas'* [grasses or herbs] *will come up; also to catch the rabbits which get confused by the smoke.*" (Rivera y Moncada, 1774, I, p. 57-58.) The practise was noted elsewhere in the vicinity of Monterey Peninsula: On July 5, of the same year, the captain wrote of smoke from fires set by the Indians in the country "to the south" being visible from the presidio. The party sent that afternoon to investigate did not return until dusk, reporting that the fires were farther away than had been supposed (Rivera y Moncada, 1774, I, p. 34). These fires were probably in the Carmel Valley.

Although game drives using fire are not generally associated with Indians of this area, the account of rabbit hunting as well as early accounts of antelope hunting near Chualar strongly suggest that such drives were in fact aboriginal practise here, on a small scale (Fages, 1911, p. 61, and Crespi's diary cited in Bolton, 1927, p. 300).

California Indians also set fires to produce a needed supply of greens:

> *In all of New California from Fronteras northward the gentiles have the custom of burning the brush* so that with the first light rain or dew the shoots will come up ... upon which they feed like cattle when the weather does not permit them to seek other food. (Simpson, 1961, p. 51.)

These comments may refer to one of the several species of clover known to have been eaten by various California tribes.

Indian burning was still widespread after several decades of Spanish settlement, and a nuisance to cattlemen. Official proclamations were issued asking mission authorities up and down the coast to warn offenders "against this very harmful practise of setting fires to pasture lands." Governor Arrillaga wrote from Santa Barbara to the Father President of the Missions on May 31, 1793:

> Because of ... the serious damage that results from the fires that are set each year in the pastures by Christian and Gentile Indians ... [the mission fathers should warn] the Christian Indians, and particularly the old women ... threatening them with the rigors of the law.... (Clar, 1957, p. 6, 8, and 10.)

Mission Santa Cruz and the "other two missions of the north," i.e., Santa Clara and San Francisco (all within Costanoan territory) are specifically mentioned as having received the warning immediately.

Within the circuit of Carmel Mission the Indian used fire in harvesting pine nuts:

> The cones of the pine tree are small, and the nuts are extremely so, but very good and pleasing to the taste. The method of gathering them is to build a fire at the foot of the tree, which in a few hours falls, making the fruit available without difficulty. (Fages, 1937, p. 68.)

Which pine species this may have been is uncertain. The most important food species in this part of California was the digger pine but at least nowadays, the tree does not grow on Monterey Peninsula itself. The reference may be to a small area of digger pines in Pine Canyon a few kilometers eastward, near the north base of Mt. Toro.

Indian uses of fire were numerous. The described method of harvesting pine nuts seems rather impractical and may be incomplete. Early accounts of Indian actions are sometimes difficult to interpret—not necessarily because the accounts are inaccurate, but rather because knowledge of Costanoan customs is so limited. Thus in a Spanish explorer's diary we find the following comment from the vicinity of Aptos: "Along these hills and in their vicinity we saw groves of hazelnuts, although it had been recently

burned and not grown up again." (Bolton, 1930, II, p. 449.) The native hazelnut produces a very meager harvest of nuts, leading one to wonder what the Indians could have been doing with it. The explanation may come from the ethnographic accounts of other California tribes for whom more information is available. Hupa women sought out regrowth patches of hazelnut during the second and third year after they had been burned over, to gather shoots for the manufacture of large baskets (Goddard, 1903, p. 38).

When missionary Father Juan Crespi, coming from the south with the Portola expedition entered the Salinas Valley near the present site of King City he wrote an account of plant cover and Indian burning. Travelling northwestward along the Salinas River on September 28, 1769, in the vicinity of Greenfield his party "... followed the same valley and river by a level road, *the grass all burned.*" In the evening the party "... halted in the same plain of the valley *in the midst of a grove of live oaks* which had a *little pasture that had not been burned.*" Proceeding northwestward the next day, September 29, between Soledad and Chualar, the party followed "... the course of the river by a level road like the preceding, *although it was more abundant in unburned pasture.*" Near Chualar, the party passed along "... the wood formed by the trees of the river which must be more than four hundred varas [that is, more than 365 m] wide." On the next day, September 30, travelling northward from Chualar, Crespi again noted that "The soil is whitish and *short of pasture on account of the fires set by the heathen.*" (Bolton, 1927, p. 199-201.) Thus, Fr. Crespi saw mainly newly-burned grassland on the floor of the Salinas Valley between the present sites of Greenfield and Spreckels, with at least one isolated grove of live oaks and a broad strip of riparian forest along the river itself.

Fr. Crespi's diary goes on to describe the neighborhood of an Indian village in the lower Pajaro Valley near the present site of Watsonville: On October 8, "We halted on the bank of the river ... which was near its very verdant and pleasant plain, *full of cottonwoods, alders, tall oaks, live oaks,* and other species not known to us.... The soldiers called the stream Río del Pajaro." (Bolton, 1927, p. 211.) This floodplain forest of the lower Pajaro Valley has disappeared; today the land is used for intensive culture of field crops.

The diary next describes the country between Watsonville and Pinto Lake: On October 10, "... we must have travelled but little more than one league [about 5 km], *over plains and low hills, well forested* with very high trees of a red color, not known to us. They have a very different leaf from cedars.... We stopped near a lagoon...." (Bolton, 1927, p. 211.) These notes

are the first historical account of the California redwood. The land between the Pajaro River and Pinto Lake is now planted to orchard and truck crops. A few isolated clusters of redwood trees can still be seen east of Freedom and several large redwood trees (probably planted there) grow in Watsonville itself, but sizeable groves are now to be found only in the hills to the east.

Early historical records are sometimes discounted as being simply the careless, general observations of missionaries and fortune hunters who had little real interest in natural history. This mistaken impression arises mainly from difficulties in accurately translating the early journals in terms of the local setting and the knowledge available at the time. The first Spanish journals are filled with sound comment on plant and animal life, but since the California flora contains many genera completely lacking in Europe, the Spanish language contained no relevant names for much of it. The old diaries show that in coming upon the plants of their homeland here, the wild roses, oaks, alders, and pines, the homesick explorers, plainly delighted, greeted the "flowers of Castille" as so many familiar faces. The diaries also show the travellers, both soldiers and priests debating the botanical relationships of conspicuous species new to them—for instance, arguing about whether the redwood was actually more like a cedar or a fir.

On October 16, 1769, Crespi's party, coming from the neighborhood of Corralitos, travelled "... very near the beach, and the range of hills which follows, which has *good pasture, although it has just been burned by the heathen.*" On October 17, they came to the San Lorenzo River: "Not far from the stream *we found a patch of ground that is not burned,* and it is a pleasure to see the grass and the variety of herbs...." On October 18, they moved from what is now the site of Santa Cruz, along the coast toward Ano Nuevo: "... we descended and ascended four deep watercourses [these would include Wilder, Laguna, and Scott Creeks] .... *Only in the watercourses are any trees to be seen; elsewhere we saw nothing but grass that was burned.*" (Bolton, 1927, p. 214-216.)

The early Spanish accounts of their travels repeatedly mention tree growth: pines, oaks, sycamores, cottonwoods, and so on. Mindful both of the needs of their horses and prospects for the area's settlement, the Spanish conscientiously noted the occurrence of timber, grass, and water. There can be little question that except for the Salinas Valley, their impression was one of a well-wooded area. Nevertheless, parts of the country were plainly already open grassland in 1769, and the association of this grassland with Indian burning (done just before the beginning of the rainy season) is explicit.

Thus, when the Spanish first saw the Monterey Bay area, its potential natural vegetation was not everywhere in existence. Man-made fires were already an important ecological factor in the coastal area where lightning-caused fires rarely occur.

Grass-covered surfaces of the lower marine terraces upcoast from Santa Cruz were no doubt already kept in grass cover as a result of Indian burning in the distant past. The same is probably true of parts of the lower Salinas Valley and some of the grassy "balds" on hills in the southern part of the area (e.g., on the northern slopes of Mt. Toro). It is true that the minimal invasion of woody plants in these balds suggests that the potential natural vegetation is in fact herbaceous. But there is no edaphic or climatic explanation for the absence of woody growth in most of the grasslands. Prolonged Indian burning and in more recent times cattle grazing, high deer populations, and occasional fires probably explain the absence of woody plants.

On the other hand, except for the portions repeatedly burned over by the Indians, and despite the escape of fires into the hinterlands that must have occurred occasionally, much of the Monterey Bay area was probably covered by only slightly disturbed plant communities at the time it was seen by the Spanish. Few alien species had been introduced. The plants and animals present in Indian times were native to this region with but few exceptions.

The domesticated dog and a few household pests (e.g., fleas and lice) had arrived long before, with the first immigrants to the Americas from the Old World. The seeds of Indian hemp may have been traded here from the east.

Some of the plants known to have been used by the Costanoans still grow in the neighborhood of midden sites. In places, for example, the distribution of the buckeye is peculiar, growing as it does in small groves both along the stream courses and in isolated clusters well up on the slopes. How its heavy fruits were disseminated to give such a spotty distribution is something of a puzzle. It has been suggested (Jepson, 1923, p. 167) that this distribution is partly artificial—the result of the Indians' transporting the fruit for food and dropping some by their campsites. Buckeyes are strung along Año Nuevo Creek where a principal local Costanoan village was located; and trees grow near shellmounds on Scott and Laguna Creeks.

Collecting and transporting acorns in large quantities as they did, the Indians no doubt influenced the numbers of oak trees, and perhaps, to some extent, their distribution.

B. SPANISH-MEXICAN LAND USE: ENVIRONMENTAL EFFECTS

More than a century and a half passed between the Spanish discovery of Monterey Bay and the establishment of the first settlements in 1770, shortly after the arrival of Portola's expedition. Settlement brought about sweeping changes in landscape and ecology. New plants and animals, especially cattle, were introduced. Tillage and irrigation began, although on a very limited scale. Areas suitable for grazing cattle already existed, particularly in the lower Salinas Valley, but such grassland was extended by the burning of woody plant cover in lowlands and on the lower slopes. Cattle, horses, and sheep were soon being raised in large numbers to support a Spanish colonial economy based mainly on grazing.

Exotic plants and animals were introduced, particularly from the Mediterranean area, and the new species spread to other parts of the west coast from Monterey, the main site of Spanish activity in northern California. Some of the grasses and weeds are now among the most characteristic plants of rural California: wild oat, for instance, and mustard, wild radish, foxtail, and bur clover.

An ingenious method of determining the time of introduction of weed species involves ascertaining the presence or absence of their seeds in adobe samples taken from the Spanish missions whose construction dates are known (see Hendry's publications). For example, the wild oat and the redstem filaree are both present in the bricks of the mission of San Juan Bautista, constructed in 1797. Exactly how these plants got into the area is not known. No doubt the seeds of some arrived intermixed with crop seed and in the fleeces and pelts of domestic animals. Hay, carried by mule train to the mines in the Santa Lucia Mountains and eastward to Idria and New Almaden, probably included some of the first exotic weeds and insects imported to the hinterland.

Cattle raising was the Spanish activity that had the greatest influence on the landscape. Accounts written during the Spanish-Mexican period agree on the great numbers of cattle. A description of the Pajaro Valley as it was in mid-19th century stated: "There were no fences in the valley. Hundreds of Spanish cattle were here at that time. We went on horseback to keep from being chased by them." (Kitchen, 1952, unpaginated.)

A report by John C. Fremont written in 1846, shows that by this time parts of the original woodland and forest in the northern part of the bay area had been cleared, and that the wild oat, introduced about half a century earlier, had become well-established:

> ... in the country between Santa Cruz and Monterey and around the plains of St. John [that is, around San Juan Bautista] the grass, which had been eaten down by the *large herds of cattle*, was now everywhere springing up ... in the valleys of the mountains bordering the Salinas plains ... *wild oats* were three feet high, and well headed, by the 6th of March. (Fremont, 1849, p. 68.)

In comparison with the cattle industry, agriculture was a minor Spanish activity. It was localized mainly around the missions where Old World plants, whose cultivation in California began with the Spanish, included the wine grape, the olive, the fig, apple, pear, and English walnut. The pepper tree was also carried here by the Spanish from their colonies in the Andes.

The far-reaching ecological effect of Spanish occupancy was out of proportion to the number of settlers. Even during the latter part of the Spanish-Mexican Period population was sparse over most of the bay area. As late as 1847, the Pajaro Valley, now outstanding for its agricultural productivity, "contained only about forty inhabitants, and was a great pasture ground for their herds." (*Overland Monthly*, 1887, p. 6.) In this early census the writer disregards the few surviving Costanoans.

During the Mexican Period many land grants, *ranchos*, were awarded to Spanish-speaking settlers. Although most of the grants had been in existence scarcely twenty years when California became an American possession, they indelibly marked the landscape by establishing a framework within which future subdivisions of the land were made. The framework can still be seen from the air. In the country between the Salinas and Pajaro Rivers grant boundaries act as property divisions throughout almost eighty percent of their lengths (Foster, 1968, p. 88). Where not bounded by natural features the grants are nowadays almost everywhere marked by fences and roads. On aerial photographs the old grant boundaries often stand out strongly because field strips, furrows, and plant rows abut against them at differing angles on opposite sides. In hilly country, they may mark the edges of chaparral tracts. Different grazing stages frequently appear on opposite sides of their now fenced boundaries. Thus they commonly demarcate contrasting animal habitats as well.

The Spanish did little tilling of the soil. A British naturalist visiting Monterey in 1792, reproached the inhabitants there for "... not rearing in country like this where the soil is so very productive a sufficient quantity of vegetables for their own consumption...." (Menzies, 1924, p. 287.) And Americans arriving in the Salinas and Pajaro Valleys in the mid-19th century remarked similarly on the characteristic Spanish land use: only a few tiny

gardens, multitudes of cattle, and no fences or barns (Leonard, 1934, p. 168, and Kitchen, 1952).

Although the Spanish did not fence their range land here, they began the planting of tree rows, or living fences, near settlements—a practise which they had established over most of their cattle country in Central America. Tree rows appear in several drawings and paintings made of Monterey Peninsula in the 1840's (Van Nostrand, 1968, plates 26 and 40); and beyond the Monterey Bay area, between Santa Clara and San Jose, tree rows were given official protection from woodcutters in 1833 (Hittel, 1882, II, p. 70). Unfortunately, both from the standpoint of beautifying the countryside and maintaining its wildlife, the practise was discontinued within a few years after American occupancy began.

C. CHANGES ATTENDING AMERICAN OCCUPANCY

The Costanoan Indian population virtually disappeared during the first few decades of American settlement and hard-pressed Spanish-Mexicans survived mainly in poorer country as described in the following account written by an American in May 1870:

> From this point [about 8 km up the Pajaro Valley from Watsonville, around Aromas] to San Juan, there is little to interest the traveller: the few secluded spots among the hills adapted to farming, being occupied by Mexicans; the hills, already parched and brown, occupied by sheep, horses, cattle and the ubiquitous ground squirrel. (*The Overland Monthly*, 1870, p. 348.)

The narrator, like most American settlers, appraised the area largely in terms of its farming potentialities, in contrast to the Spanish-Mexican cattlemen.

Large scale commercial agriculture, with extensive plowing, drainage, and irrigation, began under the Americans.

The introduction of exotic species continued with the Americans and they now number in the hundreds. In addition to the numerous agricultural and horticultural species which are planted in the area, many foreign plants reproduce themselves here untended. By far the larger number of the alien plants growing outside cultivation in the area are herbaceous. More than half are composites, grasses, legumes, or crucifers. Although most were imported accidentally, many are now considered valuable additions to the flora, particularly as forage plants. In the early days came such common plants as poison hemlock, sweet fennel, bermuda grass, and common groundsel and eucalyptus. The pampas grass, which now thrives on roadcuts

and badly eroded spots is more recent. (For a thorough discussion of alien plants established in California see Robbins, 1940, and Frenkel, 1970.)

Almost one-third (31%) of the total number of 553 species of vascular plants growing without cultivation in the Santa Cruz Mountains are introduced (Thomas, 1961, p. 25). But such facts alone do not completely reveal the sweeping changes in plant cover: Over the larger part of the Monterey Bay area, particularly in the lower and drier sections, introduced plants cover much more of the actual surface than do natives.

Virtually no foreign species can penetrate and establish themselves within the natural plant associations, except where the latter are broken by open patches or otherwise disturbed. In the Santa Cruz Mountains the yellow-flowered French broom has become established along road banks throughout redwood forest and chaparral. But the shrub is not found in the undisturbed interior of these associations. Near the Pajaro River at Watsonville (as along other streams) two vines, the periwinkle from Europe and German ivy from South Africa, intrude into the narrow strip of willow-cottonwood forest between the artificial levee and the river bank. This riparian vegetation is subject to constant disturbance both natural (by flooding) and artificial. Saline environments especially resist the intrusion of alien weeds. As a result, the tidal zone on the open coast appears to be completely without foreign plants, although exotic animals are found there. There are exceptions: brass buttons, an African species, grows within the pickleweed area in salt marshes of Elkhorn Slough and Japanese marine algae grow on neighboring mudflats.

Relatively few native plants have developed the weedy characteristics of Eurasian immigrants and expanded their ranges into the areas disturbed by clearing, burning, and tillage. Some which have done so are the coyote bush, miner's lettuce (in shaded and moist spots), and the turkey mullein (in the drier parts of the area).

Among the native plants which have had their ranges extended through planting are the Monterey cypress and the Monterey pine: both are much more abundant than formerly. Under natural conditions the Monterey cypress verged on extinction. When Europeans first arrived there were only a few thousand of these trees, all living within several hundred feet of shoreline on Monterey Peninsula and around Carmel Bay. Perhaps in Spanish-Mexican times, and certainly in the 1870's, the cypress was being widely planted. A nursery for its propagation was located a few miles east of Monterey (*The Salinas City Index*, April 27, 1876). The Monterey pine, too, has been planted beyond its natural range in the Monterey Bay area, and especially abroad.

On the other hand, the ranges of most native species have been reduced. In an area as rich in endemics as this one, burning, logging, clearing, and draining operations, and more recently housing developments, are particularly likely to result in the extinction of species.

Seasonal color changes in plant cover have likely been accentuated since European settlement began: The most conspicuous overall seasonal change in appearance of the landscape is largely the result of deforestation. Hills, originally covered with dark evergreen trees, now are covered with grasses which turn from yellow-tan in summer to light green in winter. The bright yellow colors produced from January to April by the blossoms of mustard, acacia, and Cape oxalis, all alien plants, were lacking aboriginally.

(1) Calendar of Events of Special Ecological Significance

Following are additional historical events which were important in the development of existing ecological conditions:

For a period of fifty years after European settlement practically the only commerce on the California coast had to do with the hunting of marine animals. The principal commercial items were sea otter, fur seal, sea lion, and whale (Evermann, 1923, p. 522 and 526). Monterey was a major center. In the last half of the 19th century whaling became a major industry on the shores of Monterey Bay.

Fire has long been an important ecological factor in the area—not fires set by natural causes (these are rare here), but fires set purposely or accidentally by man. Much of the grassland in the Monterey Bay area was created by burning off woody plant cover. The intentional burning, begun during the period of Indian occupancy was continued on a greater scale in association with the Spanish and American cattle industry (much facilitated, in later years by the use of matches); and the number of accidentally set fires increased.

When woody cover is burned off, grass and forbs soon replace it. Grass-forb cover may maintain itself for years under constant grazing. If grazing is discontinued, chaparral and forest begin to reclaim the land, rendering it useless to the cattleman. Intentional burning to improve grazing was frequently condemned but "... in many backward communities [of California], it was practically considered to be a duty on the part of some citizens to burn the woods, regardless of who owned them." (Clar, 1959, p. 300.) Despite restrictive legislation the practise died slowly and violations persisted in the area at least into the 1930's.

The combined incursions of American lumbermen and agriculturists into the forests of the area during the last half of the last century are illustrated in the following description of the San Lorenzo Valley north of Santa Cruz:

> The industries of this section are in the main the manufacture of lumber and the production of railroad ties, telegraph poles, shingles, shakes, barrel staves, etc.... As the axeman and the oxteam advance ... the husbandman, the viniculturist and the orchardist keep pace.... (*The Resource of California*, June 1883, p. 6.)

Most of the numerous openings scattered over the San Lorenzo Valley, now tilled, grazed, or in various stages of regrowth, date from this period, as do most of the valley's introduced plant and animal species.

In 1871, the Southern Pacific Railroad joined the Pajaro Valley to the Santa Clara Valley with a line which ran through Chittenden Pass. After the arrival of the railroad, quantities of grain, cattle, firewood, and household goods were hauled into and out of the area. Weed and insect species were no doubt introduced repeatedly as the railroads provided continuous routes of dissemination from the east coast.

Although Spanish cattlemen had made little use of enclosures, except for corrals, American ranchers put up wooden fences. These however, were replaced almost entirely with barbwire in the early 1870's.

Lumbering was started by the mission fathers using Indian laborers, but the scale was so small that ecological consequences were slight. Under the Americans, operations were conducted on a grand scale, particularly the lumbering of redwood trees. Lumber companies penetrated virtually the whole redwood area, leaving almost no virgin stands. Old photographs show scenes of devastating and slovenly operations. The giant trees in the unharvested grove in Big Basin State Park give some impression of the original redwood forests as seen by the Spanish. Unlike most conifers, redwood sprouts from the root crown when felled and thus it has great regenerative powers. When the trees are sawed saplings sprout, forming circles around the parent stumps. In the 1870's and 1880's, the period during which the larger number of trees were sawed, many such circles were formed. Today a circular grove pattern of trees a little under a century in age is common throughout existing forests. Good examples can be seen at Henry Cowell Redwoods State Park and at Mount Madonna County Park. At one time there were twenty-five sawmills within a 8 km radius of Boulder Creek alone (McHugh, 1959, p. 16). The logs were dragged out of the forest on skid roads using oxen originally and later,

steam power. Deep gulches were gouged out. Some can still be seen, although most are now overgrown.

With the disappearance of the Indian population, the tanbark oak ceased to be a source of human food, but beginning with American settlement a completely new use for the tree was found—the use of its bark in tanning hides. Tanbark oak is an example of a hardy species which has survived very intensive disturbance by man.

Santa Cruz County is one of the oldest and largest tanning centers in California. The bark of the tanbark oak was first used in Santa Cruz (Jepson, 1911, p. 8) and the industry was concentrated there because of the large number of these trees in the area. The first tannery was built in Scott's Valley in 1843. By 1868, tanning was a major industry: "There are at present seven tanneries in Santa Cruz which consume monthly about three hundred tons of this bark...." (Cronise, 1868, p. 131.) In 1870, there were ten tanneries in the county. Great quantities of tanbark were hauled out of the Santa Cruz Mountains on mule back. Over 5000 cords of bark were harvested in 1886 alone. Large quantities of tanbark were collected in the Santa Lucia Mountains, as well.

As the tanbark oak does not form extensive pure stands under natural conditions, collecting the bark involved making many paths through the forests—already greatly disturbed by redwood lumbering operations. Within a few decades the tanning industry was threatening the existence of the oak and the industry begun its decline because of a dwindling supply of bark. In 1918, it was estimated that three quarters of the tanbark oak of Santa Cruz County had been peeled (*Timberman,* June 15, 1918). The tree was saved only by protective legislation.

Tanbark oaks are today once more plentiful. Dense, evenly-aged regrowth stands are found throughout the west slopes of the Santa Cruz Mountains; for example, in Nesine Marks State Park.

By the time the Americans reached California commercial hunting had become part of their way of life. For several decades after their arrival, hunters, unrestrained by laws, ravished the wildlife of the Monterey Bay area. Old editions of the Salinas newspapers record both the sale of game at local markets and its shipment to San Francisco. The establishment of the California Board of Fish Commissioners (forerunner of the California Fish and Game Department) in 1870, the termination of commercial hunting and the legal regulation of hunting and fishing were instituted. This was of major ecological importance, as were the building of fish hatcheries and the introduction of game animals. Another form of

regulation of animal numbers long practised on a sweeping scale is pest control. State pest control agencies (e.g., mosquito abatement) are concerned with public hygiene. County agricultural commissioners work with local farmers to protect crops (e.g., from the California ground squirrel). Biological controls have been studied and applied here on a limited scale but so far have been deemed inadequate. As a result, controls commonly involve an onslaught with pesticides, herbicides, and the like, and are a negative form of regulation compared with game laws and stocking programs, albeit necessary under present conditions of land use. These two approaches represent about all that exists in the way of planned regulation of animal numbers.

The protection of large tracts of native plant cover and associated animal life with the establishment of the state parks and beaches and the county parks is also of major ecological significance. In 1927, the State Division of Beaches and Parks was organized. More than a dozen beaches were made available for public use in the area. Año Nuevo Island was purchased by the State in 1955, and soon thereafter was made a scientific reserve, closed to the public in order to reestablish the pinniped population there. Similarly significant was the founding of the State Department of Forestry, with its regulation of logging and burning.

Technological innovations have profoundly affected plant and animal life. The introduction of turbine pumps between 1910 and 1920 greatly increased the redistribution of water and irrigation, especially in the Salinas Valley. Automobile transport, begun in the early years of the 20th century, produced a denser road network and contributed to air pollution. The widespread use of herbicides and chemical changes in insecticides (e.g., the use of chlorinated hydrocarbons) following World War II are among the stronger influences recently exerted by man on life in the area.

The larger part of the pesticide and herbicide chemicals used is for purposes of eradicating alien plants and animals, since most of the worst agricultural pests in the area are those which arrived with agriculture itself.

Following construction in Moss Landing in 1942, the Kaiser Refractories factory began hauling dolomite from Natividad in the Gabilans, extracting magnesium from seawater and emptying tailings into the bay. Local thermal alterations of the bay's water began when the Pacific Gas and Electric plant at Moss Landing started operating in 1952. Seawater is used as a coolant and the heated water is discharged partly into the slough and partly into the bay. The plant is still not operating at projected maximum output although a major expansion was completed in 1968.

(2) The Rural and Urban Biotic Associations

The total area of the natural plant associations in the Monterey Bay area has been greatly reduced. The replacement has been an extensive cultural landscape within which two culturally-induced biotic associations can be distinguished. These may be added to the twelve natural associations listed earlier:

(13) Rural Bio-association. The rural bio-association covers most of the lowlands, where the original floodplain association has been largely removed for agricultural use, and the smoother parts of the hill country which have been cleared for grazing. The herbaceous vegetation which covers many of the rounded hills approaching the coast is in large part made up of foreign plants like wild oat and the filarees. Numerous exotic weeds (e.g., mustard and bur clover) grow in old fields and on other disturbed terrain. In hay fields, pastures, lettuce and artichoke fields, and orchards most of the flora is derived from Europe and the Near East. Within this rural area are rapidly expanding patches of the urban bio-association.

(14) Urban Bio-association. This biotic community includes parks, streetsides, lawns and flower gardens, freeway landscaping and golf courses. With urban areas, an even larger proportion of the plants are foreign and more dependent upon man for survival. Many depend upon irrigation and are unable to reproduce themselves untended. Australian trees and shrubs are especially well-represented (e.g., species of *Pittosporum, Acacia, Eucalyptus,* and *Eugenia).*

(3) Replacement of Natural Plant Cover by Alien Species: Ecology of Eucalyptus Groves

The eucalypts, all native to Australia and its vicinity, have been introduced into many areas. In California, eucalyptus is so conspicuous it has become something of a symbol of human alteration of the natural landscape. There is much discussion of its merits—esthetic and utilitarian.

By far the most plentiful eucalypt in California is the blue gum, but a large number of other species has been introduced at different times, in various parts of the state for a variety of reasons. Few other introduced plants have been subject to such publicity. Eucalypts were being sold as ornamentals in San Francisco as early as 1850. A short time later great interest developed in the trees as a source of fine hardwood for furniture making and the like. Blue gum was brought to San Jose in 1858, and by the 1860's it was widely planted for hardwood.

In the last half of the 19th century, culminating around 1880, malaria was a major cause of illness in California. A segment of medical opinion favored the belief that malaria was caused by "miasma," or "bad air;" that the eucalyptus, its leaves introducing pungent, antiseptic, volatile oils into the air, was "the fever destroying tree" (Thompson, 1970, p. 236), and that by simply planting it in an area, malaria was driven out. Beginning around 1870, the belief in the hygienic merits of the trees led to their being planted on an unprecedented scale. Both the U.S. Department of Forestry and the California Board of Forestry propagated and distributed eucalyptus, mainly the blue gum. At the beginning of 1874, it was officially estimated that at least one million trees had been planted in California (Thompson, 1970, p. 235).

Even though the connection between mosquitoes and malaria became known in the 1890's, blue gum planting continued because the tree was still thought to have a great potential for hardwood. However, difficulties in curing and marketing the wood were present from the outset, so it did not live up to this promise. Instead, the trees came to have a very important role as a source of household fuel in areas where the original plant cover had been cleared. Natural gas began to replace firewood in the cities at the beginning of the century. By the beginning of World War II, tanked butane gas was burned in many country households and few eucalyptus groves were planted. Woodlots mostly disappeared from the towns and the grove which once provided the farmer with a good supplementary income became a nuisance, but costly to remove. As a result, groves planted a few decades ago in the Monterey Bay area now contain towering specimens and their total acreage is still considerable. At present eucalyptus is of only minor economic importance for firewood. Their principal worth is as windbreaks, especially in the Salinas Valley, as a minor source of paper pulp, as food for honeybees, and as ornamentals for landscaping.

Ecological conditions in eucalyptus groves contrast strongly with those in neighboring live oak woodland and redwood groves. The contrast is not so noticeable where eucalyptus trees are well-separated and develop a branched and spreading form. Nevertheless, eucalyptus groves in general seem sterile compared to neighboring oak woodland.

Eucalyptus trees have usually been planted close together to better utilize space and to encourage growth of long straight boles and few lower branches which makes them more manageable for woodcutters. Closely spaced, the trees probably use much of the available soil nutrients and water. Were abundant ground water rises to the surface in the groves the

amount of undergrowth increases. Where the trees are widely spaced there may be a light undergrowth of coyote bush, poison oak, and toyon (Russell Waidelich, personal communication). Scanty undergrowth can hardly be attributed to shading alone. In redwood groves, which are even more deeply shaded, there may be a rich ground flora—sword fern, redwood sorrel, etc.

Eucalyptus leaves usually do not weather to a thick mould like that beneath live oak stands, probably because the soil-forming bacteria present in the eucalypt's homeland are absent here. Also claimed to retard seed germination of some native plants are the terpenes present in decaying eucalyptus leaves.

In Australia itself, eucalypts have a rich associated biota including birds, insects, and mammals feeding on their leaves. Perhaps, fortunately, none of these arrived in California because eucalyptus were disseminated by seeds alone. The flora associated with the groves in the Monterey Bay area is poor. Native birds and insects find little food there. The insects which *are* found under the tree bark are mainly predators that fly out of the groves to feed (Professor Larry Swan, personal communication). The leaves rarely show insect damage and insects seem not to eat the seed capsules. As there is little grass in most of the groves, there is little food for grazing or seed-eating mammals. Wood rats sometimes build nests in the groves but they likely forage beyond their limits. At Mount Madonna County Park western gray squirrels, numerous in the redwoods and tanbark oaks, avoid the eucalyptus trees.

Eucalyptus trees may also be less attractive to some birds because of their smooth bark and vertical growth habit, providing less purchase for roosting and nest building. Eucalyptus groves are used for roosting by shrikes and hawks, however. The monarch butterfly swarms in several groves along the coast. Honeybees feed on eucalyptus blossoms and hummingbirds take nectar from the flowers.

Although the subject is debated, it appears that the eucalyptus is not well adapted for self-propagation here. It cannot be regarded as having become a permanent part of the flora, independent of man, despite its remarkable growth rate and drought resistance and despite the fact that even on poor, sandy soils it soon rises above the native live oak. True, its seeds germinate readily where soil in and around the groves has been bared by burning or scraping, but the total area of eucalyptus groves is not increasing. Seedlings rarely appear and even more rarely survive in areas already covered with other growth. (Adventive shoots from the root systems of sawed trees are sometimes mistaken for seedlings.)

Eucalyptus trees were planted along several bridle paths in the redwood forest at Mount Madonna County Park. Most of these trees are now closely crowded by redwood and tanbark oaks. They are producing large numbers of seeds but no seedlings, and will no doubt be replaced by native trees as they die off.

One reason that the eucalyptus does not spread far, even on disturbed land, is that it is almost totally dependent upon gravity for dissemination. Its fruit capsules are not eaten by native birds or mammals. There are also climatic reasons for concluding that the eucalyptus cannot thrive here under natural conditions: During the winter of 1972-73, eucalypts were much more severely damaged by low temperatures than were native trees.

The ecotone which develops at the margins of native forest, with its rich bird and mammal life, is absent from the edges of eucalyptus groves. From the standpoint of wildlife preservation, eucalyptus is not the ideal woodlot tree whatever its esthetic or practical merits.

A good place for comparison of eucalyptus with other tree cover, in addition to Mount Madonna County Park, is near School Road, east of Aromas, where eucalyptus groves and live oak woodland grow close together. The grove east of Aromas, covering some 364 hectares, is one of the largest in North America. It extends from San Juan Rocks on Highway 101 northward, on the old Las Aromitas y Aguas Calientes grant, toward Soda Lake. The grove, planted between 1911 and 1920, is said to have been intended as a supply of furniture wood. It has been harvested repeatedly for firewood and for the manufacture of cardboard. At present, the trees are mainly regrowth from root shoots.

There is said to be a correlation between the length of time an introduced plant has been established in California and the number of native insect species which feed upon it. The percentage of native insects on introduced plants tends to reach a level comparable to their occurrence on native plants within some two hundred years (Azevedo, 1965, p. 70).

These conclusions suggest rapid evolution of insect populations in terms of food tolerances and preferences, all in response to certain consequences of human occupancy. Few native insects feed on the eucalyptus, however, despite the fact that it has been in California for upwards of a century.

(4) Dissipated or Threatened Plant Associations

Several of the area's natural plant associations have been virtually eliminated: for example, the native bunch-grass association and much of the riparian forest association.

(a) Bunch-Grass Association

The pre-European grasslands were occupied mainly by perennial bunchgrasses, particularly nodding stipa and needle grass. Other grasses and forbs filled in spaces between the well-separated clumps of bunchgrass, but just which grasses and forbs these might have been is conjectural. Although no undisturbed remnants of the original association remain, there is no evidence that any of the grass species themselves have become extinct (Beetle, 1947, p. 343). Small patches of nodding stipa can still be found scattered over parts of the area, but generally only on rougher terrain, inaccessible for grazing or cultivation.

As noted earlier, some of the bunchgrass association was itself probably the product of human action—a result of burning done by the Costanoan Indians. With Spanish and American land use, grassland areas were enlarged and became more completely a human artifact. Although the native bunchgrasses sprout strongly after being burned over, making rapid recovery possible (Sweeney, 1967, p. 114), they cannot stand heavy grazing. While light burning of clearings as practised by the Indians favored their spread and persistence, under grazing and faced with the competition of annual plants, they were soon eliminated and replaced. Thus, only scattered patches of native bunchgrass survive, although the total area of grassland itself has increased.

When Europeans first settled the Monterey Bay area, the largest expanses of bunchgrass association were located in the Salinas Valley southward from Chualar and along the coast to the west and northwest of Santa Cruz. "Few places on earth, if any, have had such rapid wholesale replacement of native plants by introduced species," according to a specialist on California range lands (Burcham, 1957, p. 198) discussing such plant cover. In Monterey County, more than one-third (71 species out of 162) of all grasses now growing are introduced (Howitt and Howell, 1964, p. 27). The aliens are overwhelmingly dominant.

It is hard to find areas where grass cover can be shown to be natural vegetation. Most of the west slope of the northern Gabilans and the lower east slopes of the Sierra de Salinas, both now grasslands, were once wooded, as was the Moro Cojo-Elkhorn Slough area. Only cultural maintenance and grazing keeps the grass-covered hills east of Watsonville from experiencing successional change. Occasionally the hills are seeded (e.g., with rye grass) and fertilized by airplane. Grasslands of the Prunedale hills are only now being recolonized by coast live oak.

Although the perennial bunchgrass association and parts of several other plant associations were converted to annual grassland within the first century following European settlement, a good deal of this new grassland itself later disappeared. This occurred particularly in the flatter, lower country where tilled land and residential aggregations replaced it.

(b) Riparian and Floodplain Vegetation

A century ago a chain of shallow lakes and marshes extended from a point 8 or 10 km to the southeast of Salinas northwestward almost to the bay, for example, Smith Lake, Heinz Lake, Carr Lake, Sausal Lagoon, Boronda Lake, Espinosa Lake, etc.; most have now disappeared. In 1854, the following description was given of the northern Salinas Valley: "... much of the land is swampy and overgrown with tule, rush, willows and marsh vegetation...." (Antisell, 1854-55, p. 38-39). In addition to willows, the local riparian forest probably included tracts of alder as indicated by the Spanish rancho names: Rancho Sausal (Willow Ranch) and Rancho Alisal (Alder Grove Ranch). Possibly the reference is to the sycamore, to which the Spanish in parts of California also applied the name "aliso." Neither tree grows along the river near Salinas today.

The importance of these lakes and marshes to birdlife is indicated in another early newspaper account from Castroville:

> It is astonishing to see the number of wild fowl that have taken up their abode for the winter in this vicinity, and fly back and forth between the lakes and sloughs where they rest, and the fields and marshes where they feed. The air is sometimes positively alive with them for miles, and their clangor is almost deafening. All kinds are represented, from the useless and ugly mudhen to the coveted 'honker.' (*The Castroville Argus*, 1869, Dec. 4.)

Mid-19th century residents of Monterey travelled to the "Salinas plains" to shoot wild geese (Hutton, 1961, p. 4).

The variety of birdlife in freshwater marshes is not fully shown in such popular descriptions of large flocks of wildfowl. The "tule, rush, willows, and marsh vegetation" included a complex assemblage of hydrophytes with a correspondingly varied birdlife, most of which disappeared when such areas were drained.

These wetlands slowed the expansion of agriculture. The site of Salinas was surveyed in their midst in 1962 and the town was incorporated in 1872. In 1871, a local newspaper referred to "... the tule swamps on our Salinas Plains. They cover a large area, are shallow ... and could be reclaimed at a

small cost...." (*Santa Cruz Sentinel*, Nov. 11, 1871). A program of drainage operations began around 1877. Writing about fifty years ago, a renowned naturalist stated, "The most serious adverse effect of the human occupancy of California upon bird life thus far has, I believe, resulted from ... reclamation of swamplands." (Grinnell, 1922, p. 671.)

In 1876, angling enthusiasts were stocking the lakes with introduced fish.

> One hundred of the young fish ['Schuylkill' catfish, brought by rail from Sacramento] were put in *Sausal* Lagoon ... and the other hundred were placed in that fine body of water known as *Espinosa Lagoon, about six miles northwest of Salinas City ... the entire chain of lakes, from Sausal to the bay,* will, in a few years be swarming with them. (*The Salinas City Index*, Aug. 31, 1876.)

Catfish had also been planted in Carr's Lake (now disappeared) at the outskirts of Salinas in 1876 (*Overton Manuscript*, 1877, p. 3) and in 1878, landlocked salmon were planted in Espinosa Lake (*Castroville Argus*, 1878, April 20). However, hopes that this chain of shallow lakes would be used for sport fishing were short-lived, as drainage operations began on the larger ones within a few years.

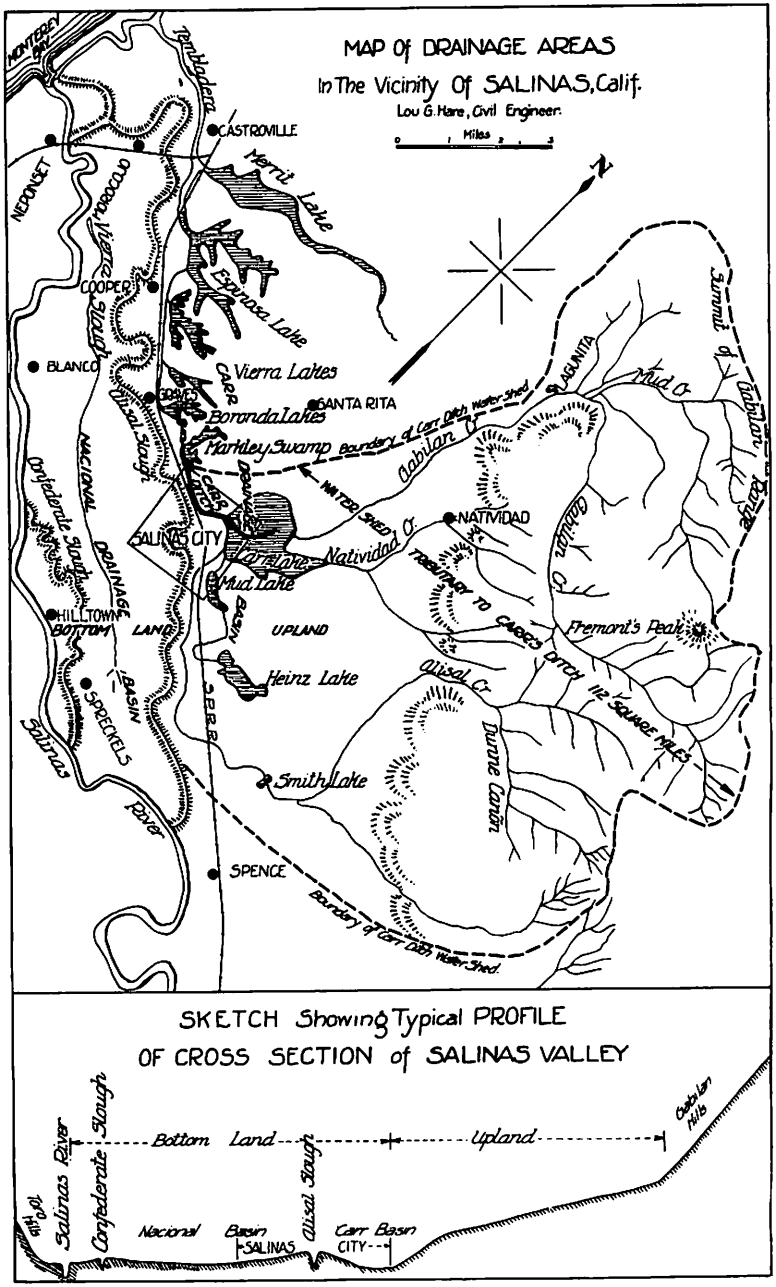
Rancho Sausal included 216 hectares (533 acres):

> ... covered with a dense growth of tules and having water to a depth of over two feet standing on it the year around. .... Some fifty acres [20 hectares] adjoining the northeast boundary of the tract was covered with a dense growth of willows. (*The Salinas City Index*, Feb. 15, 1877.)

By the end of the following year a private company had completed draining the lake to provide agricultural land.

The original pattern of lake distribution in the lower Salinas Valley was still recognizable until around 1916 (Hare, 1916, p. 3). Drainage operations continue to the present. Plans for more canals and pumping stations in the Lake Merritt area are described in the Monterey County Flood Control and Water Conservation District report for 1960, as is the agency's ongoing spraying program to control tules in wetlands and along drainage ditches west of Salinas.

Although little now remains of what appears to have been a well-developed freshwater marsh biocommunity in the lower Salinas Valley, a number of the marsh species have been preserved and widely spread throughout the Monterey Bay area by the construction of irrigation ponds.


MAP Of DRAINAGE AREAS
In The Vicinity Of SALINAS, Calif.
Lou G. Hare, Civil Engineer.
Miles
MONTEREY BAY
Tembladero
CASTROVILLE
NEPONSET
Merrit Lake
Espinosa Lake
Vierra Slough
COOPER
BLANCO
Vierra Lakes
CARR
Borronda Lakes
SANTA RITA
Markley Swamp
Boundary of Carr Ditch Water Shed
Gabilan
SALAMITA
Mud Cr.
Summit of Gabilan Range
WATER SHED Cr.
NATIVIDAD
Natividad Cr.
TRANSFER TO GABILAN CREEK DITCH
Gabilan Cr.
Fremont's Peak
SALINAS CITY
Mud Lake
HILLTOWN
BOTTOM LAND
UPLAND
Heinz Lake
Alisal Cr.
11½ SQUARE MILES
Durne Canon
SPENCE
Smith Lake
Salinas River
Boundary of Carr Ditch Water Shed
SKETCH Showing Typical PROFILE
OF CROSS SECTION of SALINAS VALLEY
Salinas River
Confederate Slough
Bottom Land
Alisal Slough
Upland
Gabilan Hills
Nacional Basin
SALINAS
Carr Basin
CITY

Drainage areas in the vicinity of Salinas in 1916, showing distribution of lakes in lower Salinas Valley. Before American settlement, a chain of lakes and marshes extended from Heinz Lake, south of Salinas, northward to the vicinity of Castroville, over 18 km; the lakes have since been drained.

Two broad catchment basins are distinguished on the map—the Carr Drainage Basin, in which most of the lakes were located (named after the former Carr Lake) and the Nacional Basin, between Alisal and Confederate Sloughs. Physiographic evidence indicates considerable shifting of the Salinas River channel in past centuries, with the river repeatedly building up its bed, then breaking through natural levees to establish a new course. For example, Alisal Slough, which runs through Salinas, is the remains of one of the river's old channels (Hare, 1916, p. 4). Although the natural drainage pattern was still recognizable in 1916, it has been almost obliterated within the last half century by drainage operations, field levelling, and the building of artificial levees.

The history of a single small lake in the chain, one of the Vierra Lakes shown on the map between Lakes Espinosa and Boronda, indicates the magnitude of changes recently made throughout this lake area.

The bed of the lake is on the Chinn Ranch a little over 1 km N of San Jon Road and about 9 km from Monterey Bay. The surrounding terrain is low, the highest land being less than 20 m. The lake bed is 3-6 m above sea level. Pumps keep the bed dry during the rainy season. The area is now almost treeless and used for cultivation of artichokes and other vegetables. Coast live oaks, some with trunks over 1 m thick, survive on the SW side of the lake bed—the only trees in the vicinity. Several appear to be dying, perhaps because of a lowering of groundwater table following drainage operations.

The scene was very different when the Costanoan Indians lived here. Shallow lakes, patches of tule and other marsh herbs, and broad willow thickets covered the lower parts of the country, surrounded on higher ground by oak woodland. Since early records note only a few conspicuous game species (such as tule elk, ducks, and geese), little is known of the original marsh fauna.

There has been considerable earth-moving in and around the lake bed to reduce slopes for cultivation. For example, an island about 12x300 m, which rose approximately 4 m above the N third of the bed, has been completely levelled.

In 1967, in grading the W bank which rises about 8 m above the lake bed, some 48 Indian graves were exposed. Recently about a dozen more burials have been uncovered. The skeletons were in a flexed, seated position, the heads of some capped with inverted, bowl-shaped stone mortars—implements which suggest the use of herb seeds or acorns. Mussel and clam shells, and various mammal and bird bones which are intermixed with the dark soil scraped from the site indicate that a village was located on or near the burial grounds, the villagers drawing here upon the food resources of lake, woodland, marsh, and sea.

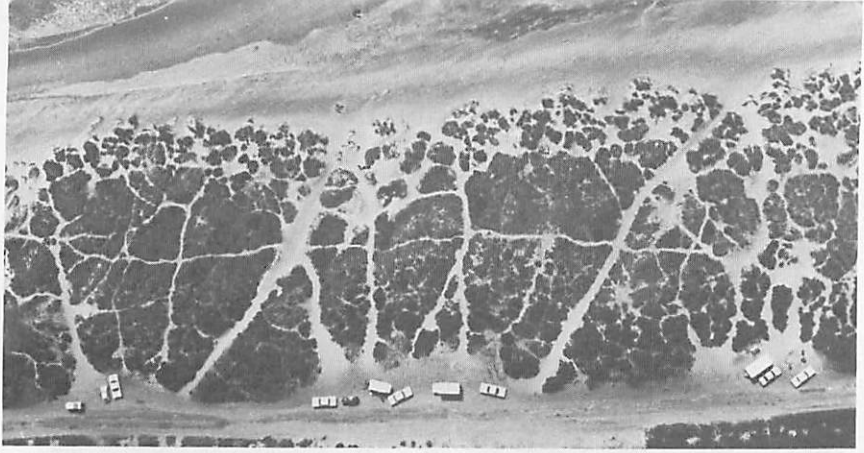
Left undisturbed, the area would gradually be reclaimed by native plant life—and the lake bed, soon covered with water again. During very rainy weather as much as 100,000 liters (25,000 gallons) of water per minute are pumped from the bed, for periods as long as 15 days. There can be little sub-surface drainage as the peaty soil beneath the bed remains waterlogged throughout the year. The area of the bed being about 120 hectares (300 acres), only one such pumping period removes enough water

to produce a lake averaging 1.7 m deep, probably a minimum depth at the end of the rainy season.

In Costanoan times most of the water in the lake evaporated during the dry months. But since the bed was not originally flat the depth varied, and water holes likely lasted through the summer. 1.7 m is too deep for tule and cattail, so the original lake would have had areas of open water during the winter season which attracted migrant water fowl.

Wild oat, one of the most common plants of the area, was introduced from Europe by the Spanish. (Photo, B. Gordon)

Fullers' teasel *(Dipsacus fullonum),* an Old World domesticated plant was introduced into the Americas with the Spanish sheep industry, was formerly widely cultivated for use in raising nap on woolen fabrics. (In remote Guatemalan blanket-making villages, it is still cultivated for that purpose.) In the Monterey Bay area, feral teasel is often found near roadsides and on other recently disturbed sites. (Photo, B. Gordon)



Dunes near Sunset State Beach. Footpaths leading from cars to beach illustrate this problem of providing public access to beaches and, at the same time, maintaining dune vegetation. Residential use of dunes eliminates even more natural plant cover. If this plant association is not to be completely destroyed, conservancy tracts will have to be set aside. (Photo, B. Gordon and D. Hawley)

(c) Coastal Dune Vegetation

One type of plant cover presently under threat of elimination is the coastal dune association. The total area of this association was never great. Recent dunes are mainly along the shores of the southern half of the bay and much of their plant cover has been destroyed by urban development and sand mining. The largest and least disturbed tract of coastal dune vegetation lies between Moss Landing and Mulligan Hill.

Investigation of the distribution of coastal dune vegetation was only recently begun (cf. Bluestone, 1970). As unused coastal dunes have recently become very attractive to builders, this plant cover may disappear before it has been adequately studied. A brief description of the dune vegetation in the vicinity of the Salinas River State Park, perhaps the best-preserved remaining tract, is given below with notes on the changes it has undergone.

One of the stronger contrasts in dune plant cover is that which exists between the rear dune area, with its transverse ridges, and the flatter, lower fore dunes. Typical rear dune species are coast *Eriogonum*, bluff lettuce, and lizard tail. Woody plants are mainly confined to the rear dunes, where blue beach lupine and mock heather develop woody stems as much as 2.5 to 4.0 cm in diameter. (Mock heather extends from the rear dunes onto inland parts of the fore dunes, there becoming less common.) Organic material in the sand is most abundant in the rear dune area. Some species there, particularly mock heather, coast *Eriogonum* and ice plant, produce a considerable litter and in places development of a soil profile has begun.

On the extreme back edge of the dunes, the slope is steep and sand particles are fine and intermixed with silt. Growing on this fringing strip are a number of plants not at all characteristic of dunes for they are less tolerant of salt than is most sea dune vegetation: for example, wild roses, blackberries, and willows. They extend downslope to the rear base of the dunes and, inland from the dunes, meet salt marsh vegetation or plowed ground. Curiously, in a few patches salt grass has spread up onto these steep dune slopes, beyond its typical marsh habitat.

Vegetation on the fore dune area is largely herbaceous. The silky beach pea is limited to this zone. Note, too, that the sea rocket grows down closer to the ocean than do other plants. Along much of the central California coast, if one emerges from the surf and walks up the beach, the sea rocket is the first flowering plant encountered. Though sand verbena, intermixed with sea rocket, is most common close to the beach, it appears elsewhere along the profile on bare sandy spots. Being one of the first colonists on disturbed surfaces, sand verbena is often the only plant growing on stretches recently denuded by dune buggies.

Although the larger number of plant species are natives, several have been introduced from abroad. Holland dune grass (marram grass), imported to San Francisco in 1869, was used to stabilize dunes in Golden Gate Park. The grass spreads mainly by the growth of horizontal rhizomes and these tend to bind the loose sand. In 1919, Holland dune grass was planted on dunes near the mouth of the Pajaro River (Locke-Paddon, 1964). This is the earliest known reference to its use in the Monterey Bay area. Scattered patches grow on the fore dune area in the vicinity of the Salinas River State Park.

About nine species of ice plant *(Mesembryanthemum)* are established in California. All have been introduced, mainly from southern Africa. Ice plants are commonly used as stabilizers on roadcuts and in landscaping freeways, where they provide welcome greenery, especially in summer. The sea fig, a Chilean species, forms a dense cover over large areas of these dunes.

The sea rocket typically grows at the seaward edge of the beach. The sea rocket seen now along the central California shoreline is not the native *Cakile edentulata* but rather *C. maritima*, a cosmopolitan beach species. The latter was first reported from Stinson Beach, north of the Golden Gate, and from the coast of San Mateo County in 1935 (Rose, 1936, p. 224). On many beaches and dunes of the Monterey Bay area it has entirely replaced the native species.

New Zealand spinach, indicated as alien by its name, was introduced here as a food plant only a few decades ago. It appears in disturbed portions of the dunes and on saline soils. (Specimens can be found within a few feet of Moss Landing Marine Laboratories.)

It is apparent that the structure and species content of the dune vegetation have already been considerably modified by the activities of people. Far more sweeping, however, are changes in vegetation marginal to the dunes.

The vegetation of coastal dunes is notoriously fragile, yet the surface continues to be disturbed by vehicular traffic. Tracks and roadways travelled by dune buggies and motorcycles crisscross the dune area.

It is advisable under any land use program (e.g., recreational use) to maintain as much of the existing plant cover as is possible. This largely native vegetation, adapted to the dune environment, can be maintained without special care. It has developed over a period of many years and, were it removed, considerable time and expense would be required to replace it. Where broad surfaces are denuded, sand will move under wind action. With loss of dune vegetation, an incursion of the dunes into the alluvial farmland to the east may occur.

In terms of plant regeneration, burning is not nearly so damaging as a devegetation resulting from churning the surface, as happens when wheeled vehicles pass over it. Fire scars along the inland edge of the dunes are quickly resettled by grasses and other plants and show little evidence of sand movement, probably because the soil profile, only weakly developed, is not destroyed. This should be kept in mind where limited clearing must take place and the bare surfaces replanted.

Near the mouth of the Pajaro River, the dunes are the site of a large housing complex. Native plant cover there has been virtually eliminated. Vegetation consists mainly of marram grass, ice plant, and eucalyptus. Another complex is under construction on the dunes a short distance northward. Still another, and larger, housing development is planned for the dunes between Salinas River State Park and Mulligan Hill.

(5) Regrowth and Succession in Old Fields

Succession has correctly been called the most informative ecological process. Successional studies are particularly relevant for planning purposes. Each successional stage (sere) has its potential both for purposes of creating maximum biological diversity in the area and for beautifying

the cultural landscape: "... as an instrument for the control of the entire range of human uses of the vegetation and the land, succession is wholly unrivalled." (Clements, 1935, p. 345.)

Most of the Monterey Bay area, subjected as it has been to thoroughgoing human change, exists in an intermediate stage between a disturbed and a climax condition. Scores of exotic species have been intermixed with the native biota. Although the overall successional trend is toward elimination of these foreigners and the reestablishment of native species directly under natural climatic and edaphic controls, the stages in the return are varied and poorly known.

> The natural process [of succession] once thoroughly understood, it becomes possible to retard or accelerate it, to 'telescope' it or hold it more or less definitely in one stage, or deflect it in any one of several possible directions.... (Clements, 1935, p. 345.)

The considerable phenological information for the area must be compiled and its interrelationships studied. A comprehensive ecological almanac is needed, synchronizing the flowering and fruiting seasons of regrowth plants with food demands and reproductive cycles in the animal world. Thus, it may be possible to discover components which are critical to the ecological balance of each successional stage and to determine the points in time at which such a balance can be most easily tipped. With such information at hand future landscapes can be planned to include people in more harmonious relationships with their biotic environment.

(a) Abandoned Orchards and Farm Buildings

Before discussing plant succession in abandoned orchards and around farm buildings a few preliminary notes are needed here on the decline of subsistence farming and hill-land orchardy:

A type of farm common some forty years ago has now become a rarity. The diversified, largely-subsistence farm comprised a fruit orchard, several hundred chickens, a few cows, and a team of horses. Farm operation busied the whole family with chores such as hoeing weeds, milking cows, chopping wood, cleaning hen houses, and canning fruit.

Hundreds of such small farms were scattered around in hilly country in the Prunedale district, around Aromas, Corralitas, and in Larkin Valley, in the northern part of the bay area. (The valuable alluvial land along the Pajaro and Salinas Rivers, however, is another matter. It supported, instead, a highly mechanized and specialized commercial agriculture which was prosperous then as now.)

Most of the farm houses still stand, freshly painted, and looking as good as ever. However, the people who live in them now are likely to be employed in urban industries.

In the early 1930's, many farms were operated by "Okies" who came from the southeast. The "Okies" continued here, on rented farms, a livelihood similar to that which they had known back home. Shortly before World War II this type of family farming began to break up. Good wages and the war drew younger people away and farmers were unable to afford outside labor.

Although many of the houses remain, the barns and chicken houses have mostly fallen apart, and little use is made of the land. Old orchards are overgrown and new ones are not being planted. Around Aromas, for example, stumps of apricot trees cover the hills. Fields there used to be orange in summer with trays of apricots set out to dry. In Larkin Valley the principal orchard crop was apples.

The living contents of abandoned buildings and dooryards themselves show the character of succession on sites of recent human disturbance:

About 1.4 km south of Hudson Landing, an abandoned two-story, wooden frame house overlooks Elkhorn Slough. In a visit there, in the fall of 1969, several ring-necked pheasants flew out of the shrubbery behind the house. From the top story window there was a fine view over the slough, covered with pink pickleweed and dotted with marsh birds.

The house is built in the style common four or five decades ago. Its many rooms are small, all separated by doors. There was a honeybee's nest in the wall. Scattered around the doorstep were a few broken fruit jars of a brand once kept by the dozens in most farmhouses for canning, along with an old ironing board and a window sash weight. A pair of harness hames lay in the weeds.

Live oaks shade the higher ground behind the building. Water from the spring that supplied the household now seeps unused out of the oak grove and down through the yard, making a soggy patch pretty well taken over by willows. Garden flowers still grow among the weeds around the front steps. The varieties are those favored by an earlier generation: hollyhock, foxglove, periwinkle, and calla lily. A bellefleur apple tree produces about a box of apples a year and only needs pruning to yield more.

The backyard is overgrown with Himalayan blackberries—an old standby around California farm houses. Its berries have a tangy, wild flavor. Like the bellefleur apple, it was once widely grown hereabouts but loganberries and boysenberries replaced it commercially. Its thick, tough canes

make a formidable bramble. Below the house, extending toward the slough, lies a field, which was probably used for corn and tomato cultivation. It is now covered with weeds, mainly European umbellifers like the poison hemlock.

Note: Transoceanic pheasants, honeybees, berries, garden flowers, and apples linger on here, growing alongside native marsh birds, willows, live oaks, and pickleweed.

One warm summer afternoon we visited an old barn which stands behind an abandoned house in the Carneros district, some hundred meters from Highway 101. As we approached, about a dozen alarmed ground squirrels scurried toward the building, making for nests under the rotting floor boards. Inside there was a sweet odor of mouldy hay. A few pigeons still nested in the barn, evidence that house in front had probably been vacant only a short time. Pigeons usually don't stay long after people have gone.

The barn was still used as a shelter for a team of horses, and the barnyard was trampled and dusty, with gray-green clumps of hoarhound scattered around. Yellow-jackets had built their large, papery nests under the eaves. Numerous linnets fluttered in and out of the weedy growth around the corral. We had hoped to see barn swallows or barn owls nesting here, but there were none. Nothing could be more typical than the lone phoebe which was perched on the watering trough.

Note: Squirrels, yellow-jackets, linnets, and phoebes are natives, drawn here to a human habitat; the horses and pigeons were introduced purposely from the Old World, whence came by chance the hoarhound and the other corral weeds.

There are several dozen abandoned apple orchards in and around Larkin Valley, between Aptos and Watsonville. Approximate dates of abandonment have been established by questioning long-time local residents. This information and the inspection of aerial photographs have led to the following tentative reconstruction of the general order of succession.

A number of alien annual weeds grow in the orchards, even while they are still in production—mustard, amaranths, and mallows, for example. Within several years of the time cultivation of an orchard stops, most of these disappear and a dense herbaceous, largely grassy cover becomes established. This cover is made up of introduced plants such as various grasses, filarees and plantains, intermixed with natives including lupines, ferns, blue-eyed grass and Brodiaea.

Under favorable conditions woody plants may appear within four or five years of the time the orchard is abandoned. Within twelve years, woody plants may have spread to cover most of the surface. The general successional trend is strongly toward elimination of alien species. This is accomplished on some sites within twenty years. Within thirty years oak woodland itself may be reestablished.

Usually the first woody plant to arrive is the native coyote bush. From a conservationist's standpoint this shrub is a godsend, taking as it does the first step toward the reestablishment of woody cover on deforested spots. Most agriculturists don't see it that way. The coyote bush is an aggressive invader of pastures and difficult to eradicate. A composite, it produces windborne seeds in profusion. And the shrub's ability to flower and seed over a long season is hardly rivalled by any other woody species here. If broken off, new plants sprout from the roots, and if chopped up by discs the shrub may reproduce vegetatively from the cuttings. On the other hand, its seedlings are very susceptible to damage from grazing and burning (McBride and Heady, 1968, p. 106). Although they rarely browse on mature shrubs, cattle eat its seedlings along with grass and other herbs. Thus, heavy grazing may arrest plant succession in the herbaceous-cover stage, indefinitely.

One abandoned orchard is located on a slope near Larkin Valley and White Road junction about a quarter of a mile from Highway 1. The orchard was last tilled some fifteen years ago and many of the apple trees are still living, although in poor condition. The taller undergrowth in the orchard is made up of coyote bush and poison oak which rise some 2 to 3 meters to more than half the height of the apple trees. Coffee berry and honeysuckle are present, particularly under the apple trees. Poison oak and Pacific blackberry are most abundant there, too. The last four plants named all bear fleshy fruit and are likely disseminated by birds which roost in the trees. There are a few live oak seedlings in the orchard. Those toward its center are only two or three feet tall but several growing near the orchard's upper edge rise to the height of the apple trees. Having diameters 12 to 15 cm, they are probably over ten years old. Probably the live oak seedlings are oldest and most abundant near the margins of the orchard because the acorns are carried there soonest by animals, or simply roll into the edge of the orchard clearing from surrounding oak woodland.

Another abandoned orchard is on a hillside west of Larkin Valley Road, about a kilometer or so from its junction with Highway 1. Aerial

photographs show that this orchard was ploughed in 1952 and 1956. The owner, who purchased the property in 1960, is certain that the orchard has been untended since that time. A eucalyptus grove covers the crest of the hill above the orchard. Low, herbaceous growth marks spots where farm machinery has been driven or parked since the orchard's abandonment. Otherwise the plant cover is mainly woody, the principal species being coyote bush, blue blossom, coffee berry, and poison oak. Again, regrowth under the apple trees is denser than elsewhere and poison oak, coffee berry, and blackberry tangles are especially common. On intermediate areas away from apple trees, coyote bush and bracken predominate. (In December, coyote bush seedlings appear by the thousands. Having germinated after the beginning of the rainy season, they are only a few centimeters high.) Blue blossom, coffee berry, and coyote bush rise to heights of over 3 meters, with trunks 10 or 12 cm in diameter at the base. Only a half dozen live oak saplings grow in the whole orchard, there being no groves in the vicinity to serve as seed sources. Instead, eucalyptus seedlings have sprung up in the upper part of the orchard, seed capsules' having rolled down from the grove upslope.

A third abandoned orchard of several hectares is located on a north-facing slope along the sout side of Mar Monte Road, just off Larkin Valley Road. The orchard is one of the first in the area to be abandoned. It has not been tilled since about 1940, but its apples were occasionally picked and its regrowth grazed during the following decade. An aerial photograph taken in July 1952, shows the orchard with all of the apple trees in full leaf and the ground between the trees covered with grass. Grazing was discontinued about this time. An aerial photograph taken in June 1956, shows the apple trees still living but with what appear to be shrubs, probably coyote bush, growing in the grassy spaces between the trees. Most of the apple trees are now dead, though many are still standing. The orchard is overgrown and in a later stage of succession than are the orchards discussed above.

The following plant-cover categories can be distinguished in the abandoned orchard on Mar Monte Road:

1. Coyote bush, Pacific blackberry, and bracken make up about 95% of the ground cover, with coyote bush predominating. The coyote bush has not reached its maximum size—bushes range from 1 to 2.5 cm in height with trunks averaging about 5 cm in diameter at the base. Coast live oak seedlings are very sparsely scattered through this plant cover; there are only about a dozen in the entire tract. The oak seedlings are

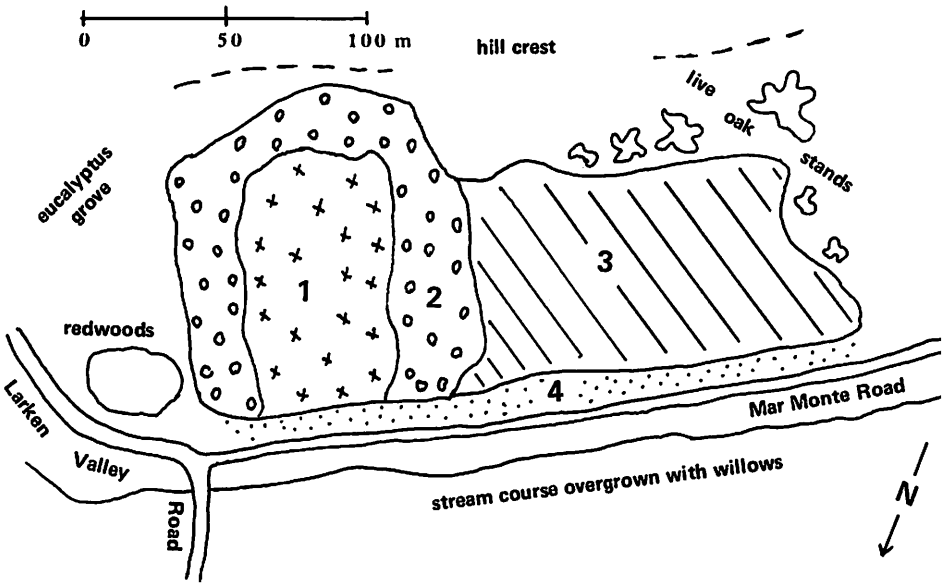
Aerial photo (June 1956) shows plant cover on hill country south of Aptos, Larkin Valley. About a dozen apple orchards appear, including the 3 discussed in text. One of the largest remaining tracts of live oak woodland in the Monterey Bay area is in the lower part of the picture. Redwood is known to have been hauled by cart from Corralitos to Monterey in the 1840's. Probably both redwood and Douglas fir were then lumbered in the Larkin Valley, too. Long-time residents state that as late as the 1880's, their parents burned redwood stumps here in preparing land for the plough. Woodcutters, since, have harvested firewood in these hills for sale in Watsonville. In the 1940's, manzanita burls were dug up in parts of the woodland for making pipe bowls. Openings in the woodland have been grazed for over a century. This woodland is not a remnant of undisturbed vegetation.

Because of poor records, the total mass of the potential natural vegetation is underestimated. In fact, the rate of reestablishment of native trees in orchards here is not exceptionally rapid, this hill country being edaphically less favorable for plant growth than neighboring lowlands. The hills, 30 to 160 m above sea level (very soft sandstone of Aromas red sands) has low water-holding capacity and ready erodibility. These characteristics were demonstrated here by severe erosion and slumping on roadcuts made in the process of widening Highway 1. In oak woodland a loamy sand, covered with deep leaf mold, develops, but this soil horizon is lacking over much of the area, profiles having been greatly modified by grazing and tillage. Original soil profiles are best preserved along old land grant boundaries.

Live oaks cover the woodland tract more thickly now than in 1956. Many shrubby areas in woodland are now densely overgrown with oaks, still under 9 m tall with trunks less than 30 cm in dia. Coniferous growth is reestablishing itself slowly. There are more than a dozen circular groves of redwood between orchards 2 and 3, growing from old stumps missed in clearing. But redwood is not spreading. Seeds of Douglas firs scattered west of Highway 1 seldom germinate. Recovery is slow because the area is near zone of natural transition from coniferous forest to oak, this now being the SW-most extent of redwood and Douglas fir in the Monterey Bay area.


blished in 1833, still visible,
rked by lines of native vegetation.
Valley
Road
Corralitos Creek 1 km
Orchard
No.
Live oak woodland: dominantly coast live oak with dense understory of coffee berry and poison oak; on drier slopes, brittle-leaved manzanita.

mostly 2.75 to 3.0 m tall, still unbranched, with trunk diameters averaging about 5 cm at the base. Blue blossom is lacking and there are only a few small coffee berry bushes. About 5% of this area is covered with grass and other herbs.



Regrowth categories in abandoned orchard on Mar Monte Road. Categories in text.

2. Almost the whole area is covered with woody growth. As in category no. 1, coyote bush is the dominant plant. But the bushes, 2.0 to 3.5 m tall and with trunks commonly about 10 cm in diameter at the base, are mature or senile. Most have bare branches with leaves growing only at their tips. Next to coyote bush, blue blossom is the most extensive species, forming close to 30% of the ground cover. The blue blossom grows to a height of 4.25 m with trunks about 12 cm in diameter at the base and forms a dense canopy, shading the ground so completely that there is little undergrowth except yerba buena. Although blue blossom here has not attained maximum size, it is apparently excluding coyote bush.

3. This category covers the upper, western part of the orchard. Tree-sized coast live oak, coffee berry, and wax myrtle make up about 45% of the plant cover. Another 45% is made up of low-growing coyote bush and blackberry, intermixed with young oak saplings and small coffee berries. And some 10% of the category, on especially steep slope, is bare ground or covered with mosses and scattered herbs.

The live oaks are branched and rise to heights of 6 m, with trunks about 20 cm in diameter at the base. Coffee berry and wax myrtle grow to almost the same heights as the live oak. One coffee berry measured was 5.5 m tall, with a trunk 12.5 cm in diameter at the base. The wax myrtle commonly has six or seven branches rising from a broad cluster at ground level. One myrtle rose to a height of 4.25 m, with individual branches measuring 10 to 17 cm in diameter.

Blue blossom makes up a small percentage of the cover here, as compared to its occurrence in category no. 2. As there are few young bushes, other plants are probably taking its place, but one blue blossom was between 5.5 and 6.0 m tall with a trunk 15 cm in diameter at the base. Young wax myrtle are numerous, but the most vigorously reseeding woody plants are coast live oak and coffee berry. These are present in many stages of growth.

Wax myrtle appears to be confined to the orchard. None was found in the other plant cover categories nor elsewhere in the neighborhood. How its seeds arrived in the orchard is uncertain but the plant's abundance may be explained by its preference in this general area for moist, north-facing slopes.

4. Poison oak and hazelnut form a dense cover along the lower edge of the orchard near the road. Intermixed are a few flowering currants. Actually poison oak grows plentifully throughout the entire orchard but it is easy to underestimate its total area because it often grows intertwined with other plants. Furthermore, being deciduous, the poison oak is not conspicuous in winter and early spring.

The percentage of canopy formed by coast live oak is generally on the increase. As they are overtopped by the oaks, other trees and shrubs reproduce less successfully.

Several native ecotone plants, common in the vicinity, play no part in succession within the orchard. Although a large madrone (12 m tall, with a trunk 46 cm in diameter) stands at the crest of the hill above the orchard's south edge, there are no young madrones growing in the orchard itself. Only one toyon was found, and one brittle-leaved manzanita.

However, young madrone, brittle-leaved manzanita and bush lupines are common on grazed slopes which are also in process of successional change immediately to the south. Perhaps ploughing in the orchard has inhibited reestablishment of these species.

Piles of twigs, accumulated for nests by dusky-footed woodrats, are scattered throughout the orchard, especially around the trunks of dead apple trees. Hazelnut shells and the husks of wild cucumber seeds litter the ground around the nests. In several cases, wild cucumber vines are growing out of the nests themselves.

All of the principal plant species present in the orchard are natives. Aliens have been virtually excluded in the process of plant succession. Feral pigs appear to have been rooting under oaks. Otherwise, introduced animals seem also to have disappeared.

The general extent of deforestation in the area as a whole influences local succession rates. The availability of acorns is an important factor in the establishment of oaks and areas distant from oak groves are slow to produce oak seedlings. Also important in the reestablishment of oak trees are the numbers of those animals which carry acorns such as jays, woodpeckers, and squirrels. Although the California acorn woodpecker transports many acorns, jays may be the more important animal in the dissemination of oaks, as they sometimes actually bury the acorns (Ritter, 1938, p. 35).

The presence of browsed seedlings in some orchards indicates that the abundance of deer is a factor in succession rate.

Progression to woody cover proceeds more rapidly and with greater diversity in orchards where apple trees are left standing, rather than being cleared. The trees serve as roosts. Seeds in bird droppings are concentrated below their branches. Nitrates in the bird droppings may also encourage undergrowth beneath the trees. On orchard sites where the trees were felled, succession has been arrested in the grass-coyote bush stage for long periods.

The time elapsed since the original clearing was made is also significant: Succession on degraded soils, and soils from which the A-horizon has been eroded, will have special characteristics. The lowering of groundwater table by pumping from wells may make reestablishment of the original plant cover impossible in some localities unless the pumping is stopped. All of these factors in turn are related to the character of human occupancy and land use.

(b) Live Oak Woodland

The coast live oak is the oak species most widely distributed in the area and the only species common along the coast. The Spanish made charcoal from its wood for use as household fuel. The tree became a major source of firewood for later immigrants as the population of the area increased, partly because of its easy accessibility. The limits of the coast live oak's distribution include some of the most attractive areas for human settlement. As lumber the wood is inferior and it has been but little used in building and tool-making. On the other hand, the coast live oak is one of the easier oak species to plant and put to horticultural uses. At present it is of major importance because of its influence in supporting wildlife and because of its considerable promise for beautifying the countryside.

The primary sources for woody-plant succession in the orchards in the Larkin Valley area are scattered tracts of live woodland with poison oak, coffee berry, coyote bush, *Ceanothus*, etc., growing at its margins and in open spaces between the oaks. These adventive plants congregating at the sunny margins of orchard clearings in oak woodland exemplify the special importance of ecotone content in succession studies.

Historical sources cited indicate that oak woodland was not the only tree cover in Larkin Valley at one time. In pre-European times groves of redwood were scattered around, especially on north slopes. A few clusters of redwood still grow in the valley. Douglas fir grows near the junction of Larkin Valley Road and Highway 1. Given time and without human disturbance of the land coniferous growth would reestablish itself in parts of the oak-woodland area, despite the fact that most local seed sources have been eradicated by over clearing.

In the early American Period of settlement, sizeable coast live oaks grew scattered over the lands to the east of Castroville around Moro Cojo Slough and to the east and north of Moss Landing, i.e., on all sides of Elkhorn Slough and northward to the floodplain of the Pajaro River. The region is now mainly open grassland or planted to such crops as artichokes and strawberries.

The oaks were cleared by American settlers, partly for use as firewood and partly to make the land available for tillage. Until the middle of the last century this country, divided into the Spanish-Mexican land grants, was used for cattle raising. We read in the field notes of J. E. Terrell, surverying under instruction of the U.S. Surveyor General in 1859, that the east boundary of the Bolsa de San Cayetano Grant, as it ran from the

uppermost end of Elkhorn Slough northeastward toward Watsonville, extended from an "oak tree 2½ feet in diameter, thence to an oak tree 3 feet in diameter ... to an oak tree 2½ feet in diameter, on the edge of the estero [that is on Elkhorn Slough itself, near the site of Hudson Landing]."

Since today's fuel comes mainly from mineral sources, the quantities of trees which were once consumed as firewood are easily underestimated. The following account refers to oak woodland which extended to the east of Castroville in 1881:

> On the uplands and low hills east of town there is an almost inexhaustible supply of good oak cordwood, a large trade in which with San Jose and other points is carried on by the medium of the Southern Pacific Railroad. (*The Resources of California,* April 1881, p. 93.)

Although today only a few tracts of oak woodland remain immediately east of Castroville, to the northeast, in the higher lands of the Prunedale district, many patches survive on the Aromas Red Sands. Most of these trees are much smaller, being recent regrowth which has developed since the depression of the 1930's, a time when agricultural use of the Prunedale district reached a maximum. The appearance of this regrowth indicates the persistence of undiminished regenerative powers.

Oak woodland also covered parts of Salinas Valley. The following note describes this growth on the southwest side of the river.

> Lands [i.e., potential agricultural land] south and west of the Salinas River are not so great in quantity as on the north and east. They are *mostly covered with oak timber which is being chopped into stove wood* for market, and apparently for the purpose of clearing the land for cultivation. The Guadelupe Rancho is mostly covered with a growth of small oak timber. (*The Salinas City Index,* Nov. 25, 1875).

Valuable evidence of the historical plant cover of the lower Salinas Valley to the north of the river is provided by a grove of large live oaks which still grows on the valley floor, northeast of Salinas near the foot of the Gabilan Mountains. This grove is made up of 75 or 80 trees on several acres near the junction of Williams and Old Stage Roads—an area of intensive culture of truck crops. The trees, among the largest live oaks in the Monterey Bay area, have trunks 1.2 to 1.5 m in diameter. They are said to have been growing here in the 1850's. The grove is especially significant since it shows that oak woodland is part of the potential natural vegetation of the lower Salinas Valley along with bunch grass, tule marsh, and riparian forest.

The interior live oak has, as its name suggests, a more inland distribution than does coast live oak, and tends to favor higher slopes. Nevertheless, interior live oak does come within a few miles of the coast in such places as on the University of California campus at Santa Cruz, and between Aptos and Larkin Valley. The two species rarely grow intermixed with each other. The interior live oak, reputedly the best fuel of any California oak, was much sought by woodcutters at one time.

Although its total expanse in the Monterey Bay area has plainly been much decreased since European settlement began, oak woodland has been extended into coniferous forest areas on higher, wetter lands.

> More than half of its 97,190 acres [39,333 hectares; i.e., the oak woodland area in the Santa Cruz Mountains as a whole] are potential redwood and Douglas fir lands, having taken over the areas following removal of the conifers either by logging and fire or by fire alone. (Jensen, 1939, p. 16.)

(Most of these 39,333 hectares are within the Monterey Bay area as defined here.) Even within coastal portions of oak woodland there may well have been patches of coniferous forest.

Monterey pine cones. Distribution of the western gray squirrel is influenced by the planting of isolated groves of Monterey pines. In the Larkin Valley area, the squirrels travel from their preferred coniferous-tree cover, consisting of surviving patches of Douglas fir and redwood, through scattered live oaks and chaparral to find the pines and feed on their seeds. They gnaw apart the green, unopened cones like the one near the center of the photograph. (Note the gnawed cones, some with only the cores remaining, and the mature cone, open and undamaged.) The nearest naturally-growing Monterey pines are located near Año Nuevo and on Monterey Peninsula where pine seed are one of this squirrel's major food sources. (Photo, B. Gordon)

(c) Foothill Woodland

The principal oak species found in foothill woodland are the blue oak, the black oak, the valley oak, the maul oak, and coast live oak. Although coast live oak is also present here, it is not dominant as it is northward in the live-oak woodland.

The blue oak is outstanding among native oaks for its drought resistance. It is adapted to the driest slopes and so intolerant of water that it is actually killed by irrigation (Jepson, 1910, p. 216). The tree is absent from wetter parts of the Monterey Bay area, does not come into the northern half of the area, and is found only on the east side of the Santa Cruz Mountains. On parts of the west slope of the Gabilans, it is the principal oak. In the northernmost Gabilans, east of Natividad and Old Stage Road, coast live oaks grow scattered over the slopes. But as the rainfall decreases southward, coast live oak gives way to blue oak. This is seen to the east of Soledad where blue oak is the most common tree, followed by coast live oak and digger pine. Blue oak is also common, intermixed with other oaks, at middle elevations in the Sierra de Salinas.

The black oak is found mainly in the southern half of the Monterey Bay area. The tree's response to fire explains its occurrence and distribution. "Of all our oaks, fire is the most destructive to this one." (Jepson, 1910, p. 233). No doubt this also explains its rarity in parts of the area. In the northern Gabilans, black oaks are restricted to those sites most distant from the many man-made forest fires which have swept the area. There is a grove of large trees in the state park on Fremont Peak. In the Monterey Bay area the tree is common now in the Sierra de Salinas.

The valley oak is commonly described as being unable to thrive in the immediate vicinity of the coast. This large, deciduous tree is most common in interior valleys, it grows high up on slopes as well, and can be found in the Gabilans and Sierra de Salinas. Like the black oak, the valley oak is almost absent in the northern half of the Monterey Bay area, being rarely found west of the crest of the Santa Cruz Mountains. However, a century or so ago some grew in places from which it is absent today: "In Scott's Valley we find a kind of white oak *(Quercus lobata);* it grows in moist, open valleys." *(Santa Cruz Sentinel,* Aug. 12, 1871.) No doubt this oak has suffered from the clearing of valley bottoms for agriculture. At present, the major center of occurrence in the Monterey Bay area is the Sierra de Salinas. Some large trees grow near the entrance to Toro Regional Park.

Although maul oak is found scattered throughout the Santa Cruz Mountains it is more abundant in the Santa Lucia Mountains and in the Sierra de Salinas. Of all the western oaks, it produces the most valuable lumber, yet was probably never harvested enough to be seriously depleted.

Thus, the general setting of foothill woodland is different climatically and floristically from the more northerly live oak-woodland, discussed above. There is no dense coniferous forest in the vicinity except at high elevations, scattered digger pine's being the principal coniferous growth. (There are also isolated colonies of Coulter pine in the Gabilans and California juniper is present at Pinnacles National Monument.) Chaparral is the main other form of woody vegetation present. The foothill woodland is extensively interrupted by annual grassland, with such herbaceous, introduced plants as wild oat, cutleaf filaree, and soft chess the dominant species. Coyote bush, the aggressive colonist of old fields in northern parts of the Monterey Bay area, is rare in the foothill woodland and plays a small part in the first settlement of cleared land there; coyote bush only grows well in areas close to the coast. Coffee berry, red berry, and buck brush are sometimes present at the edges of the oak woodland. In addition, seedlings of blue oak and coast live oak themselves often appear in the margins of neighboring grassland. Deerweed commonly appears on badly eroded spots. Reestablishment of woody cover here is slow compared to northern parts of the area. And by comparison, a plant cover of introduced herbaceous species appears to be very stable—judging from the slight changes that have taken place in the last few decades in openings between Palo Escrito and upper Pine Canyon. From such evidence alone one could well conclude that patches of grassland, especially on south-facing slopes, might maintain themselves hundreds of years, or indefinitely. But this would not be so under natural circumstances; despite increasing protection from fire and overgrazing, conditions here are not at all as they would be if human influences were totally removed. Historically, the effect of predator extermination and game laws has been to keep deer populations in the whole area at artificially high levels. It is unlikely that low rainfall is the only explanation of the retarded succession rate. Probably, the browsing of seedlings at the edges of the grassland by deer is a major factor in slowing the regeneration of woody plant cover.

Digger pine grows only in the southern part of the Monterey Bay area, southward in the Gabilans from Gloria Road east of Gonzales. (It is not found on the west slopes of the Santa Cruz Mountains.) Near the road leading from Soledad to the west entrance of Pinnacles National Monument,

it descends the west slopes of the Gabilans almost to the floor of the Salinas Valley.

An isolated stand of Coulter pine grows on Fremont Peak, largely in Fremont Peak State Park. Patches of the trees are also scattered along the crest of the Gabilans southward to Gloria Road. (Digger pine and Coulter pine are said to hybridize in that vicinity.)

Unlike the closed-cone pines, digger pine is intolerant of burning. In areas protected from fire, digger pine is reestablishing itself vigorously. The total area of digger pine (and perhaps that of the Coulter pine, as well) was once more extensive on the west slopes of the Gabilans than now: the U.S. Government survey of the El Alisal Grant, east of Salinas, in referring to the northeastern part of the grant extending from the valley toward the Gabilans used the description "*pine timber*, low hills." The area was frequently swept by forest fire: in 1888, a local newspaper described "A fire in the Gabilan Hills west of Fremont's Peak ... burning over thousands of acres of brush and field.... Considerable *pine timber* was destroyed." (*San Benito Advance*, August 10, 1888.) As late as 1929, another paper reported a fire in the foothills of the Gabilans ten miles east of Salinas which "... levelled 30,000 acres of timber, brush, and grassland." (*Gilroy Advocate*, Sept. 20, 1929.)

A site of remarkable expansion of digger pine is to be found at Pine Valley in Toro Regional Park. In 1846, the botanist Hartweg returned to Monterey from the Rancho de Tularcitos, in the upper Carmel Valley, by way of El Toro Peak: he travelled "... over El Toro, a high mountain destitute of trees or shrubs, but thickly covered with wild oats (Avenae species), I found, on the north side, in a ravine, *a few small trees of Pinus Sabiniana, the highest of them not exceeding 30 feet.*" (Hartweg, 1847, p. 188.) The digger pine area in Pine Valley now includes at least 400 hectares of mature trees. This area is of special interest because it is quite isolated from other areas of digger pine well to the south in the Salinas Valley.

(d) Chaparral

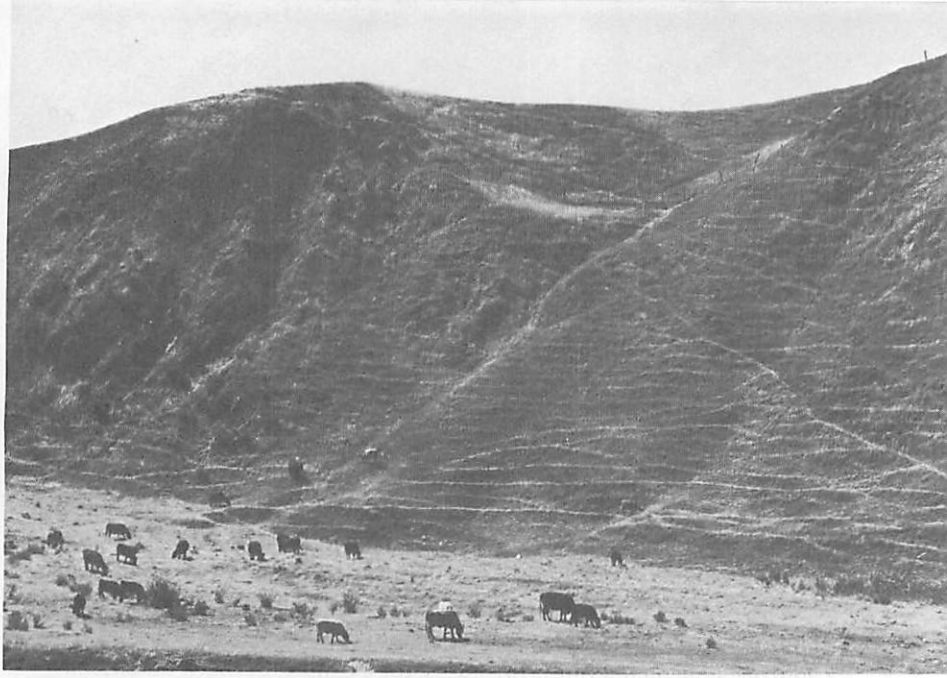
Three subdivisions are made here in the chaparral vegetation of the Monterey Bay area, although all chaparral associations have species in common. The subdivisions are timberland chaparral, hard broad-leaf chaparral, and chamise chaparral. In this order, the three occupy progressively drier and, as regards summer temperatures, hotter parts of the area.

Timberland chaparral is found mainly in the Santa Cruz Mountains. Its dominant species are blue blossom and coast whitethorn. It is sometimes classified as "subclimax brush of the coastal forest [because] ... in most cases it is quite evident that these species occupy areas from which former timber stands have been removed by logging or fire." (Jensen, 1939, p. 15.) Stands of timberland chaparral are dense and somewhat taller than other chaparral types, rising to heights of 2.0 to 4.6 m. Blue blossom is strongly associated with the redwood tree and with the physical conditions favorable for the redwood's growth. Thus blue blossom may serve as a rough marker of those areas which were formerly covered by redwoods—and of human disturbance of natural conditions. Coast whitethorn spreads over burned or logged slopes from stream banks, where it is most commonly found under undisturbed conditions in the Santa Cruz Mountains.

Characteristic species of the hard broad-leaf chaparral are manzanitas, California scrub oak, jim bush and chaparral pea. They often grow with knobcone pine on old forest fire burns, for example, between Mount Madonna County Park and Loma Prieta, and south of the Bonny Doon area along Empire Grade Road.

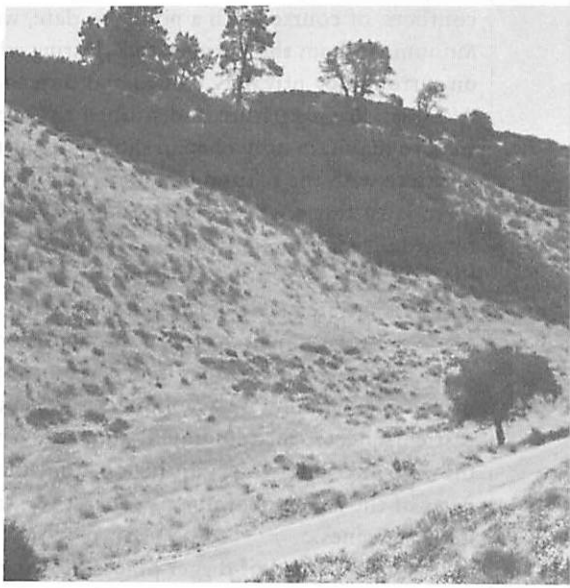
The chamise plant is different from most other chaparral species in having thin, needle-like leaves. This plant is to be found scattered through the chaparral of northern parts of the Monterey Bay area, for example, on the west slopes of Loma Prieta; but chamise chaparral, in which the plant is strongly dominant, is most extensive in southern parts of the area. Geographically, it is closely associated with foothill woodland. In the Santa Cruz Mountains, it is found mainly along ridges and on slopes with southerly and westerly exposures: "From such localities its spread to adjacent areas is favored by recurrent fires." (Jensen, 1939, p. 15.)

While in the Santa Cruz Mountains chaparral usually appears as an interruption of darker-hued coniferous forest or woodland, the chaparral cover farther south, on the lower slopes of the Gabilans and Sierra de Salinas, commonly stands out as dark tracts adjoined by a lighter grassland. There, the sharp zig-zag lines which usually mark the junction of chaparral and grassland rarely express climatic or edaphic contrasts, but rather the limits of burning and grazing. In places where the chaparral has recently been burned, old cattle-trail terraces are sometimes uncovered, indicating that the same slopes have been cleared previously for grazing purposes, and that the chaparral is of no great age.



Above, **Cattle trail terraces** in the Gabilan Mountains. Within the general human influence on landscape, different cultures leave disctinctive imprints. Absent here before the introduction of cattle, this terracing is a specifically European contribution, and thus goes back little more than two centuries. Note the lack of terracing on the very steep slopes at the left. (Photo, R. Buchsbaum)

Below, **California sea lions** on the Monterey Harbor breakwater in June 1974. Approximately 200 were in sight when the photo was taken. Observers walk to within a few meters of the resting animals. (Photo, B. Gordon)



Plant succession in the Gabilan Mts. W. of Pinnacles Nat. Mon., off Highway 146. For over 150 years, chaparral has been cleared to produce grassland. Earlier chaparral was burned off; most of the grassland shown was produced by mechanical clearing (beginning in 1969) undertaken to increase deer population for hunters. Aging chamise plants, the dominant plants of the chaparral, were uprooted. *Below,* a clump of chamise, pulled up with much its root system intact. Many such clumps contain over 10 stems, some 7 cm in diam. and 4.3 m long. Also shown are young chamise shrubs which, except for grasses and herbs, are the dominant regrowth in the clearings. In the summer of 1974, this young chamise, a good deer browse, was mainly between 0.5 and 1 m tall. In places *Eriogonum* grows to about the same height, and on eroded soils, deerweed thrives. The scattered digger pines and oaks, *above* and *center,* are an indication of the successional trend: foothill woodland would eventually have developed if the old chamise had been undisturbed. Without knowledge of recent human disturbance, the remarkable plant boundaries shown *above,* might be mistakenly thought to result from natural processes alone. Where chaparral here is burned rather than mechanically cleared, golden ear-drops (*Dicentra chrysantha)*comes in very plentifully. In 1974, in the first extensive tillage in this area since the grain-growing years—1880-1880—a large tract of nearby cleared land was planted to safflower, a Near Eastern composite. Succession on such tilled land will differ somewhat from that on either burned or or mechanically cleared sites. (Photos, B. Gordon)

Chamise chaparral as a succession feature is well illustrated at Pinnacles National Monument, where it represents something of a management problem. The forest service has long advertised the Monument as a prize example of the chaparral biotic community and has considerable interest in maintaining this plant cover. It has found this difficult to do. Much of the dense chaparral at the Monument is now composed of old and weakened chamise plants which yield inadequate supplies of food for chaparral animals. For example, studies of deer population show that "... sprouting chamise on a recent burn is far superior to old-growth chamise as forage." (Longhurst, *et al,* 1952, p. 45).

If the chaparral community at the Monument is to be maintained it will probably have to be renewed by periodic burning or clearing. This conflicts, of course, with a policy to date, which has been to protect the Monument from the burning and clearing which have been commonplace on surrounding privately owned and Bureau of Land Management lands. Although leaving nature undisturbed has been an ideal of the forest service, to maintain only chaparral on parts of the Monument is, in fact, to interfere with the natural plant succession.

In most tracts where chaparral is dying off, the successional trend is toward digger pine-blue oak forest; these trees are dominant species in the foothill woodland association, probably the climax vegetation for much of the area. The digger pine is particularly intolerant of burning. Since the government acquired this land any fires that have occurred have been accidental and extinguished as soon as possible. Consequently young digger pines are now very common, for example, around the gate at the east entrance of the Monument and westward throughout the area of the visitors' center. Indeed, the most obvious change in the vegetation on parts of the Monument during the last several decades has been the increase in digger pines.

A similar spread of digger pine, following reduced burning during the last half century, has occurred in Pine Canyon in the northern Sierra de Salinas—on lands of the recently-established Toro Regional Park.

(e) Ponderosa Pine Forest

The ponderosa pine stands in the Santa Cruz Mountains are noted here both as an example of human modification of natural plant cover and as an example of the significance of potential natural vegetation in the planning of land use.

The very existence of ponderosa pine in the Santa Cruz Mountains is of considerable biogeographic interest; its total area here is small (at present covering some 247 hectares, or 610 acres) and quite isolated from other ponderosa pines. One particularly associates this pine with the great forests on the western slopes of the Sierra Nevada. The nearest naturally-growing ponderosa pines to those of the Santa Cruz Mountains are located in Napa County to the north, on Mount Hamilton to the east, and in the Santa Lucia Mountains to the south. There are actually two stands of the pine in the Santa Cruz Mountains, separated from each other by a short distance and both growing within (16 km, or 10 miles) of Santa Cruz itself. The larger stand extends from the Harry Cowell Redwood State Park east of Felton northeastward for a distance of about 5 km. The other stand is located in the Bonny Doon area, along Martin Road. In the Santa Cruz Mountains the distribution of ponderosa pine is limited by edaphic factors. The tree is confined to certain light-colored, sandy soils, derived from soft sandstones, and to relatively smooth terrain. This sharp edaphic limitation is not characteristic of the species in its other areas of growth. At the same time, certain other tree species are excluded from the ponderosa pine stands, presumably by these same edaphic factors: for instance, redwood and Douglas fir, which grow in the neighborhood, do not grow on these sandy soils.

These unusual groves of ponderosa pine were discovered by the botanist, Hartweg, in 1846. He noted that "The trees rise to a height of 100 feet, with a stem 3 or 4 feet in diameter." (Hartweg, 1847, p. 189.) The groves have been changed considerably since American settlement in the area began. Only about 60 hectares (150 acres) of the total area are classified as virgin growth (Jensen, 1939, p. 23). According to an account of an old resident, the best ponderosa pine trees were cut long ago. Around 1890, part of the area was logged to supply the local market for box-making lumber. Ponderosa pine has reestablished itself on parts of the logged area, and grows there now to heights of over 30 m (100 feet) (Jensen, 1939, p. 23). Elsewhere in the vicinity, the presence of ponderosa pine stumps is evidence that the pine once covered a larger part of this area of distinctive, sandy soils than it does now; chaparral and knobcone pine now cover a considerable part of it. As we have seen, chaparral and knobcone pine commonly come together in areas which have been cleared and burned. It is estimated that ponderosa pine could reestablish itself upon some 400 additional hectares. The young pines appear and grow vigorously "wherever the soils have not been badly depleted." (Jensen, 1939, p. 23.) Near

the east entrance to Henry Cowell Redwood State Park, an area now protected from disturbance, there is a fine growth of young ponderosa pine.

Unfortunately the biology of the ponderosa pine association has not been studied in detail. Whether or not it had a distinctive association of animal life is unknown; some of its original ecological associations may well have been lost. Under what appears to be least disturbed conditions, the pine grows in parklike stands with no knobcone pine and little chaparral intermixed. The sparse undergrowth is composed mainly of scattered live oak, silver-leaved manzanita, and bracken. The importance of maintaining the ponderosa pine association here is underlined by the fact that it is evidently a preserve for two plant species which, although not confined to the pine groves, are of but very limited distribution elsewhere. One is the above-named silver-leaved manzanita and the other, the even more narrowly endemic Santa Cruz cypress.

The significance of the ponderosa pine area for land use planning can be considered from several standpoints. The natural potential vegetation of a large part of this area of sandy soils is ponderosa pine. These soils are of little agricultural value; various attempts to them agriculturally have failed (Griffin, 1964, p. 410). Natural plant succession where ponderosa pine has been burned or cleared yields chaparral and knobcone pine. This plant cover is not as valuable as the ponderosa pine itself. Chaparral and knobcone pine, being plentiful in the area, are of neither equal biological interest nor equal scenic or economic value. Furthermore, extensive stands of knobcone pine are a fire hazard. The potential natural plant cover, namely ponderosa pine, would provide a more attractive and safer setting for homesites and at the same time older trees might provide an occasional supply of valuable lumber.

(f) Closed-cone Pine Forest

The principal closed-cone pine species in the Monterey Bay area are the knobcone pine and the Monterey pine. There is also a small stand of Bishop pine at Huckleberry Hill on Monterey Peninsula.

As noted earlier, the knobcone pine is concentrated in burned areas. Since fire opens the cones and permits their seeds to scatter, burning not only tends to produce stands of increased density, but also facilitates the knobcone's spread into adjacent areas. Seeds are said to remain viable some 40 years if the cones don't rot. Stands are scattered but of frequent occurrence in the Santa Cruz Mountains. Most large stands are made up of

even-aged trees dating back to recorded forest fires. The trees are commonly between 4.5 and 20 m tall and the stands, either dense or open. Interspaces are commonly taken up by manzanita, chamise, chinquapin, and chaparral pea. There are large tracts of knobcone-manzanita-chinquapin association in the Santa Cruz Mountains between Mount Madonna County Park and Loma Prieta and along Empire Grade Road near Bonny Doon. Most of the Empire Grade groves date from a fire of 1927, which started near Eagle Rock and burned toward Santa Cruz.

The knobcone is a fire hazard because of its high resin content. Furthermore, in densely crowded stands, many trees begin to die within 10 years of the time of sprouting. As surviving trees live only some 50 to 70 years, such stands may be half-filled with dead and dying trees. The knobcone has no commercial value. Even as firewood it is of poor quality, beginning to rot within a year of the time when the trees are cut. Under ideal conditions extensive stands of knobcone pine would not exist. The tree will, however, continue to have value as cover on patches of dry slope where it is too steep, rocky, or infertile for other conifers to thrive, this being probably its original distribution.

Since virtually all of the forest fires which have occurred in the Santa Cruz Mountains in the last 75 years have been set by people, the whole complex of knobcone-pine stands and interspace plants is largely a successional phase brought into existence through human action.

Reference should be made here to the extensive closed-cone pine forest in the vicinity of Año Nuevo. Along Highway 1, between San Francisco and Monterey Peninsula, there is only one small area in the whole stretch where coniferous forest extends to the shore, and that is from a little north of Año Nuevo to a little south of Waddell Creek. Elsewhere along the coast forest has either been cleared or is excluded by edaphic conditions.

The persistence of an isolated forest along shoreline near Año Nuevo is something of a puzzle. An attempt is made here to explain the circumstance in terms of human disturbance, plant succession and of certain characteristics of the Monterey and knobcone pines, the two dominant species. Across the bay on Monterey Peninsula itself, another tract of forest approaches shoreline and, there, too, Monterey pine is dominant. (Indeed, as defined here the Monterey Bay area is enclosed between two coastal forests dominated by this tree, named for the bay and known only from the California coast.)

Although pines alone appear in the shoreward parts of the forest at Año Nuevo, away from the shore they grow intermixed first with douglas fir and then redwood groves, the latter becoming dominant farther inland. Monterey pine is not found over about 1.6 km (a mile) from the sea in the Año Nuevo area, nor at elevations of over 244 m (800 feet) (Forde, 1964, p. 61). The total area of its distribution is approximately 405 hectares (1000 acres).

The fact that forest survives near Año Nuevo cannot be explained on the basis of the area's being remote and little-used. As noted earlier, the vicinity of Año Nuevo was something of an Indian population center. Spanish accounts of Indian burning are particularly numerous in this general area and leave the impression that much of it was well-cleared before European settlement began. Clearing for grazing and agricultural purposes was continued by Spanish-Mexican and American settlers. Part of the area was included in the Mexican rancho, Punto del Año Nuevo, known for its large herds of cattle. In the last half of the 19th century a dairy industry developed here; in 1867, there were eleven dairies in the vicinity of Año Nuevo. The area has long been a lumbering center; in the 1860's and 1870's, lumber was shipped from Waddell's Wharf, boards being brought from a sawmill 8 km (5 miles) inland on Waddell Creek (Stanger, 1968, p. 8 and 12).

Curiously, the Monterey pine has never been considered an attractive lumber tree here in its homeland. Very little commercial sawing of the tree has taken place in the Año Nuevo area. Knobcone pine has been used even less. The Monterey pine is exceptionally fast-growing and is widely planted in foreign sylviculture. Over 121,400 hectares (300,000 acres) of Monterey pine are grown in Australia and New Zealand alone—many times the total area of its natural distribution in coastal California. Seeds for the foreign plantations seem to have come in large part from the Año Nuevo area. One of the first lumbermen there had a:

> ... flourishing trade with Australian farmers in the nuts of the bullpine [a lumberman's name for species which produced inferior lumber, applied here to the Monterey pine] . A special retort was used to heat the pine cones to a temperature that caused them to burst and disgorge their seeds. (McHugh, 1959, p. 16.)

No doubt a principal reason for the neglect of Monterey pine by lumbermen has been the presence in the area of two superb lumber trees, the Douglas fir and the redwood. (A lumber mill still operates near Waddell Creek, located in pine forest near the highway; the mill does not harvest local pine species.)

Several fires have occurred in the Año Nuevo forest within the present century. Douglas fir stands suffer more from burning than do redwood stands; while the Douglas fir is completely killed off by fire, the redwood regenerates by sprouting. On the other hand, the reproduction of Monterey pine and knobcone pine may even be stimulated by fire, as their cones are opened by heat. Their seeds tend to germinate abundantly after forest fires, particularly those of the knobcone pine. (The two species intermix and hybridize naturally near Waddell Creek; Stockwell and Righter, 1946, p. 155-159.) Thus, notwithstanding all the disturbances noted above, pine forests are probably more extensive now than they have been at any other time in the historical period.

An edaphic factor also favors the knobcone pine here over other conifers. Some rough hills rise within the area occupied by closed-cone pines, Douglas fir, and redwoods; for example, between Waddell Creek and Green Oaks Creek. Parts of their crests and upper slopes are made up of a crumbly, white, diatomaceous shale which is permeable and almost devoid of soil cover. The land is quite useless for agriculture or grazing. Forest fires have burned parts of the area. For example, the area between Green Oaks Creek and Año Nuevo Creek was burned around 1917. It is covered by chaparral made up of dwarf maul oak, manzanitas, chinquapin, etc. Knobcone pine is plentiful. During the periods of most intensive land use in the surrounding area, these surfaces probably served as seedbeds for the knobcone pine which tolerates thinner, poorer soils than do other conifers in the vicinity.

In 1846, the botanist Hartweg sailed along the coast from Santa Cruz to San Francisco:

> ... we sailed again, and ... kept close in shore. The whole of the coast is destitute of trees or shrubs, with the exception of Point Año Nuevo, where some pines or cypresses seem to grow. (Hartweg, 1847, p. 189.)

Hartweg was a careful observer, and his is an early description. But it should not be assumed that the conditions he described were natural conditions. Neither the present plant cover nor that of Hartweg's time represent the natural vegetation of the area.

Although redwoods do not thrive at shoreline itself because of their intolerance to salt in the air, the trees probably once approached the coast, on favorable sites, more closely than they do at present. Even today the redwood extends seaward along Coja Creek, about 8 km west of Santa Cruz, to within a kilometer of the shore. Even this hardy tree

would be killed off by a burning program which continued over a period of hundreds, perhaps even thousands, of years. The fires set by the Indian inhabitants in coastal grass and brush burned inland unchecked, where many spent themselves in the seaward edges of redwood-Douglas fir forest. Even within the historical period, before commercial lumbering began, Douglas fir and redwood probably grew closer to shoreline than they do at present, those stands near the coast which survived Indian burning having been harvested by lumbermen at an early date. Presumably, given enough time without human disturbance, they would approach the shoreline more closely again.

The closed-cone pines are not only better able to regenerate under burning and clearing operations than are Douglas fir and redwood but the pines are more sun-loving than are the other two conifers: "When a mixed stand is logged, the opening-up leads to dense regeneration of pine seedlings." (Forde, 1964, p. 67.) And where Monterey pine and Douglas fir grow intermixed, the pine grows the more abundantly of the two at the forest margin; examples can be seen along Scott Creek (Forde, 1964, p. 67). The pines are also faster growing species than are Douglas fir or redwood. When pastures which were made by clearing mixed forest are abandoned, the faster-growing pines take over in the earlier successional stages. Pines are spreading south on seaward slopes in the vicinity of Swanton Road (Forde, 1964, p. 63), indicating that the potential natural vegetation of these slopes is coniferous forest.

Under undisturbed conditions forest would approach the shoreline much more closely than it does at present—both upcoast and down, from Año Nuevo. The fact that the trees which have been planted along the coast thrive, shows that climatically and edaphically the area is suited to tree growth. During the last years of reduced grazing and tilling of the hills, the amount of woody growth has increased. Old-time residents say that within the period they remember, more such plant cover exists now than ever.

The vegetation along the present route of Cabrillo Highway from Santa Cruz past Davenport and Año Nuevo was burned by Indians annually, probably over a period of many centuries, and heavily grazed by the herds of Spanish and American cattlemen. Within the present century the flat land, mostly to the west of the highway on the lowest marine terrace, has been ploughed for field crops.

Because this coastal strip was almost without forest when first seen by Europeans, except around Año Nuevo, and has remained so throughout

historic times, its ability to support tree growth has been underestimated. Some maps which attempt to reconstruct natural vegetation show the area as largely coastal shrub. Patches which have not been grazed or tilled for a five or ten year period do, in fact, develop a dense cover of shrubs (especially California sage). But undisturbed, this shrub cover is later usually replaced by oaks—and this is true on both north and south exposures, and even on steep slopes. The oak grove on the knoll facing the highway to the north of Laguna Creek is an example. The potential natural vegetation along most of the coast is live oak woodland or coniferous forest.

Another major closed-cone pine forest is on Monterey Peninsula, where Monterey pine covers an area of approximately 4860 hectares (12,000 acres). Knobcone pine is absent here.

The distribution of tree species on Monterey Peninsula has long been in a state of flux, vegetation there having been subjected for hundreds of years to constant disturbance. In reviewing the historical events, mentioned earlier, which have changed the plant cover of the area, it will be recalled that Monterey Peninsula, like Año Nuevo, was a major Costanoan population center. Indians of the peninsula consciously used fire to produce a desired plant cover; they used fire also, at least to a limited extent, to capture game. Furthermore, the peninsula is the oldest center of Spanish settlement in northern California. In early Spanish times cattle-growing became the only major industry in the area. Thus, a specialized economy developed based upon the use, botanical transformation, and extension of grassland. Under the Spanish and Mexicans, the port of Monterey was both a shipping and a refueling center—the peninsula supplying firewood not only for local use but for ocean-going vessels as well. Later, American settlers continued the Spanish cattle-growing tradition—using badly overgrazed ranges into the late 1870's. During the present century, as such uses of the land were gradually discontinued, the area of tree growth on the peninsula has greatly increased—and this despite several destructive forest fires—and despite urban expansion except, of course, in the cities themselves. *Tree cover on the peninsula is probably denser and more extensive now than at any other time in the historical period.*

In Indian times there appears to have been a considerable tree cover on the peninsula despite fires set by the Costanoans (cf. the accounts of Cabrillo, Vizcaino, and Crespi).

Within the first few decades of Spanish settlement, much of the forest had been cleared and the peninsula was heavily grazed. According to a traveller who crossed the peninsula in 1792, the country between Monterey and Carmel was grassland with tracts of chaparral and scattered pines:

> Our ride was through a pleasing hilly country interspersed with pines thinly scattered, coppices of stiff scrubby brush wood and extensive spots of clear pasturage swarming with horses and cattle feeding in herds. (Menzies, 1924, p. 283.)

The sparse tree cover of Monterey Peninsula during the Spanish period, contrasting strongly with the abundant tree growth of the present, is shown in pictures made by visiting artists; for example, the drawings made in 1822 by John Sikes (see Van Nostrand, 1968, p. 32) and William Smyth in 1827.

According to an Englishman's account in 1837-39, the country surrounding Monterey "... resembles as near as possible a gentleman's park in England ... the large knots of pine and oak were beautifully grouped ... with rich pastures on which numerous herds were grazing." (Simpkinson, 1969, p. 29.) A few years later, in 1841-42, another British visitor drew much the same picture of the peninsula, describing it as "... a succession of grassy slopes with a sufficient sprinkling of timber to relieve the monotony. The number of cattle that grazed on the rich pasturage was very considerable." (Simpson, 1930, p. 109.)

By 1830, woodcutters had cleared so many trees around Monterey that the Provincial Assembly issued an ordinance (the Reglamento of August 17) regulating the felling of trees there. Wood from the trees remaining around Monterey in 1840 was much in demand:

> Housekeeping is very expensive in California. Oak fuel is $3.00 a carload and rough pine in billets $2.00 [oak is superior to pine as fuel] .... *There is no wood save a few scattered oaks and sycamores in the valleys, the only timber in the country being produced in the mountains.* Timber is in fact inconveniently scarce. (Douglas, 1929, p. 109.)

Despite the above reports of good pasturage elsewhere on the peninsula, in 1840 the north side appears to have been overgrazed and almost devegetated, at least seasonally:

> This plane extending from Monterey to the Salinas River is covered with a low evergreen bush closely resembling wormwood [probably *Artemesia californica,* common on overgrazed surfaces] .... A few diminutive live oak trees grow in the hollows, but *not a blade of grass appears either on the ridges or in the intervening depressions.* At dusk we descended into the valley of the Salinas river; its banks are covered with willow of great size and the cottonwood tree. (Douglas, 1929, p. 109.)

If the potential natural vegetation of this area is tree growth, it has never recovered. Evidence of Monterey pine forest here "...in the very recent past is the finding of pine roots in the soil layers in the country to the north

along Monterey Bay. It is probable that this forest may have occupied much of the region from Monterey to the Salinas River." (Mason, 1934, p. 124.) Unfortunately, it is not known how old these pine roots actually are.

By 1913, a regrowth of chaparral covered southern parts of the peninsula, now residential area or regrown to pines. North of Carmel chaparral was described as extending between elevations of 30 m (100 feet) and 610 m (2000 feet) above sea level and approaching to within 1 km of the sea. Around Carmel itself, the chaparral was at that time being replaced by Monterey pine and coast live oak, "... forming an open forest with the pine dominating." (Cannon, 1913, p. 36.)

(6) Potential Natural Vegetation

Taking into account all of the natural changes in relief, sea level, and drainage which are known to have occured along this coast in the geologic past, one may well ask whether the potential natural vegetation itself is not so variable as to make the concept useless for land use planning. In answer, brief comment is made here upon the rate and magnitude of environmental change in the Monterey Bay area—as it relates to a planner's time scale.

It must be admitted at the outset that the environmental history of the area, before European settlement, is poorly known. But available evidence indicates that it has long had a mild and foggy maritime climate, and did not experience such drastic climatic oscillations during the Pleistocene Period as are known to have occurred elsewhere, for instance in the northeastern United States. Abrupt changes in relief and drainage may occur with little corresponding local climatic change: thus, the changes in sea level which produced the spectacular marine terraces of the Monterey Bay area (especially clearly marked as one looks northward from Natural Bridges State Park) were a response both to local tectonic activities and to worldwide climatic changes not strongly expressed here. In fact, paleobotanical evidence indicates that despite all such fluctuations most of the native trees and shrubs mentioned in this text have survived in the area at least since mid-Pleistocene times—grouped in plant associations very like those which exist today (Mason, 1934, p. 120), that is, throughout a period of hundreds of thousands of years. If we make the reasonable assumption that all these plants have not synchronously experienced marked and parallel changes in their physiologic requirements—and studies elsewhere

indicate that this is unlikely (Whittaker, 1969)—such evidence suggests past climatic conditions not dissimilar from those of the present. Nevertheless, slow climatic change has been the rule everywhere, probably up to the present day. Even in post-Pleistocene time climatic change has probably produced some redistribution of the natural plant associations in the Monterey Bay area. However, little evidence has been found to indicate such alterations of climate here within the last two millenia. Any such climatic trends have proceeded too slowly to be detected in modern climatic records based upon instrumental records. All in all, it can be safely assumed that well into the future human habitants of the Monterey Bay area will be dealing with these same native plant species (barring their extinction by misuse of the land) and that environmental controls similar to those of the present will continue their potent moulding action.

How similar is the present potential natural vegetation of the area to that of some two centuries ago when the first Spanish settlers arrived—taking into account the many man-made changes in plant cover? Have not so many irreversible changes been made that the two potentials are quite different? Plant successional study indicates that this is not the case. Granted, the actual extinction of a species is indeed an irreversible act, but the number of Monterey Bay area species known to have been completely exterminated is as yet relatively small; and it includes no plants. Most of the environmental changes made, sweeping though they may have been, are by no means so fundamental. For example, the lowered groundwater tables would soon rise if pumping and human use of water were discontinued. On the other hand, soil formation proceeds slowly and the removal, in spots, of the A-horizon by erosion will long delay revival of the original plant cover.

What would the successional chain of events be were the Monterey Bay area suddenly depopulated? Plant growth in abandoned orchards and farms suggests a rough outline: Truck crop species would disappear forthwith. Most of the weeds now associated with tilled land would follow. Grasses and forbs, partly exotic and partly native species, would replace them. Exotic plants would disappear in an order scarcely related to their historical order of arrival: Some of the first to arrive, e.g., the wild radish, would be among the first losers in successional competition, whereas the wild oat, introduced at about the same time, might even find a permanent niche for itself (perhaps within a reestablished grassland of native perennials)—but within a much restricted area. Several other introduced plants might continue to grow in sites subject to natural disturbance: tree tobacco,

an early arrival, is one of the few introduced woody plants which might remain; it is firmly established along rocky stream courses in the Gabilans and elsewhere. Forget-me-not, a more recent introduction, thrives on sand bars along streams in the redwood forest of the Santa Cruz Mountains. *Cakile maritima* would likely persist at the boundary between beach and dune.

The narrow strips of shrubby ecotone vegetation would broaden into wide transitional belts and for a time such plants as coyote bush, poison oak, Pacific blackberry, and coffee berry would flourish. For instance, in orchards this shrubby undergrowth would grow taller and, aided by invading live oak, suppress the orchard trees within a few decades. Thus, grassland and pasture areas would shrink—grasses, filarees, etc., dying off beneath overgrowing shrubs. Virtually all introduced animals would disappear as the plant cover changed and the population of native predators grew. The ecotone shrub phase would be followed in parts of the area by a long oak woodland phase: Slowly, Douglas fir would intermix in moister parts of the oak woodland and redwood would somewhat extend its range toward the coast in valley bottoms. Oak woodland without admixed conifers would remain and spread on thin soils and exposed hilltops—areas like the Aromas Red Sands. Probably within a century the plant cover of the Monterey Bay area would be similar to that seen by Vizcaino and Fages: oak woodland, Douglas fir, and redwood groves covering the lower parts of the northern bay area; oak woodland and perennial grasses in the Salinas Valley; blue oak and digger pine on the upper slopes and chaparral covering the lower slopes of the Gabilans; broad strips of riparian forest and freshwater marshes on the floodplains of the Salinas and Pajaro Rivers; etc.

Granted, the present trend in the Monterey Bay area is definitely not toward depopulation; increases in population densities are virtually certain to occur. Nevertheless, the concept of potential natural vegetation and the principles of plant succession can be usefully applied as the area of the rural and urban biocommunities expands.

Chapter 4

FAUNAL CHANGES

A. MAMMALS

(1) Native Mammals which are now Extinct in the Area

The first account of the California grizzly comes from the Vizcaíno's party at Monterey in 1602. The bears were seen feeding on a whale carcass which had drifted onto the beach.

The California grizzly was a remarkably omnivorous animal but as the Spanish settlers established the cattle industry in the last part of the 18th century, the bear was offered a great new food supply. The Spanish devoted themselves single-mindedly to a pastoral economy. Visitors were astonished at the number of cattle. Only choice cuts were eaten; only hides and tallow were marketed. Horses became so numerous that they threatened the range and had to be killed by the thousands. Herds were driven into the sea at Monterey in 1810 (Vallejo, 1890, p. 189). "With so many dead bodies of domestic animals to be had without effort, grizzlies ... multiplied as they had never done before." (Storer, 1955, p. 130.)

In 1792, soldiers at Mission Santa Cruz were sent out to hunt grizzlies (Torchiana, 1933, p. 193). Near Monterey during the decade 1801-1810, the bears often ate cattle before the very eyes of the herdsmen (Bancroft, 1888, II, p. 142-143). On December 1802, the *Provincial State Papers of Monterey* reported that bears, mountain lions, wolves, and coyotes had killed 207 cattle of the government hacienda's 2284 herd during the year. Bull and bear fights became common entertainment during the Spanish-Mexican period and lasted over into the early American period. Bear and bullfights were held at Monterey, Carmel, Castroville, and elsewhere. A pioneer American in Watsonville in 1852 recalls that: "Here at First and Main Streets we would have bullfights and occasionally a grizzly bear and bullfight." (Kitchen, 1952, unpaginated.)

As noted above, the first account of bear in the Monterey Bay area (no doubt a grizzly, since the black bear is not native along the coast south of San Francisco Bay) describes it as feeding on a whale carcass lying on the beach. This food supply was also to be augmented. Shortly after the arrival of the Americans a whaling industry developed at Monterey (in the 1850's). Whaling crews rendered the fat on the beaches, and "the grizzlies fed on the offal that floated ashore." (Storer, 1955, p. 58.)

The California grizzly appears to have been unusually gregarious; several accounts refer to its congregating on beaches: In September 1846, John C. Fremont's party travelling in the Salinas Valley came upon a number of grizzlies in the oaks. The party killed 12 and others escaped (Fremont, 1887, p. 571).

The Americans adopted the grizzly as the symbol on the California State flag. Nevertheless, as large steel traps, strychnine, and in later years the repeating rifle, came into use, the bear population began to decrease. In the 1870's and 1880's, grizzlies were still frequently reported in the area: A rancher named Waddell was killed by a grizzly on the Rancho del Oso (Bear Ranch), near a stream now called Waddell Creek. The last recorded killing of a grizzly in Santa Cruz County was in 1885.

In 1878, the sheriff of Salinas and his party "... while hunting back of Tassajara Springs saw a huge grizzly bear. Pine Valley is full of grizzly at present." (*Overton Manuscript*, 1877, p. 18.) The grizzly was probably extinct in the Monterey Bay area before the turn of the century, although the animal survived into the 20th century elsewhere. (The last California grizzly was seen in Sequoia National Park in 1924.)

The outstanding authority on the California grizzly suggests that a graph of its population numbers—

> ... would have shown a long plateau through the centuries with minor ups and downs, then a rise in numbers—particularly in the coastal regions adjacent to the missions where cattle were abundant—that reached a peak about the time of the American occupation. This was followed by a quick descent—a half century or less ... to the base line, extinction. (Storer, 1955, p. 26.)

Before the American settlement, tule elk were numerous in the lowlands of the Monterey Bay area. As its name suggests, the animal prefers a moist habitat, like the marshes and bunch-grass prairie that extended from the lower Salinas Valley to Elkhorn Slough. (Probably the animal gave the Slough its name, its antlers having often been found there.)

As noted earlier, bones of the elk have been found in Costanoan middens. In 1602, the explorer Viscaíno mentioned the presence of elk near the southern shore of Monterey Bay: "Among the animals there are large fierce bears, and other animals called elks, from which they [the Indians] make elk-leather jackets." The animal was reported by other early explorers of the area, and it survived here throughout the period of the Spanish cattle industry.

According to one American settler whose childhood was spent at Gilroy, he remembered his family's going "... over the mountains to the Pajaro

Valley to hunt elk and returning with wagon loaded. At times the trip extended down to the Salinas plains." (Evermann, 1915, p. 89-90.) A French acquaintance of this settler, who had come to California either in 1843 or 1846, and lived in the vicinity of what is now Pajaro Junction, "... often spoke of the sport he had killing elk here, saying that on occasions the vaqueros would ride among them and the cattle, single one out, ride him down and hamstring him with a machete;" he also spoke "... rather bitterly of the Americans killing them so wastefully." (Evermann, 1915, p. 89-90.) Another settler, writing of the year 1852, said, "There were plenty of elk in the Castroville hills." (Kitchen, 1952, unpaginated.)

Elk are said to have survived nearby in San Benito County until 1864. The animals were killed in various parts of central California and shipped to San Francisco markets. Likely commercial hunters, and the tilling of increasingly large tracts, were responsible for the elk's extinction in the Monterey Bay area. At least one unsuccessful attempt was made to reestablish the tule elk here; in 1915, ten were brought from Kern County and kept at Del Monte, near Monterey. About 15 descendents survived there as late as 1936.

To the south of the Monterey Bay area some Rocky Mountain elk were brought to San Simeon and released on the William R. Hearst Ranch. Some of these animals escaped into the wild and their descendents make up the existing Santa Lucia Mountain herd (Dasmann, 1965, p. 22). The Rocky Mountain race of elk, however, prefers a mountainous and forested habitat and cannot be thought of as replacing the native tule elk.

Pronghorn antelope also ranged over the grass-covered parts of the Salinas Valley when the Spanish arrived. The explorers repeatedly mention the animal. For example, on September 27, 1769, Father Crespi reported from the area between King City and Greenfield, "We saw in this day's march two bands of antelope some distance from us." And the next day from around the present site of Greenfield itself, "... some bands of antelope were seen but not within gunshot." (Bolton, 1927, p. 199.) In the year 1770, Pedro Fages (1911, p. 149) reported from the vicinity of Chualar "... seeing many herds of antelopes, some of them exceeding fifty." The antelope seems to have been most numerous in the drier country to the south of Salinas (while the tule elk was mainly in the swampier area to the north). The antelope appears to have become almost extinct here within a short time after the Spanish cattle industry began; there seem to be no records of them in the 19th century except for the following notes: According to an old-timer's account of an excursion made in January 1852,

"We rode along the hills on the east and northeast side of the Salinas Plains [that is, along the west base of the northern Gabilans] .... We saw several bear and plenty of deer and *antelope.*" *(The Salinas City Index,* Feb. 15, 1877.) And "... older settlers can remember the time in the Hildreth and Dunphy herding days when *antelope were not uncommon on the Salinas plains from Gonzales southward.*" *(Monterey Democrat,* June 30, 1888, p. 6.) Probably the antelope's grassland haunts were quickly taken over by cattle, while the tule elk survived a little longer in marshier, hence for cattlemen less usable, areas downriver.

The Guadalupe fur seal once ranged from the Farallon Islands, off the coast near San Francisco, to Baja California, including the Monterey Bay area. Hunted intensively for its fur, it was already rare by the mid-19th century. According to one estimate, throughout the animal's entire range "... the total number killed must have exceeded 400,000." (Evermann, 1923, p. 524.) (Actually this figure may include some Pribilof fur seals.)

By 1846, the rookery on the Farallon Islands had been entirely wiped out. By the first years of this century, the animal was thought to have become extinct. It was rediscovered, however, on Guadalupe Island, off northern Baja California, in 1926. The species is still precariously close to extinction, though under protection by the Mexican government the seals are slowly growing more numerous. Two hundred and forty were counted on Guadalupe Island in 1964 (Dougherty, 1965, p. 57). None have returned to the Monterey Bay area.

(2) Native Mammals which have been Reduced in Numbers

LePerouse in 1786, wrote while in Monterey Bay, "It is impossible to describe either the number of whales with which we were surrounded, or their familiarity. They blowed every half minute within half a pistol shot from our frigates...." (LePerouse, 1799, vol. 2, p. 178.)

According to Sir George Simpson, when he visited Monterey in 1841-42: "Several whale were spouting near our vessel, the Bay of Monterey being a favorite resort of the fish...." (Simpson, 1930, p. 105.)

Around the middle of the 19th century a whale processing industry developed on the shore in the area; a company was founded at Monterey in 1854. By 1861, Monterey was described as a great whaling port: "The number of whale bones on the sandy beach is astonishing—the beach is white with them." (Brewer, 1949, p. 105.) The following description dates from 1871:

> Though many whale were killed during my visit, chiefly the "California Gray" (*Rachianectes glaucus* Cope), it was impossible to obtain measurements and drawings of them as they were always cut up while floating, and the mutilated carcasses when washed ashore were deprived of "flukes" and other essential parts, besides smelling so strong that the odor for miles was almost unbearable.... (J. G. Cooper, 1871, p. 757-758.)

That whale populations along this coast were being threatened by industry was already recognized a century ago.

> The whale fishery, which for the last twenty-five years has constituted one of the most important of our local industries, is likely soon to become a thing of the past. The whales are gradually becoming scarcer.... Many years ago, while California was yet a province of Mexico, the New Bedford whaling ships caught large numbers of Sperm and Right whales along this coast; but these species have now almost disappeared, and our whalers have to content themselves with the more numerous but less valuable California Greys and Humpbacks. (Walton and Curtis, 1875, p. 44.)

The reduction that was made in the California gray whale population within the following half century is illustrated by the fact that the California Sea Products Company, which began operating a whaling station at Moss Landing in 1918 (and another at Trinidad in 1920), had, by 1923, been able to take only five individuals of this species on the California coast (Evermann, 1923, p. 527).

The sea otter was a major economic factor in the exploration and settlement of the California coast. Its pelt was highly prized in both Asia and Europe and the animal was hunted along the west coast of North America by the Spanish, Russians, and Americans.

Actually, there are two geographical races of the sea otter, a northern and a southern. The northern race protected by international agreement, is now relatively numerous from the Alaskan coast to the Commander Islands of the western Bering Sea. The total population there has been estimated to be between twenty and thirty thousand.

By the middle of the 19th century (ironically, about the same time Darwin was writing on the *Origin of Species)* the California race of the otter had almost disappeared. The following account describes the hunting of sea otter in the Monterey Bay area:

> About 1823 was organized a company of otter hunters. They were Kadiaks [Kodiaks] from Alaska. Their way was to pursue in their boats the otter in the bay of Monterey, and when the latter became tired out, kill them with arrows. The otter used to sleep on a bed of seaweed opposite the sand banks of the bay. The Kadiak skin boats would take positions in line; then from a

> large boat several shots were fired; the frightened otter would start on a run, and the boats pursued them with the utmost speed. Their boats were made of seal-skin, the hair having been removed.... In this manner were destroyed all the otter on that part of the coast and further down. (Bancroft, 1888, p. 470-471.)

During the first decades of the present century the southern variety was thought to be extinct. Then, in 1938, a herd of about 100 was discovered south of Carmel in Monterey County. Since that time it has become one of the most closely guarded and intensively studied wild animals. At present, it lives mainly between Monterey Bay and Moro Bay. In June 1969, 1014 were counted along that stretch of the coast. About 250 of these were in the Monterey-Carmel area. I do not have a census from the coast northward; some have been sighted as far north as Año Nuevo. Within the bay proper, sea otters are commonly seen near Hopkins Marine Station.

The sea otters' principal foods are mussels, sea urchins, and abalone—animals found on rocky shores and among the kelp beds in shallow offshore waters. Thus its habitat is restricted; it is generally situated less than 1.6 km (a mile) from shoreline and in water less than 30 m (100 feet) deep; in short, within that part of the sea which is today subject to the most garbage accumulation and pollution. Even with the legal protection that it enjoys, the sea otter will probably not reestablish itself in great numbers.

The elephant seal, a huge animal carrying a large mass of blubber, once ranged from Baja California northward to Point Reyes. Males reach a length of over 4 m (13 feet) and may weigh some 1814 kg (4000 pounds).

The animal, which shows little fear of man, had been almost exterminated for its oil in 1869 (Scammon, 1968). By the end of the 19th century the estimated population was less than 100 (Radford *et al*, 1965, p. 602), living mainly on Guadalupe Island, off Baja California. As a result of protective measures the elephant seal has made a remarkable recovery during the last few decades. In 1911, the Mexican government prohibited killing it on Guadalupe Island and by 1930, the population there had built up to about 500, estimated then to be one-third of the total number. At present, the total population is estimated at over 15,000, with the center still in the Guadalupe Island area. Within the last few decades, the elephant seal has spread northward and recovered a large part of its original range. In 1955, several were discovered on Año Nuevo Island. Since that time, the island has become an important breeding ground; 483 were counted on the island in 1963 (Orr and Poulter, 1965, p. 400).

(3) Native Mammals which are now more numerous than in Aboriginal Times

Before the arrival of American settlers black-tailed deer were very plentiful in parts of the coastal country which had been cleared by the Indians and Spanish. The following is a note from a record kept by a visiting party of Americans travelling between Año Nuevo and Monterey in 1833: "In the evening the hunters all returned to camp with the tongues of 93 deer and some of the hides...." (Leonard, 1934, p. 156.) This suggests a surprising abundance of deer. It also recalls the hunting habits of early Anglo-Americans—soon to be demonstrated, and more tellingly, on the elk and other mammals in this area, as they had been on the bison and passenger pigeons east of the Rockies. Nevertheless, considering the area as a whole, deer may be more numerous now than they ever were.

Deer both graze and browse and have a varied appetite. In the Santa Cruz Mountains the animals damage orchards by feeding on the bark of prune and pear trees. They are often found near the edges of openings: the grassy clearings along the crests of the Santa Cruz Mountains are favorite spots for deer hunters to wait while their hunting companions flush the animals upslope out of forest margins below. "The clearing of foothill and mountain homesteads, the cutting of timber, forest fires, and other events that created openings and led to the spread of palatable herbs and browses have actually improved the deer habitat." (Dasmann, 1965, p. 4.)

As noted earlier, human settlement need not necessarily lead to the impoverishment of wildlife. In fact, with suitable planning such settlement may be accompanied by increased variety and abundance. For instance, the following comment bears on the importance for animal life of generating new successional cycles in the plant cover: "... influences which tend to keep woody vegetation in a subclimax stage increase the carrying capacity for deer." (Longhurst, *et al*, 1952, p. 45.) The main such renewing influence is human activity. Granted, the above comments refer only to deer (which in places are actually already overly plentiful because of the official encouragement they get as a favored game animal), but the principle could apply to other species as well—for example, to deer predators, to avifauna, etc.

The California sea lion is probably at least as common now as it was in aboriginal times, and likewise the Steller sea lion. In 1961, 18,400 California sea lions were counted, more than three-quarters of these being in the

southern part of the state, where the animal breeds. Año Nuevo Island has the largest population of Steller sea lions in California: 2300 of the total of 7000 animals in the state were counted there in 1961.

A great herd of California sea lions appears seasonally at Año Nuevo Island. They bark almost incessantly in contrast to the rather quiet Steller sea lion, making one of the characteristic sounds along the rocky stretches of shoreline. A small herd, made up of everchanging individuals, stays much of the year at Seal Rock near Lighthouse Point, Santa Cruz. The annual appearance of a large herd on the breakwater at Monterey Harbor (seasonally related to the time of squid spawning) shows how adaptable the animals are to human presence and activity: The breakwater was not built until 1932.

Note may be made here on the large pinniped herds at Año Nuevo Island Scientific Reserve: It appears that the large numbers there represent more than a renewal at an old center. The population was probably never so large in the past, mainly because of the legal protective measures taken recently, but also because of natural changes: In prehistoric times pinnipeds probably did not enjoy a protected insular rookery because, as noted earlier, it is likely that the *island* of Año Nuevo did not exist as such —that instead there was only a long, narrow promontory here, Point Año Nuevo, fringed with a few offshore stacks. The Costanoans made this neighborhood something of a population center; there is a concentration of midden sites in the vicinity. Considering the nature of Costanoan foodstuffs, Año Nuevo Point would have been a rather precarious location for a pinniped rookery, compared to the island as it exists today.

The cottontail rabbit is probably another example of an animal which has spread with the extension of its favorite habitat—the ecotone vegetation.

The coyote is often given as an example of an animal which tolerates human presence. It is thought to have been largely a plains animal at one time and to have spread almost throughout the continental USA since European settlement began but it is not abundant in the Monterey Bay area.

The raccoon, likewise, tolerates human presence, obtaining part of its food from orchard fruits, like cherries, apricots, prunes, and apples. Food is put out for them around some residences in wooded areas such as the San Lorenzo and Carmel Valleys.

The mountain lion now lives only in the more remote mountainous areas but it is uncertain how significantly its numbers have changed in this century. Legislation removed the bounty on the mountain lion in 1967.

Meadow mouse populations are known to experience remarkable fluctuations, both under natural conditions and under conditions of human land use. The lower Salinas Valley is California's major artichoke growing center. The industry was established here in 1922, and by 1925, 1620 hectares (4000 acres) were under cultivation (Jones, 1949, p. 542). The approximately 3440 hectares (8500 acres) now under cultivation furnish about 90 percent of the U.S. supply of artichokes. The growers' three worst environmental problems here arise from depredations made on artichoke plants by the meadow mouse and the plume moth larva, and the intrusion of marine salt water. All three problems are closely linked to environmental changes resulting from human activities, present or in the recent past. Unlike many agricultural pests in this part of California, the plume moth and the meadow mouse are native species.

Meadow mice are always pests in the artichoke fields but during the last ten years they sometimes have become a veritable plague. The worst such infestation occurred in 1968, and a lesser one was in progress in 1971. In the summer of 1968, their effect was disastrous. Some growers lost nearly 50 percent of their crops. The infestation was finally brought under control, in mid-July, by an aerial broadcast of 9072 kg (20,000 pounds) of rolled oats treated with zinc phosphide, spread over 2830 hectares (7000 acres).

On May 12, 1971, we visited artichoke fields near Mulligan Hill to see the evidence of mouse destruction (accompanied by Mr. Nat Bracco, a grower with a detailed knowledge of local natural history).

Each year caterpillar tractors pull long blades through the fields severing the artichoke stalks from the roots, thus starting the plants on a new growth cycle. We arrived during the noon hour when the cutter had stopped operating. Half a dozen vultures stood in the field gorging on mice killed by the blade. When the machine started up again, we followed it. As the mice build their nests among the artichoke stalks slightly below ground level, most of the nests were being exposed by the cutter. Thousands of mice were either mangled or scurrying for cover. They seemed to fall into three age groups. One group was made up of full grown adults; another of mice a little less than half grown but already covered with hair and with their eyes opened; a third group was hairless newborn with eyes unopened. Thus, at least two litters had already been produced at this early date in the main breeding season. During its peak reproductive season, the meadow mouse is said to produce up to 12 or even 15 young every 28 days. Although litters are produced throughout the year, the number borne by each female is unknown.

Within a short time after the cutter started, a large flock of sea gulls arrived to feed on the exposed mice. The gulls, largely California gulls, were catching live young mice for the most part, but some also made off with adults in their beaks. Mr. Bracco made the interesting observation that the gull, like some other shore birds, rarely lands on ground covered with shrubs or other tall plant growth. Thus it avoids fields in which artichoke plants still stand, but comes in readily when the plants are knocked down and the ground bared.

Virtually all of the mice in these fields are of the one species—the meadow mouse. We collected only one specimen of the deer mouse. According to Mr. Bracco, yet another species inhabits the fields. Judging from his description this may be the western harvest mouse, but we were unable to find any. The number of mice of the last-named genera appears to remain fairly constant, as does the number of moles and shrews. The reasons for occasional outbursts in meadow mouse populations are unclear. Granted it is generally more numerous than the other two species but here it is probably the dominant species because of its food habits. It *will* eat seeds, but feeds mainly on plant leaves and stems, while the other species are *primarily* seed eaters. And since seed producing plants like mustard and oat are weeds here and cut back wherever possible, seeds are often scarce. (Ingles, 1945, p. 219, says of the western harvest mouse, "... fortunately it seems to prefer the seed and fruit of native plants to those of plants introduced by man." If true, this could well explain the scarcity of the species here: oat and mustard are introduced, and native plants can only be found around the edges of the artichoke fields.)

Even in untilled areas meadow mouse populations have been observed to be higher than those of the western harvest mouse and the deer mouse (Brant, 1962, p. 167). But when the land is cultivated the resulting vegetation favors the meadow mouse more strongly still over other species.

No censuses of the meadow mouse in the Castroville area have been published. However, as a basis of comparison, in one study of an uncultivated field near Berkeley the widely fluctuating meadow mouse population was estimated to range, over a period of several years, from less than 2 to 62 per hectare (1 to around 25 per acre)—based upon the results of a trapping program (Brant, 1962, p. 144). Another study near Berkeley detected densities varying between less than 1 to at least 800 per hectare (325 per acre) on one area within a period of three or four years (Krebs, 1966, p. 270). Granted, these counts were themselves not made under natural conditions: the fields studied are overgrown with dominantly alien

plants—wild oats, soft chess, wild mustard, etc. Nevertheless, there is an obvious contrast between these Berkeley populations and those of the Castroville artichoke fields. During the Castroville population outburst of May 1971, the number of mice in each artichoke plant cluster averaged at least six. As the number of plant clusters on a hectare averages 1285 (520 on an acre), the mouse population was at least 7700 per hectare (3120 per acre). In mid-January 1973, the average was slightly less than one mouse per plant cluster; that is, some 1285 mice per hectare (520 per acre). (At that time only about 10 percent of the nests contained young, and the litters were small—only 2 or 3.) This is probably not the minimum mouse population as there is evidence that it had been building up lately. Nevertheless, it is unlikely that the numbers ever drop to the levels found in the untilled fields studied near Berkeley. In the Berkeley area it was observed that the meadow mouse avoids riparian vegetation (Brant, 1962, p. 108), which was probably the original cover of the Castroville artichoke fields. This suggests that the species was not common here under natural conditions and that man-made changes in plant cover were responsible for the increases in number.

The mice change their eating habits somewhat during times of peak population outbursts: for periods of two or three years they live mostly below ground, feeding on artichoke roots and the pith in the center of the stalks; when population outbursts occur, they surface and feed mainly on upper parts of the plants, eating the growing shoots and gnawing on the artichoke fruits themselves. Although the plants are usually only weakened, some are killed. The mice are said to survive irrigation of the fields by climbing into the tops of the plants.

Vultures feed only on dead mice. Hawks catch a few live ones but we saw only one, a redtailed hawk, hunting over the fields. Plainly hawks are not numerous enough to be a significant control at times like these. (Kites are reported to have suddendly become numerous during the 1968 plague but we saw none hereabouts in 1971.) On occasion a few crows come from a string of trees growing upstream along the river, but they are roughly treated by the gulls. Whenever a crow catches a mouse it is promptly set upon by the gulls and forced to drop its prey, and this despite the fact that mice were definitely not in short supply.

Native mammalian predators are now of little help in keeping down the mouse population. Most, like the weasel, are discouraged by agricultural activities. As practically all tree growth has been removed in this neighborhood, roosting places for bird predators like hawks, owls, and crows have

been eliminated. Furthermore duck hunters who congregate near the river mouth often shoot these birds simply for sport.

This is yet another instance of the thoroughgoing influence of human action on ecological conditions. People have removed the native riparian plant cover here and introduced exotic plants like the artichoke, mustard, and oat, thus altering the food base of a native mammal, the meadow mouse. The numbers of most native predators have been reduced (hawks, owls, etc.) while another, more adaptable species, the gull, has multiplied.

Probably the most commonly seen native mammal in the state is the California (Beechey) ground squirrel. And few animals in the Monterey Bay area better illustrate the control problems created by changing land use. Of native mammals the ground squirrel is by far the most costly pest, both in the Monterey Bay area and in the state as a whole. Federal, state, and county agencies have been enlisted in programs for its extermination; millions of dollars have been spent. Only through the use of all manner of poisons, through trapping programs, and the payment of bounties has it been possible to keep squirrel numbers in check.

Under natural conditions the ground squirrel likely inhabited the grassy interspaces in oak and foothill woodland and those small areas of natural grassland which existed. It was no doubt already plentiful before Spanish settlement began; it was a common food item among the Costanoans.

After the introduction of cattle and the associated changes in grasslands, the ground squirrel became even more numerous than it had been in aboriginal times. And its range was extended by the increase made in the total area of grassland. Ground squirrels thrive on overgrazed range. And periods of intensive livestock industry are associated with increases in squirrel populations. Sheep were once raised in great numbers in the southern part of the Monterey Bay area, at which time ranges were especially heavily grazed: In 1860, Monterey County "... contained more sheep than any other county in the United States ... and 100,000 cattle." (Cronise, 1868, p. 122); in 1870, there were 290,000 sheep in Monterey County. From all accounts, ground squirrels swarmed over the area during this period of maximum use and extension of grassland.

The abundance of squirrels at sites of human disturbance, particularly where woody plant cover has been removed (on overgrazed ranges, around abandoned ranch buildings, etc.) is characteristic. In 1792, a naturalist describing Monterey Peninsula wrote of the ground squirrel, "... a large, variegated squirrel which burrowed in dry sands were very abundant, *particularly about the Presidio.*" (Menzies, 1924, p. 287.) In 1861, a visitor

to the ruins of Carmel Mission exclaimed "... the number of ground squirrels burrowing in the old mounds made by the crumbling adobe houses was incredible—we must have seen *thousands* in the aggregate. This seems a big story, but hundreds were in sight at once." (Brewer, 1949, p. 107.) In such numbers the squirrel is associated only with the earlier stages in plant succession.

In 1869-70, the state legislature authorized payment of bounties on the squirrel, permitting the counties to levy an assessment on taxable property. One poison commonly applied down to the present day was sold in 1878, for private use: "J. A. Malloy has just received a large supply of *bisulphide carbon* [CS_2], a preparation said to be unexcelled for the extermination of squirrels. For sale at the drugstore." (*Castroville Argus*, April 12, 1878.)

Agricultural development took place earlier in the Pajaro Valley than in the Salinas, where, like the Spanish before them, many of the first American settlers became cattlemen. However, by 1890, most of the cattle ranches in the Salinas Valley had been subdivided into grain farms; but here, too, squirrels continued to be a problem. In 1888, sugar beets were planted in the valley, and by 1897, beet-growing and dairying were replacing grain farming on the more fertile soils (Allen, 1935, p. 139). But cultivation and irrigation only locally reduced the squirrel populations.

In 1908, it was discovered that the ground squirrel flea sometimes harbors the bubonic plague bacillus, and that plague exists endemically among ground squirrels. Between 1908 and 1914, a concerted, but unsuccessful, effort was made to exterminate the animals with federal, state, and local agencies participating. (The California State Department of Public Health still periodically inspects the animals for evidence of the disease.)

In 1908-09, the U.S. Bureau of Biological Survey began a program of squirrel poisoning using strychnine-coated barley. In 1917, the state legislature assigned the duties of rodent control to the County Agricultural Commissioners, where it remains. By 1930, a formidable assortment of poisons was in use, including strychnine, carbon bisulphide, cyanide salts, sulphur dioxide, chlorine gas, and thallium sulphate. The effects of thallium sulphate which had but recently become a common poison (the federal government printed directions for applying it to grain bait in 1931), were so far-reaching that a number of articles were written objecting strongly to its use. In 1930, when squirrel poisoning with thallium sulphate was in progress in the Gabilans, quails, doves, blackbirds, larks,

woodpeckers, linnets, rabbits, deer, jays, and magpies were poisoned, as well (Linsdale, 1931, p. 98). Squirrel-poisoning programs also destroyed many of the principal predators capable of naturally limiting squirrel populations; e.g., wildcats, coyotes, and gray fox, because these carnivores ate the bodies of animals killed by the poison (Grinnell, Dixon, and Linsdale, 1937, p. 29). The use of thallium sulphate has been discontinued. In recent years, the most commonly used poison has again been carbon bisulphide—one of the oldest in use. Anticoagulants are also used.

The overabundance of ground squirrels in the area results from clearing the woody plant cover. The squirrel avoids dense forests, both because most of its favored foods are in short supply there and because its principal predators are common. The ground squirrel feeds on many introduced plants of the annual grasslands, such as the filarees, soft chess, and ripgut grass. The more extensive the grassland the farther removed are the squirrels' predators—most of which, including most hawks and owls, need some woody cover. An exception is the badger, which also lives in open country; but it is itself often destroyed. Ground squirrels are not common at Toro Regional Park, Royal Oaks County Park, or Mount Madonna County Park, where no poisoning is done and where woody cover has been encouraged and predators protected. The squirrels are very numerous at Fremont Peak State Park, on parts of which the tree cover is still sparse and which adjoins large tracts of grazing land. The ground squirrel population of Larkin Valley and the Prunedale district, both sites of woody regrowth, has much diminished during the last several decades.

Of course, cattle growing and agriculture are only possible when the land is cleared of much of its woody plant cover. Ranches and farmers cannot be expected to permit large tracts of this land to revert to its natural vegetation simply to reduce the squirrel population. On the other hand, the total cost of controlling ground squirrels in the Monterey Bay area has been a major economic factor; millions having been spent on this program in California. It does seem that in the long run there would be economic advantage in supplementing a squirrel-control program based upon the use of some of the less noxious poisons with a program of limited revegetation (to be discussed later) and the protection of predators.

The significance of predators in regulating animal numbers goes beyond their promise for the control of ground squirrels, to a more general biological role. Studies in other ecosystems suggest "... that local animal species diversity is related to the number of predators in the system and

their efficiency in preventing single species from monopolizing some important, limiting requisite...."; that, in fact, predation may be capable of preventing extinctions in competitive situations (Paine, 1966, pp. 65 and 73).

(4) Introduced Mammals

In addition to the strictly domesticated animals like livestock and poultry, which are cared for by people, the following mammals have been introduced into the area—some purposely, some accidentally.

The house mouse, which is of central Asiatic origin, was brought into California by the earliest Spanish settlers, probably in foodcases, barrels, and the like. It is now common not only in human dwellings but in neighboring fields and weed patches as well, where it comes into competition with native mice. Although it may be found at some distance from human habitations, the house mouse does not go beyond the urban-rural habitat created by human settlement. Two varieties have been distinguished; one is commensal with man and the other a feral variety adapted to living in old fields. When it ventures into less altered country, it is kept in check by native predators like hawks, owls, weasels, skunks, and snakes. And even in areas where plant cover is largely made up of alien herbs, the house mouse may be kept in check by interaction with native mouse species. Study of a dense feral house mouse population on an island in San Francisco Bay showed a remarkably rapid decline of the population to extinction when the native meadow mouse colonized the island (Lidicker, 1966, p. 49).

The gray-brown Norway rat and the black rat are both found in the Monterey Bay area. (The roof rat, also present, and the black rat are races of a single species.) Just as the ground squirrel is the worst native mammalian pest, the Norway rat is the worst introduced mammalian pest in the state. It is more aggressive and destructive, and larger and more prolific than the black rat and where it is numerous, black rats are likely to be scarce.

The Norway rat, probably native to western China, is thought to have arrived in the eastern United States during the Revolutionary War. In any case, it has been introduced into the country many times by ship and probably arrived first in California with the Spanish. It is a good climber, digger, and gnawer, and ideally suited by its food habits to a life commensal with people and, as it seems unable to protect itself from native predators

in the wilds, does not range beyond urban areas and the vicinity of rural dwellings. By spreading the rat, people have produced a variety of new interspecific contacts. Bubonic plague, carried by fleas infesting rats, has occasionally been brought to port cities; humans have also been infected with trichinosis by eating pigs which have eaten infected rats.

Few land mammals thrive better in the marine shoreline environment than do rats. For example, they sometimes infest rock rubble, placed to protect the cliffs from waves, living there on food scraps dropped on the beaches by picnickers.

Five Virginia opossums which had been brought from Missouri were released near San Jose in 1900 (Koppel, 1915, p. 195). In 1910, at least five more escaped from cages in San Jose. By 1915, opossums were established in the Monterey Bay area; several were captured that year near Boulder Creek. It has since established itself, with great success, not only around Monterey Bay but well beyond. Although limited to settled areas, it is now found in remote, sparsely settled parts; for example, at Mount Madonna County Park. Because it is nocturnal, and apparently easily confused by headlights, it is (with the housecat) probably the most commonly seen dead animal on the roadside.

The arboreal native western gray squirrel is common throughout forests of the Santa Cruz and Santa Lucia Mountains, although its area has been reduced by forest clearing and lumbering. It rarely ventures far beyond the boundaries of coniferous forest. In the Santa Cruz Mountains it has been joined by two introduced species which escaped or were released from around Menlo Park. The eastern fox squirrel is now well distributed throughout the Santa Cruz Mountains and even approaches shoreline, with the western gray squirrel, in the pine forest near Año Nuevo. In the Santa Cruz Mountains, western gray squirrels and eastern fox squirrels have been seen feeding together in the same trees (McClean, 1958, p. 39). Whether or not one has a competitive advantage over the other is not known. Eastern fox squirrel has been planted, apparently recently, near Aptos in oak woodland—beyond the present range of the western gray squirrel. (Four were seen in November 1973 east of Valencia Lake along Encino Drive.)

The eastern gray squirrel has spread more slowly than has the eastern fox squirrel, having only recently crossed the crest to the seaward slopes of the Santa Cruz Mountains (McClean, 1958, p. 35). The squirrel commonly seen in city parks is likely to be the eastern gray squirrel as the native western gray squirrel will not reproduce under these conditions.

The original stock of the European wild pig (locally called Russian boar) was brought from the Ural Mountains to North Carolina in 1912. In 1925, some of their descendents were sent to California and released on the San Francisquito Ranch between the Carmel Valley and Los Padres National Forest (Pine and Gerdes, 1973, p. 126). The European wild pig interbreeds with feral domestic pigs which are found in considerable numbers in the southern parts of the Monterey Bay area—in the Sierra de Salinas and in the Gabilans. Being nocturnal, in contrast to the domesticated pig, the European wild pig is occasionally seen feeding early in the mornings and late in the evenings. Acorns, grass roots, and bulbs are its favorite foods (Dasmann, 1965, p. 35), but farther south in the Salinas Valley, it also does considerable damage to ground crops. Areas in which coast live oak is dominant are the animal's favorite habitat, though they are found in lesser numbers in blue oaks, as well (Pine and Gerdes, 1973, p. 129). The spread of the European wild pig has been mainly south from the site at which it was first released—into Los Padres National Forest. But it is said to occur in the Mount Toro area too. Ranchers claim that the animal comes close to isolated ranch houses there in the evenings, although it is possibly being confused with feral domesticated pigs or, more likely, with hybrids between the two. In 1968, there were estimated to be 2600 European wild pigs in Monterey County with a population density within their range of 0.8 pigs per square kilometer (2.1 per square mile) (Pine and Gerdes, 1973, p. 126).

Native California species of muskrat are found only along the eastern borders of the state. An eastern United States species of muskrat which was introduced into northeastern California for fur production had become common in the Pit River watershed by 1933; it had reached the lower Sacramento Valley and the San Joaquin River by 1943 (Seymore, 1954, p. 377). The muskrat is now present in the Monterey Bay area and spreading southward in the Salinas Valley where it is found in some of the larger irrigation ponds, for example, at Salachi Dam and southward off Old Stage Road and along the Salinas River itself. Local residents around Moss Landing and Castroville say the animal first appeared thereabouts about 12 years ago. Within the last year, it has also been observed within the city limits of Santa Cruz itself, in Neary Lagoon—surprisingly, because the lagoon is surrounded by urban development. In 1970-71, 206 muskrats were reported to the California Fish and Game Department as having been trapped commercially in Santa Cruz County.

In 1945, five golden beavers trapped in Yuba County were transported to the Salinas Valley and released near Chualar (Hemsley, 1946, p. 98). Since that time the beaver has multiplied and spread along the river wherever food is available. Its principal foods here are cottonwood and willow; the beaver seems to prefer cottonwood although the willow is much more plentiful. A recent survey made by the Fish and Game Department between Chualar and Santa Margarita Dam found evidence of the presence of beavers wherever there are sizeable stands of willow or cottonwood. In that stretch the beaver population was estimated at around 12 per km (20 per mile). Downstream beaver are found near the Salinas River bridge. Northward, one colony was recently eradicated from the virtually treeless Tembladero Slough, east of Castroville, where it had built a dam from a patch of willow growing near an irrigation ditch. Some have denied that the beaver's presence in the Salinas Valley is beneficial. So far there have been complaints of beavers plugging culverts and ditches and disrupting the operation of stream gauges. At present there is a year-round open season on beavers in the Salinas Valley.

B. BIRDS

(1) Original Bird Fauna

Coastal California has a rich avifauna. Over 300 bird species have been collected in the Monterey Bay area, some 90 of which are permanent residents, according to The Monterey Peninsula Audubon Society's *List of Birds of the Monterey Peninsula Region.*

Because of the scarcity of published data on animal numbers in the Monterey Bay area, quantitative statements are on the crude order of "more than," "less than," or "approximately the same as." On the other hand, there is a close association of some bird species with a particular vegetation (carefully studied by Miller, 1951). A map which reconstructs the plant cover before the time of European settlement indicates as well, albeit very roughly, the relative numbers of various bird species under natural conditions. Thus sketch maps showing historical changes in plant cover give, at the same time, some indication of the changing relative abundance of species.

(2) Changes in Range, Numbers, and Habit

All accounts from the middle of the 19th century describe the California condor as being a bird common throughout the Monterey Bay area and northward, including San Francisco Peninsula. At present the nearest condor territory is in the coastal mountains to the south, where the species faces extinction. In 1961, only some 40 to 60 birds survived (Peterson, 1949, p. 62).

Spanish observation of the condor probably gave rise to the name of the Pajaro River. In 1769, Father Crespi described the interior of an Indian village on the banks of the Pajaro River:

> Hanging on one of these poles we found half the body of a black bird, with the two wings fastened together; spread out these measured thirteen *cuartas* [nearly 3 m] from tip to tip; and because of this bird, this place ... is known among the soldiers no otherwise than as the *Rio del Pajaro*, Bird River. (Stanger and Brown, 1969, p. 76.)

A black bird with such a wingspread could hardly have been other than the California condor.

In the Monterey Bay area the condor was commensal with the turkey vulture.. A local ornithologist writing in 1888, remarked that the condor "was common a few years ago, when *it could be seen feeding with the common turkey vulture.* The last I saw were two in September, 1885. A few still breed in the wilder mountains north of Santa Cruz." (Anderson, 1891, p. 56.) In 1904, condors were "... seen several times in mountains on the north side of the Pajaro Valley." (Hunter, 1904, p. 24.) A third of a century earlier, condors were still plentiful: It was recorded at Monterey in 1861, that hundreds of whale "... carcasses have there decayed, fattening clouds of buzzards and vultures [condors] ." (Brewer, 1949, p. 105.)

As the vulture and condor were commensal, and the former is resident here mainly in summer, the critical actions which decimated the condor population, whatever they may have been, were perhaps taken during the winter months.

The condor may have become more numerous in the days of the Spanish cattlemen and in the early days of the whaling industry than it had been in Indian times. Cattle dead in the open fields and whale carcasses on the beaches were probably a more abundant food supply than dead deer, elk, and antelope in the more heavily vegetated country of Costanoan times. In any case, the sharp and critical decrease in condor numbers appears to have begun when American farming replaced Spanish ranching (Greenway, 1958, p. 47).

Ten years later, in 1871, another account noted the influence of the Monterey whaling industry on bird numbers and distribution:

> The whale fishery *attracted several species usually seen only far off shore,* of which the enormous Petel or "Gong" *(Ossifraga gigantea),* could often be seen swimming lazily near the try-works to pick up scraps of blubber, sometimes accompanied by the dusky young of the *Short-tailed Albatross (Diomedea brachyura).* The Pacific Fulmars *(F. pacificus),* called by the whalers "Tager" or "Haglet," were common off shore, feeding also on whale meat, but oftener observed chasing the Gulls to make them disgorge. (J. G. Cooper, 1871, pp. 757-758.)

The short-tailed albatross is now near extinction. By the beginning of the present century, Californians began to miss it off their coast. According to Peterson (1961, p. 337), the last sighting of the bird off the California coast was in 1946.

The southern bald eagle is now rare here: "Two were seen in March, 1885." (McGregor and Fiske, 1892, p. 139.) Streator, writing in 1947, lists the golden eagle, too, as "Now very rare" in Santa Cruz County. They are occasionally seen in the area today and may be increasing in number.

The effects of commercial hunting before the enactment of game laws are illustrated in the following note from a historical diary written by a resident of Salinas, December 6, 1877:

> Never in the history of this section has wild game of all kinds been so plentiful. Over a ton of geese, ducks, quail, and pigeons [apparently band-tailed pigeons] have been shipped to the San Francisco market in the last few days. Ducks are a drug on the market, bringing but 10 cents apiece. Two Mexican boys brought in 20 from Santa Rita and were unable to dispose of them at any price. Quail sold for 75 cents per dozen. Mike Tynan of the Diamond Hotel killed 126 ducks on the ponds east of Salinas in six shots. (*Overton Manuscript,* 1877, p. 11.)

Plainly these were times of limited conservational concern and only superficial interest in the local natural history. Newspapers rarely commented upon wildlife of the area except in hunting stories. Either there were no city ordinances controlling the use of firearms or they gave way readily before a boyish enthusiasm for target practise:

> Joe Watson saw a hawk perched upon the cross surmounting the Catholic Church steeple Wednesday, and, getting out his rifle, brought down the bird at the third shot, together with the fish, a sucker, it held in its beak. (*Castroville Argus,* Oct. 19, 1878.)

The California clapper rail (marsh hen) is found exclusively in tidal saltwater marshes, where it is associated with the pickleweed. The number had been much reduced by hunting for the market in 1913, at which time protective laws were enacted. There are still a few in the Elkhorn Slough area.

The California least tern which nests on beaches had its northernmost nesting colony at Moss Landing in the early part of this century (Beck, 1907, p. 58). It is now an endangered species owing to human use of beaches suitable for its nesting sites (Grinnell and Miller, 1944, p. 175).

According to an American pioneer's account of the Pajaro Valley in 1852: "In the fall there were great quantities of wild geese." (Kitchen, 1952, unpaginated.) There is no way of knowing which geese these were: In autumn, snow geese and black brant geese are occasionally found in Elkhorn and Bennett's Sloughs but nowadays geese are rarely seen in the Pajaro Valley itself.

The fortunes of the western burrowing owl are tied to those of the California ground squirrel, the bird's being almost "... restricted to treeless fields and pastures inhabited by ground squirrels." (Grinnell and Wythe, 1927, p. 86). The owl nests only in subterranean sites provided by the larger burrowing mammals native to the area, especially the burrows of the ground squirrel. Like the range of the ground squirrel, that of the owl has expanded with the great historical extension of grassland. In the last century it was reported as a common resident (McGregor and Fiske, 1892, p. 139). The writer remembers it as being plentiful around Aromas in the 1930's, as was the ground squirrel. By 1947, around Santa Cruz, it was described as "Now rare due to the poisoning of ground squirrels." (Streator, 1947, p. 19). I have seen only two in the last few years: in February 1969, one flying from a ground squirrel burrow on the lower part of the University of California campus at Santa Cruz; another in a field south of Moss Landing Elementary School. The owl has so decreased in numbers that even dedicated bird-watchers think of it as being something of a find. For example, in July 1972, members of the Monterey Peninsula Audubon Society, after a successful field excursion, reported, "A bonus came in the form of a family of burrowing owls close to Highway 1, immediately north of Marina." (*The Sanderling*, 1972, 29(1).)

While discussing reductions in numbers, note may also be made of the occasional destruction of seabirds by oil lost from tankers tying up at Moss Landing.

Many of the birds which have extended their range and become more numerous, and many of those which have adapted easily to man's presence, are birds of the "grassland formation" (cf. Miller, 1951). The areal extent of forest species has been correspondingly reduced: The only place in the northern part of the area in which the Steller's jay now comes to the shore line is in the pine forest between Ano Nuevo and Waddell Creek. On the other hand, changes have occurred *within* the forest, too: Steller jays congregate near tourist camp sites; at Mount Madonna County Park, the jays obviously depend upon campers for a good part of their food. In the Big Basin area,

> Their presence in abnormal numbers around camping areas appeared to be definitely correlated with a reduction in the numbers of small passerine birds in such places, especially during the nesting season. On more than one occasion jays were seen hunting for the nests and young of smaller birds. (Orr, 1942, p. 321.)

Many of the "grassland" bird species which have increased their numbers and are now found mainly in the rural and urban bio-associations, probably existed in transitional vegetation between the woody and herbaceous plant cover of the area before human settlement began.

The western mourning dove and the western meadowlark, for example, have benefitted greatly from the extension of grassland associated with the cattle industry. The dove is now the most abundant single upland gamebird in California. In hill country, the dove favors for food the seeds of the turkey mullein, a native weed which has, itself, spread extensively with grazing on the drier range lands. Doves have also taken up residence in the towns, where they nest in trees and rest on telephone wires—singly or in pairs in summer, sometimes in groups in winter. Curiously, in 1888, the dove was described as an "... abundant summer resident, *arriving* about April 1." (McGregor and Fiske, 1892, p. 139.) Similar statements appear in several other early accounts. Mourning doves now winter within Santa Cruz city limits. Has the bird changed its range? The removal of certain seasonal restrictions with urbanization has been noted elsewhere and appears to be a trend. To the south of the Monterey Bay area, the robin and the band-tailed pigeon, formerly only winter residents in the city of Santa Barbara, have, in the last decades, been observed to remain there throughout the year, nesting in downtown parks. Similarly, a variety of the dark-eyed junco (Thurber's) which was a winter visitor *only* in Santa Barbara before 1936, has gradually become a year-round resident (E.Z.R. and J.W.H., 1961, p. 3).

In the Monterey Bay area, as elsewhere in the U.S.A., the robin became one of the most numerous birds following American settlement: "... there appears a semi-domestication, connected with lawns for feeding and scarcity of enemies." (Beecher, 1942, p. 62.)

The sparrow hawk, the tamest of the local hawks, perches on telephone wires over empty town lots, feeding on mice and grasshoppers, and is said to even nest occasionally in birdhouses.

Although not so tolerant of human presence as the dove, the meadowlark comes to the outskirts of towns. Around airports its song, certainly one of the most familiar natural sounds of rural California, mingles with the roar of aircraft motors. On the other hand, it appears to avoid cultivated fields (Orr, 1942, p. 332).

The California linnet has also benefitted greatly from human alterations of the natural plant cover. The following habitat description shows well its association with the cultural landscape: "... weedy stretches of open hills and fields, trees bordering watercourses or roadsides, orchards, barnyards, parks, gardens, and isolated weed-covered city lots. Perches familiarly about houses and on telegraph and telephone wires." (Grinnell and Miller, 1944, p. 109.) The linnet, which subsists to a large extent upon the seeds of exotic weeds, garden plants, and orchard fruits, is one of the three or four most abundant land birds in the area.

The California towhee (brown bird) is one of the more common birds in city backyards and flower gardens, and certainly one of the tamest native birds in the area; one can approach the bird to within a few feet. Hummingbirds, too, are probably more numerous than formerly, nourished as they are by the many introduced flowering plants which bloom almost throughout the year in city gardens—fuchsias, for instance. In pre-European times, nectar from the bush monkey flower, a long-blooming native plant, was probably one of their principal foods.

The clearing and reclearing of forest and woodland tracts in historical times has greatly elongated the lines of ecotone vegetation and probably extended the habitat of a number of species. The California thrasher, for example, can commonly be heard rustling the dry leaves in bushes bordering open fields and seen flying in and out of the margins of thickets.

The valley quail, which also prefers ecotone vegetation and brush and thickets along the margins of open fields, is probably at least as common now as it was before European settlement began.

The mudhen (or coot) is probably more common now than formerly. A hunting season is posted on it and a limit of 20 set, but few are taken.

Hunters disregard the bird or take it only as a last resort; the flesh is not considered tasty. As a result the mudhen is commonplace. Flocks of several hundreds can be seen in February, feeding along the highway near the salt ponds north of Moss Landing. They are numerous, too, in freshwater irrigation ponds, where pondweed is one of their favorite foods.

Barbed wire fences and telephone lines have established an artificial network within which the movements of some birds are, to some extent, channeled. Some species appear to make their territorial claims within this artificial network. The sparrow hawk (American kestrel) commonly scans the ground for prey from telephone and power lines even in towns. The shrike, also known as the butcherbird, ordinarily perches on telephone wires and fence posts along country roads; it often impales its prey on the barbed wire. For similar reasons seed-eating birds influence plant distribution; for instance, poison oak and California blackberry are now more plentiful than ever and have a more linear distribution pattern than previously—congregating along fences and property boundaries.

Brewer's blackbird, which originally probably occupied alluvial meadows, tule patches, etc., has spread to open fields, orchards, and pastures, and particularly into the suburban environment, where it is one of the most common birds on lawns, in parks, and on golf courses. It is, by the way, one of the few land birds that ventures into the salty tidal environment. It can be seen on the beaches along West Cliff Drive in Santa Cruz and picking up lunch scraps on the pier leading to the concrete ship at Seacliff Beach State Park, a hundred yards from land.

The areal extent of oak woodland and riparian forest is particularly important to bird life in this area. Because they covered the lower, more fertile lands toward the coast, these plant associations lost relatively large parts of their areas to agriculture (larger proportions than did chaparral and redwood forest). The fact that the avifauna in oak woodland and riparian forest is particularly rich is probably explained by the general diversity of plant forms in these associations and the comparatively abundant and varied food materials which they supply. For example, oak woodland appears to have a relatively large winged-insect population compared with neighboring coniferous forest or chaparral, with an associated abundance of insectivorous bird species like flycatchers and warblers (Orr, 1942, p. 280). Also the proximity of water in riparian forest no doubt partly accounts for the large insect populations there. True, the richness of oak woodland bird life is not solely a matter of that plant cover's having a large and distinctive avifauna of its own: Because of its transitional

character several bird species typical of neighboring plant associations (particularly of chaparral and redwood-Douglas fir forest) are almost equally abundant in oak woodland (Orr, 1942, p. 280).

At least one native bird, the western mockingbird, has extended its range into the Monterey Bay area in historic times in association with changes attending human occupancy. During the last 50 years the mockingbird spread northward and westward from the San Joaquin Valley. Residential areas have become a principal habitat.

The mockingbird appears to have reached the Monterey Bay area from the south. In Santa Barbara, the first sighting of a mockingbird nest was reported in 1882. It was sighted and listed as a rare bird in the vicinity of Watsonville in 1904 (Hunter, 1904, p. 24). The mockingbird was not present, or very rare, in Santa Cruz in 1891: "Our local ornithologists say they have not seen this bird about Santa Cruz.... Dr. Cooper saw it at Monterey." (Anderson, 1891, p. 65.) Around 1920 it appeared in Santa Cruz as a winter visitant, but did not begin to nest there until about 1930 (Arnold, 1935, p. 197). In 1947, the bird was listed as "Very common in Santa Cruz.... It is extending its range in the coastal district.... I do not think it will ever inhabit the higher mountains back from the coast. They first appeared here about twenty-five years ago." (Streator, 1947, p. 27.) In Santa Cruz, mockingbirds are commonly seen perched on the crosspieces of telephone poles (mourning doves prefer the wires).

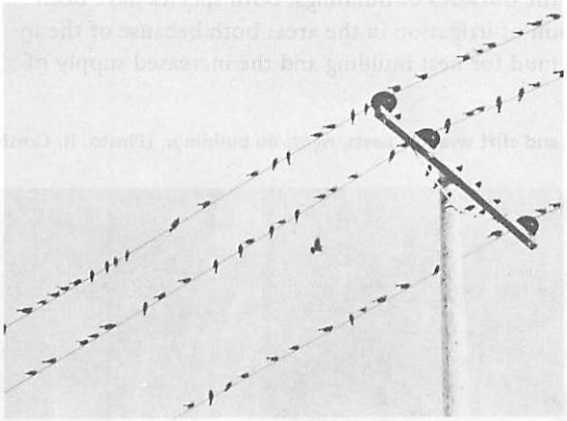
The spread of the mockingbird has been attributed to the planting of trees and shrubs. "The planting of ornamental shrubbery, such as pyracantha, cotoneaster, toyon, and other berry producers has helped the mockingbird to establish residence in the vicinities of Santa Cruz..." and elsewhere (Arnold, 1935, p. 198).

Another native which appears to have experienced a marked increase in numbers, and local changes in range, following European settlement is the brown-headed cowbird. Its numbers are reported to have "increased phenomenally" in the state in the first quarter of this century (Grinnell and Miller, 1944, p. 437). As its name suggests, cattle pastures are its favorite forage grounds, although it roosts in trees. Nowadays it appears to be much less common than it was a half century ago, perhaps because home dairies and pastures have disappeared from much of the area.

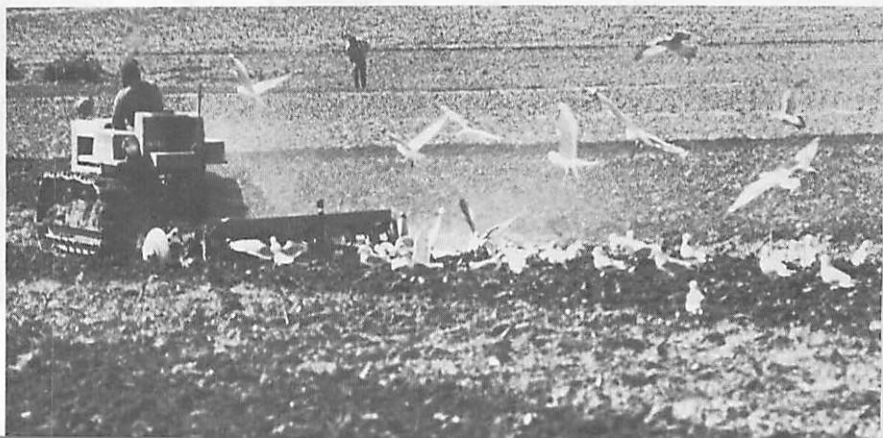
The killdeer has extended its range from shores and stream bars into ploughed fields where it feeds on insects and sometimes nests.

Of native bird species the gull is one of the least timid of human presence. Gulls loiter around piers accepting whatever turns up, be it only

crusts of bread from tourists. They steal bait from under the fisherman's very nose. Their food includes both vegetable and animal matter—living or carrion. They are more truly amphibious than most other shore birds: they follow tractors across the fields eating earthworms turned up by the plough and thousands can be seen flocking around inland city garbage dumps (e.g., Watsonville), feeding upon all sorts of waste. They also feed on floating sewage in the tanks at the sewage-processing plant near Salinas; and there, gulls and Brewer's blackbirds perch calmly together on the giant sprinkler-frame which rotates over the trickling filter, occasionally dropping off to snatch slugs and fly-larvae from the rocks in the filter tank below. Few beaches are too polluted for the gull; insecticides may be a threat to some birds but the gull seems to go unscathed. Even changes in habit have been brought about, such as learning to respond to the sound of a caterpillar motor's starting up, and to follow the machine across the fields—behavior certainly unknown to its ancestors less than a century ago. Its activity as mouse predator in artichoke fields is but another example of the gull's remarkable adaptability.



Brewer's blackbirds aligned on wires in the fall. (Photo, B. Gordon)



Gulls following disk-harrow and feeding upon earthworms, north of Moss Landing. (Photo, B. Gordon)

The barn owl has changed its nesting habits and adapted remarkably to the presence of man. In addition to natural nesting places in holes in the banks of ravines and tree trunks, the owl has taken to using the interior of barns and old buildings for nesting sites. As the barn is no longer the essential and common building it was in the early part of the century, the owl is either less abundant than a few decades ago, or less conspicuous. More than other owls, the barn owl finds its food in the cultural landscape, in fields, gardens, and orchards.

The barn swallow (fork-tailed swallow) and the northern cliff swallow, both summer residents in the Monterey Bay area, have adjusted similarly to human presence. During the early American period of settlement the northern cliff swallow, which nests naturally on beach cliffs and sometimes on tree trunks, took to nesting on the walls of buildings as well. Similarly, the barn swallow, which used caves and ravines, now also nests in barns and under bridges. While the barn swallow builds open nests of mud, one or two together and usually inside buildings, the northern cliff swallow sticks pellets of mud together to form its narrow-mouthed nests, usually in colonies on the outsides of buildings. Both species have been favored by the extension of irrigation in the area: both because of the increased availability of mud for nest building and the increased supply of insects for food.

Barn swallow nests, *left*, and cliff swallow nests, *right*, on buildings. (Photo, B. Gordon)

The black phoebe also often makes its mud nests on abandoned houses and on the understructures of bridges. A characteristic perch for the bird is on water troughs in barnyards.

After the Europeans introduced the horse, various native birds took to using its hair in making their nests. A few decades ago, when tractors and automobiles practically replaced the horse, such nests became hard to find.

Cedar waxwings visit this area in winter. Nowadays the birds are found mainly in urban sites; they commonly congregate on telephone wires and in the city gardens, where they feed especially on the berries of pepper tree, cotoneaster, and pyracantha. (All of these are introduced plants.) Judging from the cedar waxwings' habits and preferences today, the attractions of the Monterey Bay area must have been very different in prehistoric times.

Where floodlights play on beaches, sanderlings run back and forth at the edge of the swash as if it were daytime.

The names of such native birds as the barn swallow, the cowbird, the barn owl, and the house finch themselves suggest changes in habit which have been made since European settlement began.

(3) Introduced Species

Certainly the best-known introduced bird is the English sparrow, a native of Europe. The English sparrow first appeared in California about 1871, in San Francisco, where it was introduced from the eastern United States. Although it was probably first introduced purposely, the bird no doubt entered the state spontaneously a number of times, for instance, along railroad lines, accompanying grain and stock cars. The Southern Pacific Railroad was extended into the Monterey Bay area in 1871; the English sparrow may have entered the area shortly thereafter. In any case, it was common in towns of Santa Cruz County by 1888 (McGregor and Fiske, 1892, p. 141).

The sparrow became well-established in California towns during horse and buggy days, at which time its food is described as having consisted largely of undigested oat seeds in horse droppings, then plentiful in the streets. In 1916, the California Fish and Game Commission initiated a campaign against the English sparrow (*Calif. Fish and Game*, 1916, (2), p. 141) and government circulars even recommended the sparrow for human consumption. (It has been eaten for centuries in the Old World.) Although still abundant, the sparrow seems to have become decidedly

less so, since automobiles and parking lots have replaced horse-drawn vehicles, stables, and feedlots. The dependence of the sparrow upon human presence is strong. It "... has not as yet begun to occupy, regularly, uncultivated and forested areas." (Grinnell and Miller, 1944, p. 111.)

The ring-necked pheasant is a native of Eurasia. The State of California liberated some of these birds at Monterey in 1889. However, the pheasant was probably not well-established in the Monterey Bay area until around 1916, by which time state game farms had supplied the birds in large numbers. It is surprising to see such a large game bird close to human habitations but, in fact, pheasants favor settled areas, especially irrigated and other well-watered sites. I have seen several within the city limits of Santa Cruz, e.g., near Natural Bridges State Park and Neary Lagoon. The ring-necked pheasant does not thrive in any natural plant communities of the area. Judging from the example of abandoned orchard land in Larkin Valley, changes in cover produced by plant succession eliminates the bird within a couple of decades.

A third exotic species is the European starling. One hundred starlings are said to have been released in New York in 1890 by a group of Shakespeare enthusiasts who wished to honor the poet by introducing into this country the birds named in his writings. In 1940 (p. 148), Peterson remarked that the starling "... has at this date reached the base of the Rockies and Utah. To be looked for on the Pacific Coast." In 1961 (p. 241), he gave the starling's range as "... from Vancouver I. to southern California." At a time between these two dates a few had been seen in the Point Reyes area (Sibley, 1952, p. 32) but they appear to have entered the Monterey Bay area only within the last decade. They were likely here some years before most laymen recognized them, but the owner of a ranch by the Salinas River Road, a few miles southwest of Spreckels states that starlings appeared on his place for the first time in 1968 and within a year the birds were already a serious pest, taking figs from the trees in his yard. We saw a flock near Moss Landing cemetery in November, 1969. Starlings nest in sycamore trees along the creek at the entrance to Toro Regional Park and are said to compete for nesting sites with acorn woodpeckers in the park. They are occasionally seen in areas remote from settlement in the Sierra de Salinas.

Few birds rival the starling in adaptability. On August 9, 1970, a flock of Brewer's blackbirds was observed feeding on insects in a lawn near West Cliff Drive in Santa Cruz. Flying and feeding with them, apparently completely at ease as a member of the flock, was a single starling.

Throughout 1972, starlings and blackbirds often fed together on the same lawn and roosted in nearby Monterey pines. Again, on August 30, 1973, half a dozen starlings intermixed with about a dozen blackbirds fed together. (At this time of year the differences between the two birds are particularly marked; in fall the starling's plumage turns lighter and becomes speckled.)

In the Monterey Peninsula Audubon Society's bird count of December, 1973, more starlings were seen than any other bird (*The Sanderling*, vol. 29, no. 6).

The cattle egret, a native of Africa, having spread to South America appeared in Texas in 1955. Within the last several years, the first cattle egrets were seen in the Monterey Bay area. They have been observed around Elkhorn Slough, and were reported on Monterey Peninsula in December, 1970 (*The Sanderling*, vol. 26, no. 6).

The domestic pigeon, like the English sparrow, is rarely seen beyond those areas obviously changed by man. The first domestic pigeons to reach the Monterey Bay area were introduced by American settlers. Nowadays some are raised for food, but most pigeons in the area are feral. Although many nest in barns and old buildings, foraging for grain in the fields and barnyards, they sometimes become numerous in towns as well, where they are treated as a nuisance. As one hardly associates this bird with the marine environment, I was surprised to find it nesting in holes in the seacliff on the outskirts of Santa Cruz off West Cliff Drive between Stockton and San Jose Streets. The face of the cliff here is pockmarked with holes. The pigeons nest in these holes only about 6 m above the water, barely out of reach of the spray. Perhaps this should actually not be surprising since coastal cliffs around the Mediterranean Sea are said to be the pigeon's ancestral habitat; but I have not seen them nesting in seacliffs elsewhere in California.

The pigeon's selection of this nesting site has given rise here to a new interspecific relationship: a native marine bird, the pigeon guillemot, also nests in these holes and was no doubt doing so long before pigeons were introduced. Mostly the guillemots sit in the holes facing inwards, only their tails and white-barred wings showing. When they emerge they walk on the ledges of the cliff with a peculiar waddling gait, craning their necks and making shrill mouse-like squeaks. The nests of the two are intermixed and the birds compete for the space; occasionally a guillemot can be seen forcing pigeons off the cliff.

This species of guillemot is called the pigeon guillemot, though it bears slight resemblance to the pigeon. In fact, the two birds are so utterly different that one can only wonder that they have the same nesting place. The guillemot is heavy bodied compared to the pigeon. When the pigeon takes flight it climbs immediately and strongly from its perch. The guillemot dives off the face of the cliff and flies some distance before it can stop losing altitude. In landing, the guillemot approaches the cliff at slightly below the level of its perch; beating its wings rapidly, it literally flies onto the cliff, slowing itself by rising at the last minute to perch level. The pigeon, on the other hand, approaches the cliff from aloft, braking and lowering itself in a series of swoops; then spreading its wings widely, it falls onto its perch. Guillemots come and go singly or in pairs; the pigeons are usually in flocks. The guillemots leave the cliff early in the morning and fly along the coast to feed on marine life in the water, often returning only after dark. The pigeons forage inland, parts of the flock coming back frequently for short periods during the day, and all return well before sunset. The guillemot is here only during the summer while the pigeons stay on—although on really stormy days they spend their time elsewhere.

Wild turkeys were first introduced into California in 1908. Since that time more birds have been imported from the southwestern United States and Mexico, where the species is native. Wild turkeys have recently been established in the southern Santa Cruz Mountains (but apparently mainly on the eastern side) and in Monterey County. There is, as yet, no open season on them.

Some man-dominated landscapes have outstandingly diverse bird faunas, particularly areas of suburban park and garden. The destructive effects of human presence are much emphasized at present, and for the most part appropriately. But under suitable conditions, diversification and enrichment may accompany settlement. Such conditions have been observed elsewhere in rural California. A study of bird life in the San Joaquin Valley described the very destructive effects of marsh drainage on avifauna there. But at the same time the study concluded that not only had the species number increased in parts of that area following agricultural development, but the actual number of birds per unit area had probably increased tenfold (Grinnell, 1922, pp. 671-676). Although this statement was written before the development of modern insecticides and herbicides, it may still be valid.

On the other hand, the general observation has been made that artificial grassland and artificial forest are "conspicuous for a fauna impoverished in species though rich in individuals" (Hesse, 1937, p. 544). This statement seems applicable to most of the grassland of the Monterey Bay area (which has large numbers of individuals of relatively few species; e.g., mourning doves, meadow larks, and California ground squirrels). In at least one kind of artificial forest, eucalyptus groves, not only is the number of species small but the number of individuals, as well.

C. FISH

(1) Native Fishes: Changes in Number

The best-known example of change in numbers among native marine fishes in the area is the sardine. A local naturalist gave the following description of schools of sardine near Santa Cruz in the 1890's: "The bay near the beach is darkened for long distances, at certain seasons, with these little fish. It is an excellent food, and, owing to its great abundance, must sometime prove valuable." (Anderson, 1891, p. 33.) The fish did indeed "prove valuable," becoming the basis of an important local canning industry. Then in 1947, it disappeared from the bay in commercial quantities rather abruptly, markedly changing the economy of Monterey and Moss Landing. Whether this drastic reduction in numbers was the result of over-fishing or of natural environmental changes, or a combination of the two, is still debated.

The grunion, now common southward from Morro Bay, is renowned for its remarkable breeding cycle. In the spring and summer (especially in April and May), the fish spawn in the beach swash but only for an hour or two immediately after high tide following each full or new moon.

Although stray grunion have been reported as far north as Monterey Bay in the present century, none has been seen spawning there. A reading of old accounts of Monterey Peninsula strongly suggests that grunion once spawned on Carmel Beach. The accounts refer to "sardines," but the term was then often applied to small fish indiscriminately. In 1841, an English visitor at Monterey reported:

> The Californians ... eat no fish because they have no boats to catch them [reference has already been made to the Spanish-Mexican preference for beef; most of the Spanish settlers were landsmen], but when a westerly gale has driven millions of sardines on the strand, they do take the trouble of cooking what Dame Nature has poured into their laps. (Simpson, 1930, p. 105.)

On the face of it, there is little in this account that suggests the grunion, but gales driving "millions of sardines on the strand" does seem an odd occurrence. Some early Spanish accounts describe circumstances hard to associate with any other fish. The following note was written April 10, 1775, at Carmel:

> *Today there is a great shoal of small sardines on the beach,* and they said that *they were so abundant that they made the ground black at the edge of the water.* The commander went there in the afternoon with the fathers to walk and see this wonder.... (Bolton, 1933, p. 420.)

And, translating from an account written at Monterey on July 19, 1774:

> The Indians come down to the edge of the beach, chase the fish and throw them ashore. The fresh fish are rich in oil. I have heard so often of these sardines that I would sometime like to go over to Carmel myself to catch some and salt them down on my own account. (Rivera y Moncada, 1774, p. 167.)

A Spanish account from Carmel in 1776 refers to "... the sardines, which are very plentiful and at times are caught without any trouble because many are stranded...." (Bolton, 1933, p. 302.)

Certain recent changes in habit have been observed, also: another marine fish, the onespot fringehead, moves from deeper water into the vicinity of wharves, taking shelter in submerged junk—glass containers and the like (David Lindquist, personal communication).

The numbers and distribution of freshwater fishes has greatly changed since American settlement began—both because of man-made hydrographic changes and because of the introduction of numerous exotic species. On the other hand, at least one native fish, the Monterey sucker, is relatively more numerous than previously; it is a hardy species which can withstand stream pollution and is rarely taken by anglers.

(2) Introduced Species

Of the 67 freshwater fish species listed for California, 32 are introduced (Lachner, *et al,* 1970, p. 21), including some of the most abundant.

The common shad, probably the first fish to be introduced by man into California, was brought from the Hudson River in 1871. Shad were first planted in the Sacramento River near Tehema, and are now found along the coast from Alaska to San Diego. It was well-established in the Salinas River: "After the original introduction, shad appeared at various points along the coast ... the only stable populations in California [outside the

area which drains into the San Francisco Bay] however have been those in the *Salinas* and Russian Rivers." (Skinner, 1962, p. 86.) Yet there have been no shad in the Salinas for a long time now.

At a much later date, 1953, the threadfin shad was introduced into California from Tennessee as a food for gamefish species, like the native sucker, it serves as food for trout. Threadfin shad have been planted in Pinto Lake and College Lake, where it is at times very numerous.

The carp was brought to California from Holstein, Germany in 1872, only a short time after the shad. It is a hardy fish and thrives even in the warm and stagnant pools left in drying stream courses during the rainless summers. There is no doubt that it is the least popular fish ever brought to California. Great sums are spent on its eradication. This is strange because in the Old World carp has been considered to be a great delicacy for centuries, and as such was carried from the Far East into Europe at an early date. Complaints against the carp are many, for instance, that it muddies the water, eats the eggs of other fish, and digs up aquatic plant life. Some defense of the carp appears in early literature:

> ... *while they probably have been the principal cause of the destruction of the California perch* by eating the eggs and digging up the nests, at the same time they furnish the chief food of the black and striped bass [both introduced], two varieties of fish whose value more than offsets the damage by the carp. (Shebley, 1917, p. 4.)

But the judgement against the carp seems now to be generally accepted.

The smallmouth bass was among the first fish introduced into California, having been brought here in 1874. The largemouth bass was introduced shortly afterward (Brown, 1939, p. 310). Both are widespread in the Monterey Bay area; for example, the largemouth bass has been planted in water reservoirs, e.g., on Black Road west of Los Gatos, to keep the water clear by keeping the algae population down.

The striped bass, an anadromous fish, was introduced into the Sacramento River system from New Jersey in 1879, and spread very rapidly. It now ranges from Tomales Bay to Monterey. "Less than a year after being placed in Suisun Bay a specimen was taken in Monterey.... Small populations became established on the Salinas [River] as well as Elkhorn Slough...." (Skinner, 1962, p. 71.) It formerly spawned in the Salinas River (Skinner, 1962, p. 79). The striped bass appears to have established itself securely on this coast. Until 1935, it was even fished commercially. It has become one of the several most important species to sport fishermen.

(Local fishermen claim that striped bass are especially abundant around the PG&E heated water effluent in Elkhorn Slough. If this is so, what attracts them?)

The eastern brook trout (speckled trout) was introduced into California in 1872. The brown trout was brought from Germany in 1895, and the lake trout was introduced in 1889. That they are valuable introductions has rarely been questioned. (The rainbow trout and the cutthroat trout are native to California.)

There are no native catfish on the Pacific slopes north of Mexico but several species were introduced in the late 19th century. Catfish were imported into California in the early 1870's, and planted around Salinas in 1876; the white catfish and the brown bullhead were introduced into California in 1874.

Panfish and crappies were first introduced into southern California in 1891, and made their way northward to the San Francisco Bay area through later transplantations. The green sunfish was introduced in 1891 and the bluegill in 1908.

Several introduced species are widely planted in ponds. For example, we saw several boys fishing from an earthen dam between Prunedale and Natividad. One youngster, who had caught a few bluegills and a crappie, said that bass are also caught in the pond, and an occastional catfish; these appear to be the species favored for pond culture by the Department of Fish and Game.

A general despoilation of native fish habitats has taken place in the Salinas River. The position of the river's mouth has been changed, the flow has been reduced by damming and irrigation, and the channel is used heavily for sewage outlets.

In an archaeological excavation at Soledad, 41 percent of fish bones collected belonged to the steelhead "... which ascended the Salinas River from the sea to spawn." (Follett, 1972, p. 11.) Apparently the steelhead went even farther upstream. In 1776, Father Pedro Font, speaking of the many "good salmon" (i.e., steelhead) that ascend the streams, stated that "... even at the mission of San Antonio some of the fish which ascend the Monterey [i.e., Salinas] river have been caught." (Bolton, 1933, p. 302.) Few steelhead enter the river these days. Farther upstream, the introduced threadfin shad is common. Below Chualar fishing prospects are very limited. We spoke to a local landowner on the banks of the Salinas near Gonzales who said that carp and an occasional smallmouth black bass (both introduced species) and suckers were all that he could catch. The two anadromous

introduced species, the shad and the striped bass, were driven out by alterations made in the course of the lower Salinas.

Regarding ecological change in the lakes east of Watsonville, the following note from the last century is of interest:

> The three largest of these are called College Lake, Laguna Grande [now Kelly Lake], and White Lake [Pinto Lake?]; they are from two hundred to five hundred acres in extent, and, at their greatest depths measure sixty feet. Being fed by subterranean mountain streams they do not vary in depth with the seasons. *They are prolific in native* fish of excellent quality, and also have been stocked by the Board of Fish Commissioners *with eastern white fish, perch, and land-locked salmon. (Overland Monthly,* vol. 10, no. 56, August 1887, p. 7.)

The "native fish" mentioned in the quoted passage are unfortunately not identified, but even at that time three introduced species were present. The native species are gone. In 1961, the city of Watsonville, advised by the Department of Fish and Game, treated Pinto Lake with an "anoxydizing agent" (what was it?) to eliminate the carp. Since then the lake has been restocked with black bass, crappies, threadfin shad, redear sunfish (first brought to California in 1948), and brown bullhead (catfish). The threadfin shad now reproduces in especially large quantities in the lake.

When carp were introduced here is uncertain. Kelly Lake, which is privately owned, has a fish population of several species too, but is still infested with carp. Although College Lake is now used by a local rod and gun club for hunting, and drained for agricultural use in the summer, with suitable damming it has a real potential for a more general recreational use. The lakes must, incidentally, have shoaled considerably since 1887—Pinto Lake is now only 7 m deep.

The goldfish was introduced into the United States from eastern Asia around the beginning of the century. It is now established in the Pajaro River, no doubt released from aquaria. The orange and yellow stock does not survive under natural conditions. Free-living specimens are usually olive color resembling its relative, the carp. Goldfish are carp-like, too, in their preference for warm ponds and sluggish waters.

Probably the most widespread introduced fish is the mosquito fish (top minnow), which was brought into California from eastern North America in 1922, and is now found in most bodies of water (for instance, it is abundant both in irrigation ponds and in the Pajaro River). It was introduced for control of mosquitoes and has been distributed by the Mosquito Abatement program of the California Department of Public Health. The

mosquito fish is one of the few widespread and successful "biological controls" now in use in the Monterey Bay area, standing out as a promising alternative to pesticides.

D. AMPHIBIANS AND REPTILES

The Santa Cruz long-toed salamander is presumably approaching extinction because ponds in which it lives are being filled for construction purposes. The species is known from only two or three localities—e.g., Valencia Lagoon, near Aptos, and from an area about one kilometer northwest of Ellicott Railroad Station, also in Santa Cruz County. It has been placed on the list of endangered species published by the Department of Interior.

The bullfrog, native east of the Rocky Mountains, was introduced into California for food.

> The spread of the bullfrog in California has been dramatic. The earliest presumed occurrence dates back to about 1905. In a little over 30 years it had become common over most of the Sacramento and San Joaquin valleys, the lowland waters of southern California, in many valleys of the Coast Range, and in scattered localities elsewhere.... The animals are sufficiently abundant to supply the local demand for frog legs ... the state has set a limit. (R. C. Stebbins, 1951, p. 345.)

No exotic reptiles have been established here, either accidentally or purposely.

E. MOLLUSKS AND SOME OTHER AQUATIC INVERTEBRATES

Within a few decades after Americans arrived in California, the abalone had become their favorite native food mollusk—an appetite they acquired from the Chinese who had started the abalone meat industry here; as early as 1864, Chinese were drying abalone for shipment to China.

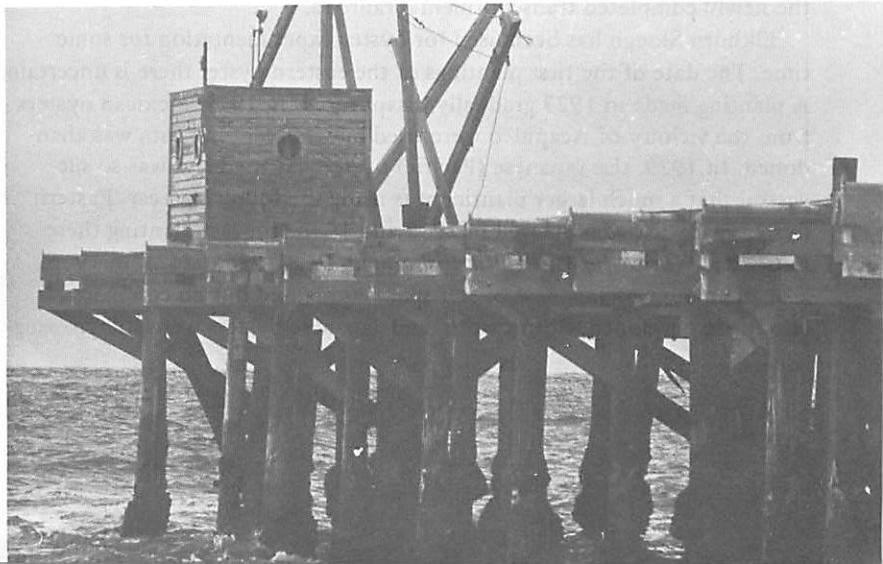
Abalone shells had become a minor commercial item at an even earlier date. The Spanish exported the shells of *Haliotus rufescens* from Monterey, shipping them to be traded to Indians of the northwest coast (Leechman, 1942, p. 160; Heizer, 1940, p. 399). In his *Two Years Before the Mast*, Richard Dana, who visited the bay in 1836-37 while it was still Mexican territory, described a fishing trip along Point Pinos with several shipmates: one "... of our numbers brought up on his hook a *large* and beautiful pearl-oyster shell. We afterwards learned that a small schooner had made a good voyage by carrying a cargo of them to the United States." (Dana, 1911,

p. 78.) Considering the reference to the size of the shells, and to their use as mother-of-pearl, these were likely abalone.

Only the red abalone is taken commercially; huge quantities have been collected in the Monterey Bay area. Over 1,360,000 kg (3,000,000 pounds) per year were harvested during the period 1929-31, inclusive. Thus, the population of red abalones has been influenced more by people than have other abalone populations. In the 1930's great heaps of discarded shells could be seen along the road leaving Monterey for Castroville. (Abalone was one of the principal items processed on "Cannery Row," made famous by John Steinbeck.) The harvest has much decreased since 1940. On the other hand, the recent development of inexpensive wet suits has had its effect on the abalone population: the noncommercial take of abalones has greatly increased.

The California mussel has never been much used as a food by Californians of north European ancestry. The fact that it is rendered poisonous by blooms of a protozoan, *Gonyaulax catenella,* during midsummer and early fall, has given it a bad reputation. Mussels are among the most common mollusks on rocky shorelines and are probably even more abundant now than two centuries ago, their Indian collectors having disappeared. Fishermen commonly strip them from the rocks for bait—using either the mussels themselves or, more often, the mussel worms which live among them. During the last few years the mussels seem to have been rediscovered as a food.

Clumps of mussels growing on pier pilings at Moss Landing. An example of human influence on animal distribution: this colony thrives here—in a stretch of beach and sandy bottom—only because the pier, a man-made structure, is present. (Photo, B. Gordon)



The native Olympia oyster was once more plentiful in Elkhorn Slough than it is at present. As noted previously, on one Indian midden site near the slough shells of the native oyster are almost the only ones to be seen. In 1926, several oystermen worked the beds there, greatly depleting them. In 1931, a diked bed for growing native (and eastern) oysters was laid out on the mud flats in Parsons Slough, a branch of Elkhorn Slough. These experimental plantings of the native oyster were apparently successful but except for a small harvest in 1935, no commercial venture developed. The oyster is found on pilings in Elkhorn Slough and Monterey Harbor. It is said to be "... especially partial to iron as a place of attachment." (MacGinitie, 1935, p. 720.) Its partiality for iron is a post-industrial adaptation.

Pismo clams were reportedly taken at Santa Cruz Beach in 1861 (Smith and Gordon, 1948, p. 162); they are not found there now. They are still taken between Aptos Creek and the mouth of the Pajaro River; Watsonville Beach has long been a favorite site for their collection. Old residents tell of times before the beginning of the century when farmers took their teams and ploughed the beach at low tide to obtain Pismo clams for hog food.

(1) Introduced Saltwater Mollusks

Several exotic oysters have been planted in California. Even where growing conditions are good, these alien species rarely reproduce themselves and none seems to have established itself; spat has to be imported periodically.

Probably the first to be introduced, the eastern oyster from the Atlantic coast of the United States, arrived at San Francisco in 1869 or 1870, on the newly completed transcontinental railroad.

Elkhorn Slough has been used for oyster experimentation for some time. The date of the first plantings of the eastern oyster there is uncertain. A planting made in 1923 gradually disappeared. In 1929, Mexican oysters from the vicinity of Acapulco were tried but this venture, too, was abandoned. In 1929, the Japanese (Pacific) oyster was tried and was so successful that a much larger planting was made the following year. Eastern oyster spat was again planted in 1932 and 1936—the last planting there until after World War II (*Pacific Fisherman*, Feb. 1936, p. 42). In 1946, a small amount of Japanese oyster spat was planted but no commercial enterprise developed. Both eastern and Japanese oysters were still growing

in the slough in 1948 (Smith and Gordon, 1948, pp. 169-170) and some very large Japanese oysters live there even today.

Although the oysters themselves were unable to reproduce here, several plant and animal species accidentally introduced with them did establish themselves. For example, the oyster drill, an Atlantic species of snail, was introduced with the eastern oyster and it has spread, attacking other mollusks. The oyster drill had already been introduced in 1898, and in the same way, into San Francisco Bay where it is still abundant. Although the drill was reported to be "fairly common" in Elkhorn Slough in 1948 (Smith and Gordon, 1948, p. 189) there are few if any there now.

The soft-shell clam, native to the southern Atlantic coast of the United States is now one of the most important food mollusks in California; it is even collected commercially. The clam is believed to have been accidentally introduced into San Francisco Bay with the first importations of the eastern oyster around 1870. However, it was purposely planted in the Monterey Bay area (Hanna, 1939, p. 306) at a later date. In 1948, it was described as common in the mud at Elkhorn Slough (Smith and Gordon, 1948, p. 176).

The Japanese littleneck clam, introduced around 1930, is now found from Elkhorn Slough northward and appears to be replacing the native rock clam, or rock cockle (Hedgepeth, 1962, p. 118). It is believed to have been introduced with the Japanese oyster.

A Japanese clam, *Trapezium liratum*, whose distribution is generally associated with Japanese oyster-growing sites, also has been reported from Elkhorn Slough (Hanna, 1966, p. 61). A Japanese mussel, *Volsella senhousei*, and the Japanese horn snail have recently been noticed around Moss Landing (Ricketts and Calvin, 1968, p. 379); the Japanese horn snail is abundant in the quiet water behind the dunes in the old mouth of the Salinas River, north of Jetty Road. On sandy bottom along the shallow margins of the slough there are patches with over 200 shells per square meter (April, 1974).

Two cosmopolitan species, the bay mussel and the shipworm *(Teredo)*, neither apparently native on this coast, are found in the Monterey Bay area. But their dates and modes of introduction are disputed: According to most authorities the shipworm, a scourge in Europe since classical times, was unknown in California at the beginning of this century (Ricketts and Calvin, 1968, p. 370). It is "... practically certain that *Teredo navalis* has been imported to San Francisco Bay within recent years, probably between

1910 and 1912." (Kofoid, *et al*, 1927, p. 194.) Although it is often called the European shipworm its origin is rather uncertain. The teredo either appeared in San Francisco Bay region between 1910 and 1914, or, if it was already there, it became suddenly abundant at that time. It especially infested pilings at Mare Island where, by 1917, its effects became catastrophic; many pilings of ferry slips collapsed as a result of teredo infestations. The shipworm is estimated to have done about $25 m worth of damage in San Francisco Bay between 1917 and 1921. Man's role in its dissemination is obvious; wherever pilings and wharves are built, they create a special habitat for the animal.

The pier at Port Watsonville, located at what is now called Palm Beach, is said to have been destroyed by shipworms: "Teredo worms had caused extensive damage to the pilings." (Locke-Paddon, 1964.) Early in November 1904, heavy seas broke up the wharf. However, this damage could well have been done by a native species: "The native species, *Bankia setacea* was noted as a serious pest as early as 1870...." in California (Hanna, 1939, p. 309). It is claimed that the materials released by Kaiser's effluent in Moss Landing Harbor suppress shipworms and that they do little damage in that vicinity. Both species may be present in pilings around Monterey Bay but *Teredo navalis* has not been recently identified hereabouts.

Unlike the California mussel, which thrives on surf-zone rocks, the bay mussel prefers a quiet water. It is found on exposed banks in pickleweed stands along Elkhorn Slough and clusters grow on pilings around the bay, sometimes surrounded by a ring of California mussels. The bay mussel now has an uncommonly wide distribution, being found around the world in north temperate regions. According to some authorities this distribution is not natural. "The common bay mussel is not a native species, but is thought to have reached our coast from Europe by way of sailing vessels several hundred years ago." (Skinner, 1962, p. 106.) On the other hand, the bay mussel has been identified so often in prehistoric kitchen middens along the California coast that it seems unlikely that shells identified as bay mussels were actually California mussels.

Curiously there has been no attempt made to grow the bay mussel commercially for food in California; in fact, in the Monterey Bay area few are even gathered. In Europe the bay mussel is an important aquacultural species, rivaling the oyster in places.

(2) Introduced Land and Freshwater Mollusks: Snails and Slugs

The brown garden snail *(Helix aspersa)* was brought to the vicinity of San Jose around 1856 by a French family, and planted for use as food on a few acres of vineyard on Guadalupe Creek (Stearns, 1882, pp. 129-130). It was also introduced into southern California and from these sites has spread to become one of the worst garden pests in coastal districts of the state. As an example of its abundance, in one evening over a thousand were collected from the lawn around a house in Santa Cruz, and the supply was by no means exhausted. On the other hand, the snail has not yet spread to yards around buildings in remoter areas (such as Mount Madonna County Park and Pinnacles National Monument). It spreads most readily in towns and in tract housing where yards adjoin. As yet, curiously, no native mammals, birds, or insects seem to have learned to prey on it.

A similar, and somewhat larger, lighter-colored, introduced species, *Otala lactea,* arrived in California around 1940, and is now found in the Monterey Bay area. At least some of the colonies of this snail were established in the state intentionally for food purposes. It is reported to have a better flavor than the more common brown garden snail (Hanna, 1966, pp. 12-14).

A small foreign snail, *Cochicella ventrosa,* infests several blocks in Santa Cruz (Hanna, 1966, p. 26); it is found, for example, on David Way near West Cliff Drive.

Several species of slug have also been introduced accidentally from Europe: probably the most common is the small brown field slug, a destructive garden pest (Hanna, 1966, p. 31).

The Japanese anemone, a small, slender, greenish species, striped with yellow or orange, appeared suddenly in Elkhorn Slough after the Japanese oyster was introduced. (It has since journeyed even farther eastward, having turned up on the Texas coast in 1947.)

The naked hydroid *Syncoryne mirabilis* is found in the Monterey Bay area.

> Agassiz found this form in San Francisco Bay in 1865. There is at least *a distinct possibility that it is a relic of the days of wooden ships,* for the same species occurs on the East coast, and it seems unlikely that its natural distribution would account for its occurrence on this coast also. (Ricketts and Calvin, 1968, p. 332.)

There are no native crayfishes in this part of California (Riegel, 1959, p. 48). But in 1912, large batches of a northwestern species *Pacifastacus*

leniusculus, obtained from the Columbia River, were shipped to the California Fish and Game hatchery at Brookdale. And later many were released into the nearby San Lorenzo River. The species is now also established near Swanton and in the Pajaro and Carmel Rivers; it is probably in many other streams as well. An eastern crayfish *(Procambarus clarki)*, probably brought to California from Louisiana, is also present in the Monterey Bay area. It appears to be better adapted to warm sloughs than is the northwestern species; for example, it is found in Tembladero Slough near Castroville. It is said to survive the seasonal drying up of streams here by burrowing to water level. How this eastern crayfish reached California is uncertain but it seems to have arrived sometime between 1939 and 1941 (Riegel, 1959, pp. 34, 46, 48). It was collected in the southern part of the state as early as 1925 (Bonnot, 1930, p. 212).

(3) Early Pollution and Depletion of Shoreline Life by Collectors

Pollution by sewage had already significantly damaged the mollusk habitat in the last century. Unfortunately, these effects on the littoral zone are likely to be obvious to specialists only. An extract from a letter mailed to the editor of the periodical *Nautilus* in 1892, by a well-known naturalist describes conditions at Monterey:

> Monterey as a collecting ground [for mollusks] is already seriously injured, and will probably be nearly ruined before long, on account of the Hotel Del Monte, the new town of Pacific Grove, and the increased population of old Monterey, all of the sewage of which is turned into the bay in front of the town. Beaches which would formerly afford several hundred species are now nearly bare, or offensive with stinking black mud. (Dall, 1892-93, p. 48.)

A similar report was made in 1893:

> Monterey is no longer the famous collecting ground it used to be. The increasing population at and around Pacific Grove is driving away all the land shells. The deadly sewage flowing from the various towns into Monterey Bay is killing the marine shells. (Wood, 1892-93, p. 70.)

Spoken at that time, these words stimulated little popular interest. On the other hand, some marine mollusks actually thrive in this environment; the black turban population around the Pacific Grove sewer outfall is the largest I have seen.

Within the last several decades, over-zealous collectors have become a prime factor in molluskan ecology in the bay area.

> No longer is it possible to collect two hundred species as Dall did in 1866 [at Monterey]. Even at extremely low tide the rocky shores are less productive, as many of the movable rocks have been overturned in the ever-increasing search for specimens of marine life. (Smith and Gordon, 1948, p. 153.)

Fortunately collection in the area has recently been curtailed, for example since the creation of California state beaches and parks; nevertheless, the shoreline has been severely depleted. Probably collection for amusement and specimens is now a more important factor in this depletion than is collection for food.

F. INSECTS AND MITES

Even among native insects one can see adjustments to changes made by human inhabitants in the area. For example, the termites in the area are native—but their prevalence has increased with the growth of human population and the spread of the wooden house.

One of our best-known native insects is the monarch butterfly. Monarchs pass the winter at many places along the coast but they congregate in huge swarms at Pacific Grove (where they are protected by city ordinance). Nowadays the swarms can be seen not only in the native cypress tree, but on the introduced eucalyptus, as well; for instance, in the groves at Moss Landing and at Natural Bridges State Park.

Another well-known native is the sulphur butterfly, also known as the alfalfa butterfly. When the alfalfa plant, a native of Eurasia, was introduced into California between 1850 and 1860, the larvas of the sulphur butterfly found it an especially attractive food. As alfalfa cultivation spread in the state, the sulphur butterfly became a major pest of the crop. The plume moth, a principal pest in artichoke fields, is also a native; its other main host here is the bull thistle which is, like the artichoke, from Europe. But such instances of native insects which have taken immediately to alien plants as food are not common. Natives are a minority among the rural-urban insect pests.

And on the other hand, few alien insects have entered the natural plant associations, except in disturbed sites. Most of the insect species in the forests of the area, both beneficial and injurious, are natives to these forests.

The louse, which has been associated with man from his beginnings, and the flea were probably brought across the Bering Straits by the earliest immigrants. In any case, these pests were known to the Costanoan Indians when the Spanish arrived.

The common housefly may also have reached the Americas at an early date. The lesser housefly, on the other hand, is definitely a European species having probably come to California in the ships of the first Spanish settlers (Essig, 1931, p. 318).

Two species of cockroach were introduced first by the Spanish, then repeatedly by Americans. The most widespread, exotic roach is the oriental roach (black roach), an insect which has spread with commerce almost throughout the world. In the Monterey Bay area it is common in basements and sewers. The light colored German cockroach is an even more serious pest in this area, particularly in kitchens, bakeries, and restaurants. Two other exotic roaches, the American cockroach (also known as Mexican cockroach, which despite its names is actually derived from West Africa and is thought to have reached the southeastern United States in slave ships) and the Australian cockroach, arrived later. . The common bedbug infested early sailing ships and probably arrived with the first Europeans; it is never far from human habitations.

Although some claim that the honeybee was brought to California by the Spanish, or even by the Russian settlers at Fort Ross, it seems fairly certain that the first hive of bees to reach California was brought to San Jose by Americans in 1853, by way of the Isthmus of Panama (Essig, 1931, pp. 265, 273). Swarms were sold in Soquel in 1859. In parts of eastern North America the honeybee is said to have become known to Indians before they ever saw a white man, swarms of the insects having moved westward well ahead of European settlement. But it is unlikely that the first bees to reach California swarmed overland.

Many domesticated plants—apples, cherries, pears, etc.—depend upon pollination by the honeybee to set fruit. But as the bee takes nectar and pollinates in all of the local associations of flowering plants, both native and alien, it may well be from the biological standpoint the most important single animal introduced into the area by man.

Driving through the apple orchards near Aromas in winter one will see buckets and cans hanging in the leafless trees. These serve as drinking "fountains" for bees: As the red delicious, an increasingly popular apple variety here, is especially difficult to pollinate, bees, the principal pollinators, are needed in large numbers. In spring, when the trees are in blossom, drinking water is poured into the cans so that the bees needn't journey back and forth between the orchard and the Pajaro River, some distance away.

Two of the more serious orchard pests introduced into this area in the early 1870's were the coddling moth and San Jose scale. By 1906, the coddling moth, a native of Europe, had become one of the most injurious insects to apples in the Pajaro Valley (*Register-Pajaronian*, May 10, 1906). San Jose scale, thought to be a native of Asia, was imported into the Santa Clara Valley on Chinese flowering peach trees; presumably, it entered the Monterey Bay area not long afterwards:

> In 1874, there occurred an event in Santa Clara Valley that was to have a profound effect on the future of the Pajaro Valley. Red (San Jose) scale attacked the apple trees, wiping out nearly every orchard. This created a void which stimulated the planting of apple trees in the Pajaro Valley, which had not been infested.... Oddly, prunes which had been grown in the Pajaro Valley were torn out for apples, while in Santa Clara, dismayed growers tore out their apple trees and planted prunes.... The Pajaro Valley did not entirely escape the terrible red scale.... A lime-sulfur combination, which proved effective against scale made a timely appearance. (*Watsonville Register-Pajaronian*, June 6, 1968.)

The European white cabbage butterfly arrived in California, by way of Canada, in about 1883. It is found not only on cabbage but on cauliflower, sprouts, and other crucifers.

The Argentine ant is the most important ant pest of farm and household. This native of the American tropics is thought to have been introduced by ship from Brazil to New Orelans in 1891. The species was first collected in California in 1905, and was found near Campbell in the Santa Clara Valley in 1908. It probably appeared in the Monterey Bay area around that time, too. The workers of this species are almost black, odorless, and do not bite or sting effectively. In towns its nesting places are often found in manholes and basements where they are kept warm by steam pipes (Cook, 1953, pp. 234-235). The Argentine ant has replaced native ants in many areas. It spreads and tends the native Monterey pine scale for the honeydew which the scale produces. This native scale causes serious injuries to Monterey pine seedlings. Another source of honeydew for the Argentine ant is the citrus mealybug which was introduced on citrus trees from the Mediterranean area. The ants tend the mealybugs, too, and protect them from enemies (Swain, 1952, p. 61).

Clothes moths, introduced from Europe at an early date, are destructive household pests.

The European red mite is a pest on citrus, apple, pear, and prune trees. The European earwig was discovered in Berkeley in 1923. Although common in the Monterey Bay area, it cannot have been here more than half

a century. Another European species, the green apple aphis, has spread around the world in midlatitudes, wherever its hosts have been introduced. In addition to the apple, its host plants include cotoneaster, pyracanthus, and loquat.

The corn earworm, the larva of the phalaenid moth, a pest on maize and tomato plants, is an introduced species here, although native to the Americas.

A number of insects have been introduced with domesticated animals: The common hen louse is parasitic on domestic poultry; it is well known to local poultry growers, as is the red poultry mite. This mite, now found throughout much of the world, infests poultry and their roosts, and occasionally people, as well.

The horse bot fly, which somewhat resembles the honeybee, lays its eggs on the hair of horses' forelegs. "The species is European and has been distributed with horses throughout the world." (Essig, 1958, p. 575.) Though sometimes found in horse-watering troughs, and mistakenly thought by some rural people to be animated horse hairs, the hairworm, *Gordius*, has a life history unrelated to horses.

Other insects have come to the area on accidentally introduced mammals:

> Neither the so-called domestic rats, Norwegian, Alexandrian, black, nor the house mouse, nor their 3 common fleas—the Oriental rat flea *(Xenopsylla cheopis)*, the European rat flea *(Nosopsyllus fasciatus)*, nor the mouse flea *(Leptopsylla segnis)* are native of this country. All seem to have been introduced through shipping channels. (Hubbard, 1947.)

These fleas are the principal vectors of bubonic plague, an Old World disease, and murine or endemic typus. The fleas are now found on native animals in California, to a limited extent.

The brown powder post beetle, which attacks house timbers and other wooden objects and reduces their interiors to powder leaving only an outer shell, is of Asiatic origin. The European lyctus is another exotic wood-boring beetle.

The pear slug, a native of Europe, is found on cherry and pear trees here and in the Santa Clara Valley (Essig, 1931, pp. 257-259); for example, it was damaging pear trees in Santa Cruz in 1973.

The following additional introduced species are probably present in the Monterey Bay area: the black scale, one of the most destructive insects in California, was introduced on citrus trees from Florida prior to 1880. It has many host plants, both introduced and native (Essig, 1931, pp. 139-144;

1958, pp. 299-300). The oystershell scale, a naturalized pest from southern Asia, is found on apple and pear trees and on ornamental shade trees. Citrophilus mealybug, said to be found on poison hemlock around Salinas, also infests pears in the Carmel Valley (Essig, 1931, pp. 131-133).

The above list of introduced insect species is quite incomplete. No other group of introduced animals is so large nor, in terms of disruptive effects of human occupancy and problems of control, so important. On the more fertile soils of the area, the natural mosaic of native plant associations, inhabited by insects with special dietary needs and subject to natural controls, has been erased. The infinitely more uniform plant cover which replaced it (consisting of row upon row, mile after mile, of lettuce, orchard trees, brussel sprouts, etc.) stands as an open invitation to itinerant insects, long adapted to just such fare.

Biological control of California insect pests has been studied for over a century. The mosquito fish (noted earlier) and the vedalia are well-known and successful examples. Because its consequences cannot be foreseen completely the application of biological controls is a potentially hazardous procedure—but probably less so than is control using toxic substances. Certainly research on biological controls is one of the most promising practical aspects of the study of human influences upon the environment.

In 1869, the cottony cushion scale was discovered in California on specimens of *Acacia latifolia*, which had been introduced from Australia. Within 20 years, it threatened to destroy the state's citrus industry. It was in response to this threat that "the first successful introduction of a beneficial insect into any country to prey on an injurious one" was made (Essig, 1958, p. 415). The vedalia, the most famous ladybird beetle in California, was introduced from Australia to southern California in 1888 and 1889, and quickly brought the cottony cushion scale under control. An Australian fly, *Cryptochaetum iceryae*, an internal parasite of cottony cushion scale, was introduced into California citrus groves in 1888. In northern California it became a more efficient enemy of cottony cushion scale than was the vedalia, keeping the scale under almost perfect control (Essig, 1958, p. 616). All three insects are now rare in the Monterey Bay area.

As the foregoing pages indicate, about a dozen exotic bird and mammal species reproduce in the area, untended. More numerous are the alien mollusks and fish, and most numerous of all, the species of foreign insects—a veritable menagerie. While the introduced fish were brought

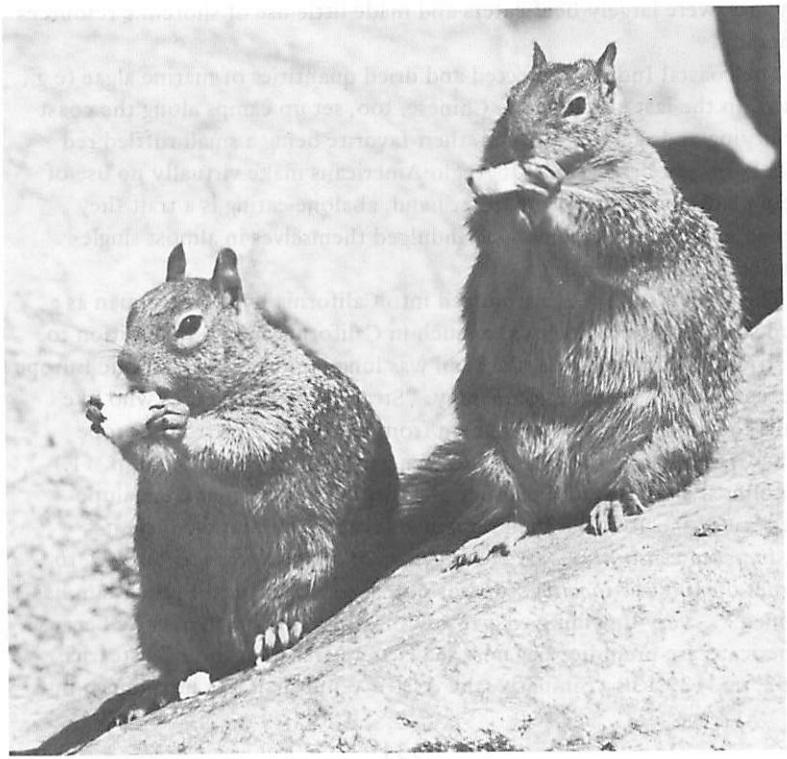
purposely, many of the other animals, including most of the insects, arrived by accident. Of animal species which arrived by chance and thrive here without care, few are now considered beneficial.

Considering the fact that the Monterey Bay area's written history is short, that it is rich in endemic species and has recently been intensively used, unrecorded extinctions may well have taken place. But balancing the list of introduced plants and animals against known extinctions, the total human effect on the area has been biotic "enrichment," at least in terms of the number of species present. On the other hand, simply increasing the total species number is not necessarily desirable; more agricultural pests could easily be imported. Plainly, many of the alien animals listed above were better never introduced. *Chance, rather than planning has characterized the area's historical development.* But condemning the introduction of all aliens in the name of conservation seems unreasonable. Surely, the honeybee, striped bass, and ring-necked pheasant are no offense to nature lovers. And all of our domesticated food plants and animals are foreigners. True, alien species cannot be thought of as permanent contributions to the area's biota, because most could not long survive the departure of people. In fact, many could not withstand drastic changes in land use. But their presence greatly increases the area's diversity. Properly selected and restricted, their threat to native species can be minimized.

Plant succession determines a sequence of faunal changes. Information on succession in the area is still so incomplete that the fate of introduced animals in the absence of human activities is largely conjectural. But, as with plant species, the trend is definitely toward the exclusion of aliens. If the human population were entirely removed, most of the domesticated animals would soon disappear. Untended aliens closely associated with habitations, such as cockroaches and the housefly, would soon follow. Populations of English sparrow, house mouse, and garden snail would decrease sharply as farms and gardens became overgrown. Around Larkin Valley, garden snails are a pest in those apple orchards which are still in production, eating tree leaves and blossom ends of the fruit. But by the time tall shrubby regrowth is established in abandoned orchards, the snails have entirely disappeared. Similarly successional change excludes the ring-necked pheasant from the orchards within about 20 years. Cattle might linger for several generations, maintaining patches of grassland until the populations of native predators built up. The European wild pig appears to have adapted well to rough country, chaparral, and oak

woodland. Probably the striped bass could survive and perhaps the carp, the mosquito fish, and the honeybee. But only a small minority, if any, of the introduced animals could become a permanent part of the area's fauna in an environment without people.

California ground squirrel. Some of the measures to reduce the ground squirrel population had limited success. In 1891, the County of Monterey published Ordinance 205, requiring the County Clerk to pay "For each and every squirrel killed ... a bounty of three cents..., the scalp of each squirrel with the ears thereon ... securely strung on a string. ..." Furthermore, the clerk "shall enter in a book, to be kept for the purpose and designated 'Record of Squirrel Scalps,' the date of the receipt and the number of such scalps...." In 1898, in Ordinance 288, the wording was amended to have the bounty paid "... on lots of at least 25 squirrel tails. ..." and the payment noted in a book, "Record of Squirrel Tails." Actually, ground squirrel numbers were of magnitudes beyond significant influence by bounty hunters. Then, too, 3 cents per squirrel, even in those days, hardly bought traps or ammunition. The ground squirrel is one of several native species which sometimes concentrate at campsites in public parks. For example, a concentration of abnormally plump squirrels, with picknickers' food scraps, scurry between lunch tables and parked cars at Point Lobos State Park. (Photo, R. Buchsbaum)



Chapter 5

CULTURAL ORIGINS AND LOCAL ECOLOGICAL CONDITIONS

A. CULTURE, CUISINE, AND ECOLOGY

IN COASTAL California, as in many other areas, specific cultural influences on the biotic environment appear among the general effects of human presence. The ecological consequences of human action have varied, in character and intensity, with the settlement of the area by different ethnic groups. For example, one can readily see relationships between culture, cuisine, and ecology. The Indians were comparatively omnivorous, whereas their successors, coming from different climates and cultures, were ignorant of many native food sources. The Costanoans used acorns and buckeyes for food; neither is so-used by Californians today. Costanoans also ate quantities of the California mussel; not so the American, at least until recently. The Spanish-Mexicans in the Monterey Bay area were largely beef-eaters and made little use of shoreline resources generally.

The coastal Indians collected and dried quantities of marine algae (e.g., *Ulva).* In the last century, the Chinese, too, set up camps along the coast for drying and sacking seaweed, their favorite being a small ruffled red alga, *Porphyra perforata.* But Anglo-Americans make virtually no use of these plants as food. On the other hand, abalone-eating is a trait they picked up from the Chinese and indulged themselves in almost single-mindedly.

The garden snail was introduced into California by a Frenchman as a food source but it is not used as such in California today. In addition to its strictly culinary merits, the snail was long important in Catholic Europe because it could be eaten on Friday. "Strange to say epicures who like snails for food seem to prefer them from imported cans from Europe rather than picking them from western gardens." (Hanna, 1966, p. 11.) For almost a quarter of a century after its introduction at Guadalupe Creek near San Jose the snail remained localized in that vicinity; its *"... increase was quite likely the measure of consumption as food by the parties owning the locality."* It was noted, too, that local French families seemed "... very unwilling to give any information, which may be because Americans are prejudiced against snails as an article of food." (Stearns, 1882, pp. 129-130.) Similarly, the Asiatic pond snail was introduced into

California for food by Oriental Americans and it is eaten only by their descendents.

Italian and Portuguese seafood appetites contrast strongly with those of Anglo-American Californians. Thus, their assessment of food resources in the littoral zone is quite different. For instance, the Italians consider the goose barnacle and black turban snails to be choice food, and the eel delectable. From their homeland the Italians brought the custom of eel fishing with pokepoles—a method growing increasingly popular among other California fishermen. If sea urchins were a popular food in California as in Italy, they probably would not be the nuisance that they are in the southern part of the state. (In Italy one sees beaches littered with their split tests. Near Año Nuevo we also came upon a little pile of split urchin tests, with a squeezed half lemon lying nearby—likely left over from lunch by some European fisherman.)

The carp, having travelled as a choice food fish from the Far East to Europe, received a less than enthusiastic welcome in North America. Only first generation immigrants continue the carp-eating tradition. In California, it is, in fact, considered the worst pest among fishes. And, like the sea urchin, it is overly abundant simply because it is seldom eaten—for cultural reasons.

B. A LITTORAL ECOLOGICAL CHAIN

When central California was still virtually terra incognita, the coastal ecology of the Monterey Bay area was already responding to cultural attitudes and economic developments in very distant places. One cultural trait which was of particular importance involved the use of animal pelts: Mandarin Chinese had long used fine furs for decorative clothing. In the 17th century this trait spread to Europe, where a great demand for fur coats developed among sophisticated women. The furs were prized far beyond any practical value they may have had in the making of warm clothing. (The obsession with furs persists: at a public auction held in Seattle in 1968, a thousand pelts of the northern variety of sea otter were sold, each bringing approximately eleven hundred dollars; several pelts are needed to make a coat. The pelt of the sea otter is said to be more valuable than that of any other furbearer.)

Furbearing animals, particularly the sea otter, were hunted even in such remote and inaccessible areas as California. The resulting changes in their numbers caused several other animals in the California littoral

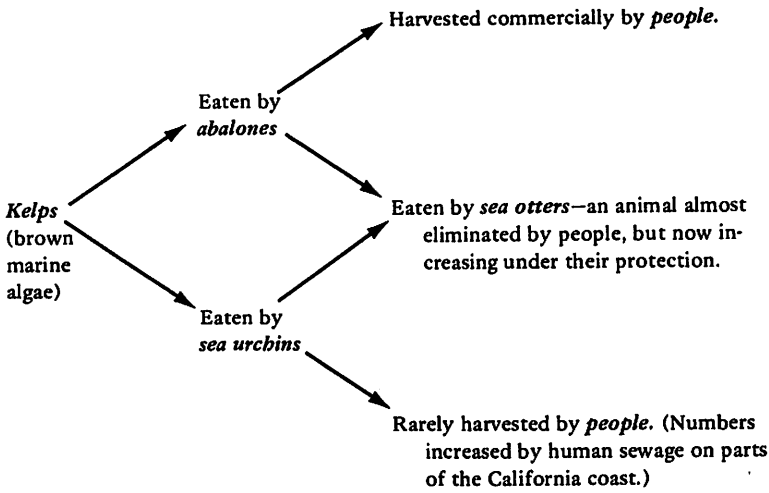
to fluctuate, as well. Two centuries ago, as now, offshore kelp beds were the favorite habitat of the sea otter, once one of the most common mammals in the littoral zone. Abalones and sea urchins also inhabit the kelp beds, feeding on these plants. The sea otter feeds, in turn, on the abalones and sea urchins. By about a century later, fur hunters had virtually exterminated the sea otter, causing abalone and sea urchin populations to increase. Around this time American immigrants in California developed a taste for abalones, following the example of local Chinese settlers. The large-scale harvesting of the red abalone, which began in the early part of the present century, benefitted the abalone's competitor, the sea urchin.

A recent study (Ebert, 1968) of the food habits of the sea otter in the Monterey Bay area shows that the animal locally exerts a potent influence on benthic biocommunities, in spite of its present reduced numbers. The red abalone, the red sea urchin, the giant kelp, and the bull kelp are noticeably affected. By foraging on the urchins and abalones, which are herbivores, the otter also encourages maximum growth in the kelp beds. (The otter feeds principally on the red sea urchin in the benthic zone, the purple sea urchin being mainly intertidal.)

Although the otter's diet consists mainly of sea urchins, abalones, mussels, and, in some places, crabs, the proportions of these animals in the diet vary considerably. This variation reflects the relative availability of the food animals as much as it does the otter's own preferences.

A tentative reconstruction of biogeographical changes in the littoral zone (based partly upon Ebert, 1968) is as follows. Before the arrival of Europeans, when sea otters were plentiful, red abalones and red sea urchins were not abundant in the offshore zone. Abalones were numerous then only in the intertidal zone where otters could not easily reach them; the huge quantities whose shells are to be found in the Indian middens along the coast were mainly obtained there. Between Indian fishermen and sea otters, the red abalone population was kept relatively small. Thus when sea otters were exterminated, red abalones and red sea urchins became more common throughout the offshore kelp beds in the deeper water. There the red abalones became the basis of the commercial abalone fishing industry. Nowadays where sea otters reappear they quickly limit the red sea urchin population and compete with the commercial fishermen for the red abalones, which activities favor the growth of kelp.

Human Effects on Littoral Populations

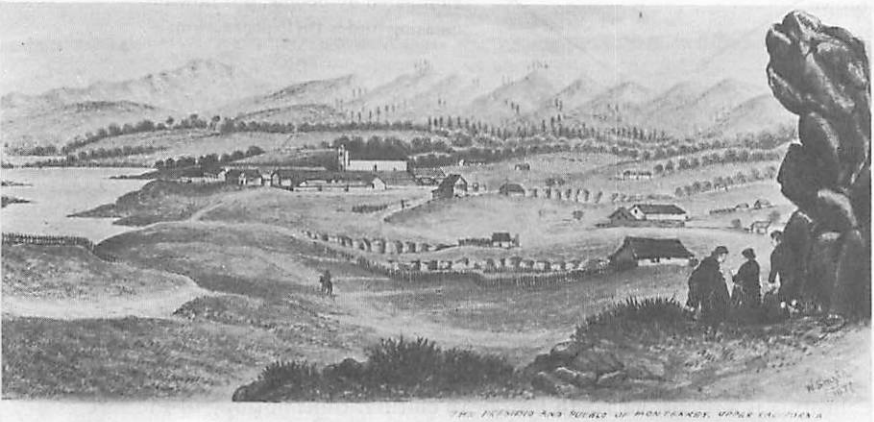


C. LAWNS

Lawns are another example of cultural peculiarity: Lawnmaking in California is a persistent north European cultural trait; nothing of the sort existed in Indian times. Nor were lawns planted for each individual house by the Spanish-Mexicans. They are scarcely functional, being primarily for public display. Nowadays, as a matter of custom, thousands of them, prim and rectangular and likely bounded on either side by trimmed privet hedges, are planted in the dooryards of every town. In fact, dooryard and park lawns, with their associated exotic ornamental trees and shrubs, are the dominant biotic features of urban areas. As a new animal habitat, lawns have had a marked effect on the range and abundance of certain species; for example, the garden snail (introduced) and Brewer's black bird and the pocket gopher (natives). Golfing, another north European cultural trait (which arrived here at a much later date), and lawns go together to produce a major form of land use in the area. Something over 60 hectares (150 acres) is required for a first class, eighteen-hole, golf course. Thus, if we add to dooryard lawns those of the large golf courses, especially around Monterey Peninsula, it is clear that the total acreage of this type of plant cover is considerable, as is the water bill for its maintenance.

Like lawns, the rectangular street grids (and fenced yards), which demarcate today's urban bioassociations were a north European, i.e., Anglo-American, contribution to the California landscape. Note the following description of Monterey in 1836, that is, before Anglo-American settlement:

> ... the houses—about a hundred in number—were dotted about here and there, *irregularly*. There are in this place, and in every other town which I saw in California, *no streets*, or fences ... so that *the houses are placed at random*.... (Dana, 1911, p. 73.)



Above, **"The Presidio and Pueblo of Monterrey, Upper California"** by William Smyth, 1827. This water color sketch shows Monterey Peninsula as Spanish-Mexican cattle country from the presidio toward the SE with San Carlos Church in the center, the crests of the peninsular hills in the right background, and El Estero (Lake) on the left. Note: scanty tree growth on hills, alignment of trees (in tree-fences or along *alamedas*), and deeply eroded gullies in the stick-fence corrals. (Courtesy, the Director, The Bancroft Library, University of California, Berkeley)

Below, **Same view in 1974 from the presidio.** San Carlos Hotel is the large building near the right. Note: heavy tree cover (Monterey pine and coast live oak) on the peninsular hills. Farther E the contrast in vegetation is not so marked: the N face of the Sierra de Salinas has little tree growth now, as then. (Photo, R. Buchsbaum)

Chapter 6

PHYSIOGRAPHIC AND HYDROGRAPHIC CHANGES AND THEIR EFFECTS

A. IRRIGATED LANDS AND EARTHEN RESERVOIRS

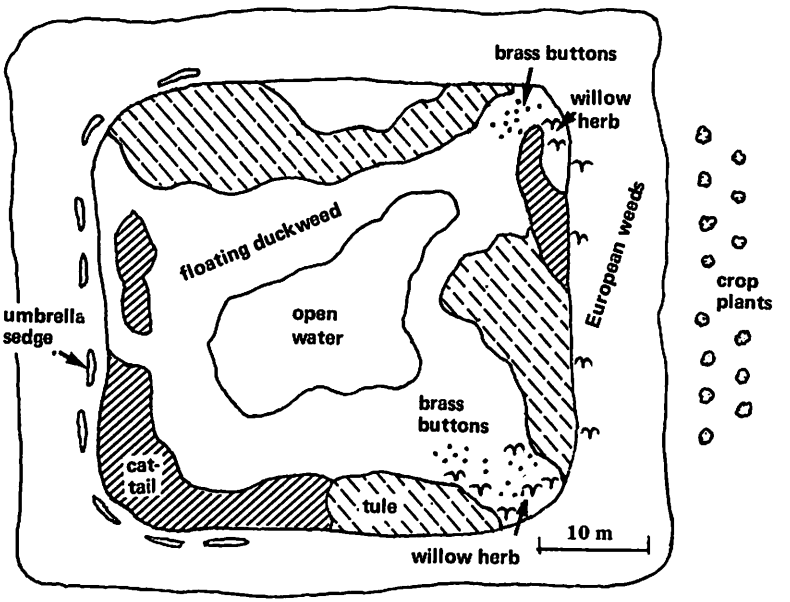
BEYOND THE floodplains of the Salinas and Pajaro Rivers, especially in the rougher land in the northern part of the Monterey Bay area, the surface is dotted with small earthen reservoirs—for example, in the area between Natividad, Aromas, Castroville, and the mouth of the Pajaro River, and on northward along the coast between Santa Cruz and Año Nuevo.

These reservoirs are on the higher ground, neighboring flat tracts of land which are suitable for artichokes and strawberries or, northward from Santa Cruz, for brussel sprouts. Water from the reservoirs is used both for ditch irrigation and for overhead sprinklers. Reservoirs of this type were made by farmers here over half a century ago by scraping up dirt with Fresno scrapers, devices shaped something like a huge dustpan and drawn by a team of horses. Most of the reservoirs postdate World War II, however. A few have been made by impounding small streams but the water in most is pumped from nearby wells.

Within a surprisingly short time after the reservoirs are filled they are inhabited: willow herb, cat-tail, and duckweed arrive within a year. Insects which are strongly dependent upon water—mosquitoes, midges, and dragonflies—appear, and within a short time others which actually live in or on the water itself, including water boatmen, back swimmers, water striders, and water beetles. Frogs and garter snakes are soon present. Coots arrive, perhaps even before plant growth develops. Mallards, too, feed and rest in the ponds. In the evenings swallows can often be seen swooping over the water, feeding upon insects. Brewer's and redwing blackbirds are common. Such quantities of an aquatic snail can be seen in the ponds that the species can fairly be said to have experienced a "population explosion." When the ponds are drained their bottoms are so densely covered with the shells of these snails that, in places, one can hardly press a finger into the mud without touching a shell. The snail appears to be *Lymnaea nuttalliana*. Whether this species is native here or a European introduction is uncertain.

Because most of the reservoirs are periodically dried and the vegetation destroyed, plant succession usually does not proceed for more than a few years. Thus there is usually no tree growth, although in ponds left undisturbed for 4 or 5 years, willows are likely to be established.

Exotic field weeds—mustard, mallows, amaranths, and the like—commonly appear in a fringe around the reservoirs, but they are well away from the water's edge. In the reservoirs themselves, most of the aquatic plants and animals are native species. (Exceptions are mosquito fish, brass buttons, and muskrats.)



Irrigation pond and associated vegetation, near junction of Highway 1 and JensenRd. The more strictly aquatic plants include tule, cat-tail, umbrella sedge, duckeed *(Lemna minima)*, willow herb *(Epilobium watsonii)*, and brass buttons. Although such irrigation ponds extend the freshwater marsh flora beyond its natural limits, the actual number of plant species spread in this way is not large. Because of periodic draining, few ponds contain more than a dozen native plant species, while over 50 native herbs alone can be collected within 10 km of the pond above, growing in surviving remnants of natural marsh. Conspicuous local freshwater marsh species which are absent from the ponds include marsh pennywort, bur-reed, and silver weed.

The manner in which several of the species are disseminated to the ponds is something of a puzzle. Presumably such plants as the cattail are wind disseminated but it seems unlikely that this is true for umbrella sedges and tules—the ponds being well-separated in large tracts of cultivated land. Thus bird dissemination must be a very important factor. How else could the snail have arrived? Possibly its eggs are carried in on the feathers and feet of coots and ducks. The western pond turtle must travel overland over surprisingly long distances. Mosquito fish, present in some ponds, are planted by mosquito abatement personnel.

There are some 300 such reservoirs, mainly in the northern half of the Monterey Bay area but also scattered generously along the eastern side of the lower Salinas Valley. Their effect on the biota of the area as a whole must be considerable. They preserve part of a marsh flora which, as noted earlier, once existed in natural freshwater lakes, now drained (especially between Salinas and Castroville), and have extended patches of such habitat over a far wider area. In most respects they must be beneficial, at least in terms of increases made in habitat and species diversity: because of them, various water-loving animals have been more widely distributed; the ponds have established resting places for birds (the subject of their importance to migrating waterfowl would bear study); they provide feeding grounds for various birds of prey; and so on.

The growth of aquatic plants in the ponds can be controlled by adjusting their water levels and shaping their vertical cross sections. The ponds can also be made more attractive to wildlife by planting shrubs and trees back from waterline.

While under natural conditions winter and spring are the times of greatest plant growth (because of concentration of the rainfall in those seasons), in irrigated areas the season of strongest growth is not only changed to summer and fall but is accelerated, as well, by the higher temperatures occurring then. This growth is mostly in crop plants. Weeds, like mustard, which otherwise flower mainly in January and February, bloom in August, too, along irrigation ditches. Many insects thrive throughout the summer in the Salinas and Pajaro Valleys on the artificial supply of water from sprinklers, increasing the need for spraying operations from aircraft.

As lawns and parks of the area only remain evergreen because of the artificial water supply in summer, plainly the whole urban bio-association is largely dependent upon the practise of irrigation.

The effect of irrigation on the distribution and number of insects can hardly be overstated. A large part of the mosquito abatement program deals with mosquitoes associated with irrigation waters.

B. SALTWATER INTRUSION

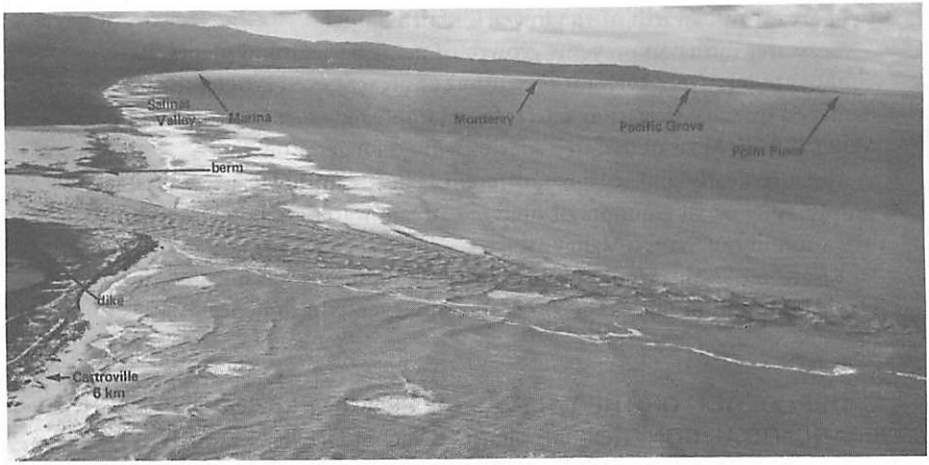
Diverting streams to supply water for irrigation is an old Spanish-Moorish custom which was continued in the Monterey Bay area. The missionaries grew irrigated crops to help feed the Indians who had been concentrated around the missions, especially at Mission Soledad and Mission San Antonio. However, irrigation was virtually given up in the area when the missions were secularized in 1833.

A few decades later, irrigation agriculture was renewed by the Americans. Between 1874 and 1890, irrigation water in the Salinas Valley was obtained mainly from wells, with pumps operated by windmills. Toward the end of the century a canal was built along the side of the valley carrying water from upstream tributaries. In 1904, several thousand hectares of sugar beets were being irrigated with water supplied by wood-fueled steam pumps which burned mainly willow and cottonwood growing along the river. Very large amounts of wood were needed: for example, on one 200 hectare (500 acre) tract it was noted that "The consumption of fuel is at the rate of one-half cord per acre irrigated." (Hamlin, 1904, pp. 80-81.) Mineral fuels were being sought at the time because the local supply of wood was inadequate.

Intensive exploitation of groundwater began between 1910 and 1920, with the spread of commercial vegetable growing in the Salinas Valley and the introduction of gasoline fuel, electrical power, and deep-well pumps. By 1963, about 95% of the water used in the Salinas Valley came from beneath the surface, and of this, 95% was used for irrigation (Manning, 1963, pp. 107, 109).

Two main aquifers carry water seaward beneath the floor of the Salinas Valley: one is approximately 55 m (180 feet) below the surface; the other is at a depth of about 122 m (400 feet). The lower ends of these aquifers are exposed and discharge along the sides of the Submarine Canyon offshore from Moss Landing. Seawater intrusion into the 55 m aquifer, a result of heavy pumping of well water, became evident in the early 1940's. By 1945, seawater had advanced two and one-half kilometers (1½ miles) inland and polluted some 2428 hectares (6000 acres) (Todd, 1953, p. 752). Since that time intrusion has been detected progressively farther inland.

In 1954 the 180-foot aquifer was polluted by seawater for a distance of about two and one half miles inland from the coast and water levels in the wells were below sea level for about eight miles inland. At that time the 400 foot aquifer had been polluted by seawater for a distance of about two miles from the coast. (Manning, 1963, p. 108.)



Present mouth, an artificial outlet, of the Salinas River, at flood stage, from an offshore point S of Moss Landing, April, 1968. Each year when the river reaches a critically high level, county flood control personnel make a ditch across the berm or sand dam separating the river channel from the bay, thus starting flow in that direction. In rainy years, flood waters impounded behind the berm may rise to between 3 and 4.5 m above sea level, and escape into the bay at high velocity when the cut is made. A dike preventing northward flow of the river in its old bed is located on the north bank of the present mouth. During summers, when stream flow dwindles, ocean wave action rebuilds the berm. One of the many consequences of these engineering activities is that the Salinas River deposits its heavy load of sediment in this area S of the submarine canyon rather than to the N of the canyon, as it did formerly. (Photo, U.S. Army Corps of Engineers)

To appreciate fully the changes made in subsurface hydrography, compare the circumstances noted above in the 55 m aquifer with those in the following early description:

In 1880, a well was drilled at Castroville to a depth of 178 feet, *producing a volume of fresh water, which at high tide flowed in large quantity over the casing and at low tide ceased flowing.* This well is near the mouth of the Salinas River, and the surface of the ground is 20 feet above the river. (Hamlin, 1904, p. 32.)

The rate of saltwater intrusion varies; from 1944 to 1945, it was 183 m. The intrusion has been observed to vary seasonally and to be correlated with the pumping of irrigation water on truck crops of the lower part of the valley (Todd, 1953, p. 752).

In 1967, indications of seawater intrusion were also noted in the Springfield area, to the north of the lower Elkhorn Slough.

Seawater intrusion prevents growth of many agricultural plants. Artichokes are relatively tolerant of salt but at present even artichokes are damaged by salty irrigation water, for example between Castroville and Mulligan Hill. Most native tree species will no longer grow there.

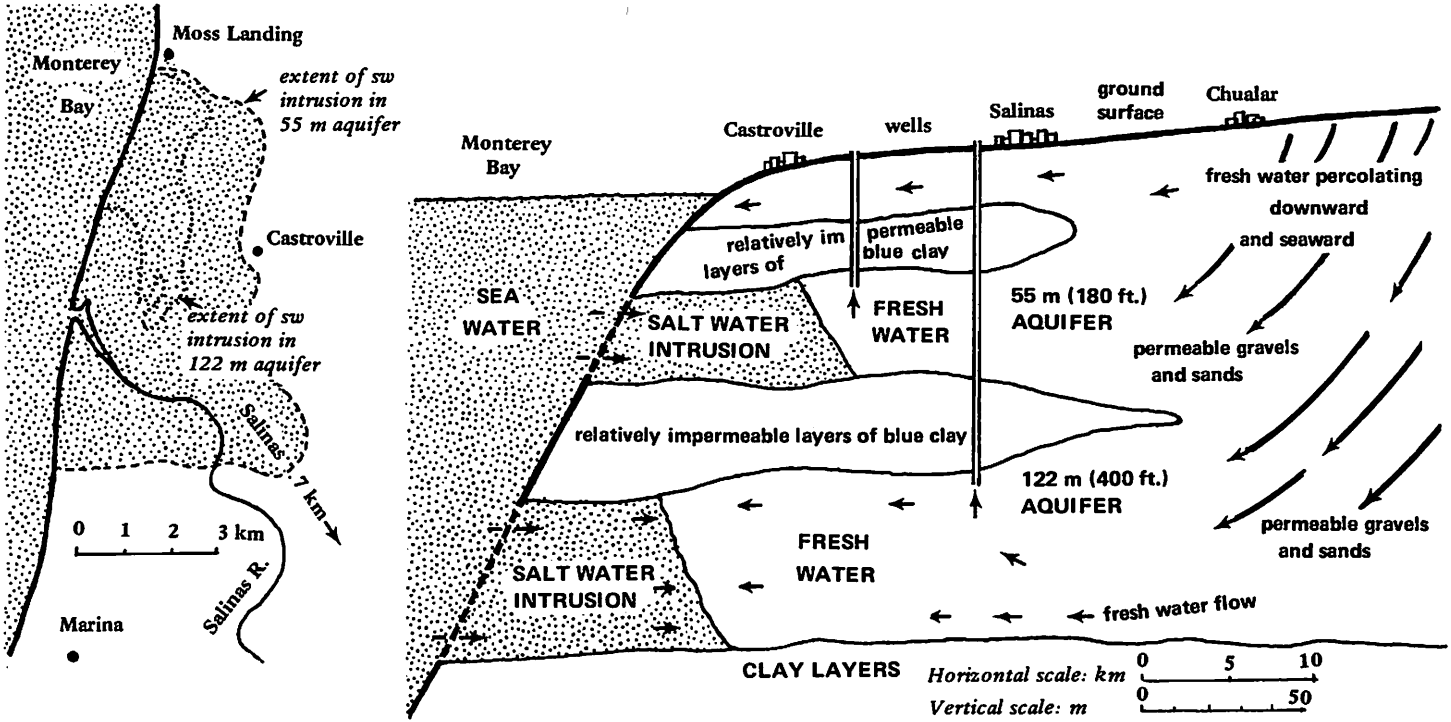
Because yearly and seasonal differences in streamflow cause uncertain supply, only small amounts of diverted stream water are now used for irrigation in the Salinas Valley.

Elsewhere in the Monterey Bay area, too, pumping has lowered the water table and in places this no doubt slows reestablishment of natural plant cover.

C. DEFLECTION OF THE SALINAS RIVER AND ELKHORN SLOUGH AND TIDAL CONTROL OF MORO COJO SLOUGH

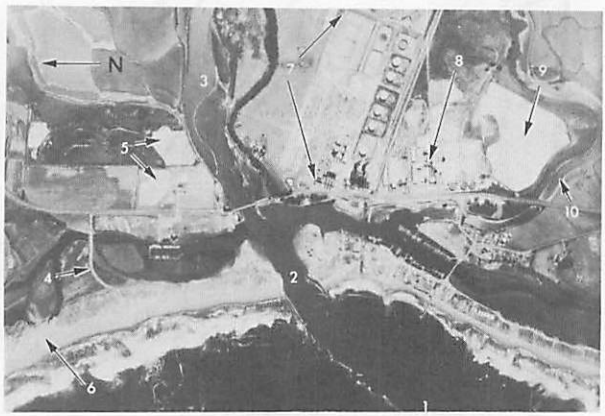
In the early part of this century the Salinas River flowed northward in the lower part of its course, paralleling the shoreline and separated from the bay for about 10 km (6 miles) by only a narrow stretch of sand dunes. The mouth of the river was then located about 1.6 km (1 mile) north of Moss Landing. Between 1908 and 1910, the river began to empty into the bay at a location about 8.8 km (5.5 miles) southward, near Mulligan Hill (G. C. Jones, 1933, p. 2). Thus, the old mouth was to the north of the submarine canyon while the present mouth is well to its south.

A question arises as to which is the more stable position of the river mouth. Geological evidence indicates that the mouth has located at its present position over long periods of time. The underground flow of the Salinas River is through aquifers reaching the bay on the south slopes of the submarine canyon, directly offshore from its present mouth. One principal aquifer, at a depth of about 55 m, is "... apparently a stream channel deposit laid down by an ancestral Salinas River and is probably upper Pleistocene to Recent in age." (Manning, 1963, p. 108.) Another feature indicates long duration of this outlet: "The position of the apex and shape of the fan [a broad, thin, deltaic wedge of river sediment, offshore from the river mouth, shown on U.S. Coast and Geodetic Survey



Salt water intrusion in Salinas Valley; concentrated intrusion only; 500 ppm or over. (Bunte, Manning, and Todd)

Section through Monterey Bay and adjacent area under Castroville and Salinas showing salt water intrusion into fresh water aquifers.

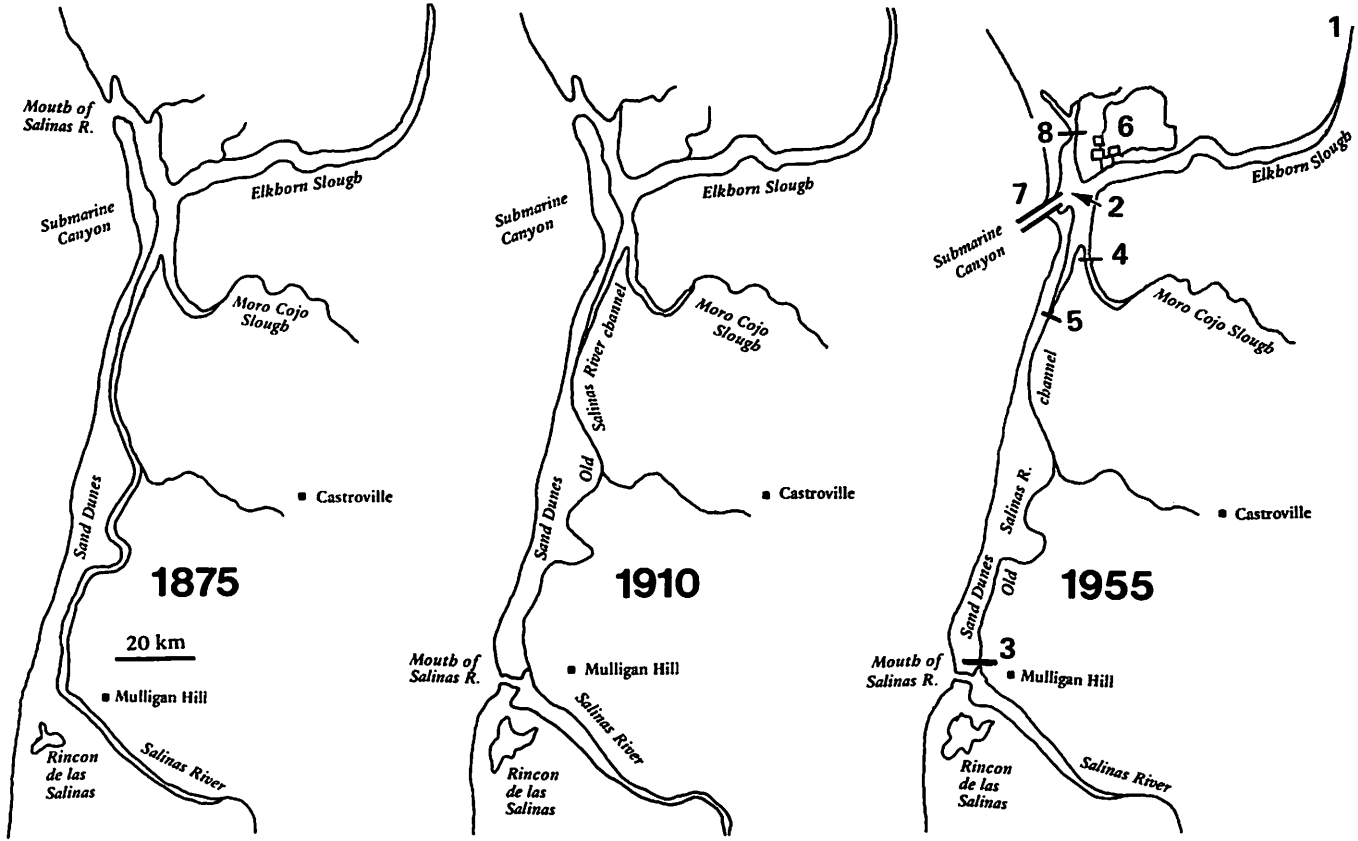


The submarine canyon (1) which approaches shoreline near the entrance to Moss Landing Harbor (2) is a controlling feature in the circulation of the waters of Monterey Bay. The nearby saltmarsh of Elkhorn Slough (3) is one of the richest and most distinctive wildlife habitats in California. Jetty Road (4) is a favorite spot for birdwatchers. Note the salt production ponds (5) and the location of the old Salinas River mouth (6). The photograph shows industrial growth that has already taken place at this critical spot, for example, the P.G. and E. power plant (7) and Kaiser Aluminum and Chemical's refractories plant (8). Note the extensive tailings-heap (9) of the Kaiser plant on Moro Cojo Slough (10). Now an even more drastic change is proposed—the development here of a deepwater port, particularly for unloading oil. The overall environmental effects of such a project will almost certainly be destructive. A certain amount of oil is certain to be spilled, with harmful consequences to the fish-breeding intertidal area, bird feeding area, sea otters, the beaches, pleasure boating, etc. Plainly the proposal needs deliberate intensive study because the adverse effects are likely to be irreversible. (Photo, USGS, 1966)

charts 5402 and 5403] show that the location of the present mouth of the Salinas River has been maintained for the duration of the deposition of the fan." (Yancey, 1968, p. 9.)

On the other hand, the river's mouth was located well to the north of its present position, and even somewhat to the north of the submarine canyon throughout most of the historical period, until 1908-1910. Natural wave refraction patterns in the bay produce increasingly high beach berms southward from Moss Landing and favor a location of the river mouth upcoast near the head of the submarine canyon (Bascom, 1954, p. 603). Counteracting this trend are the great variations in winter rainfall here and occasional flooding which explain abrupt changes in the river channel with flood waters sometimes breaking through the dunes.

A report written before the river changed its outlet describes a gradual movement of the river mouth northward, stating that drift sand:



Principal hydrographic changes made in the Salinas River-Mouth-Elkhorn Slough area, comparing conditions in 1875, 1910, and 1955. 1. Hudson's Landing. 2. Moss Landing Harbor. 3. Earthen dike across old Salinas R. channel. 4. Tide gate on Moro Cojo Slough. 5. Tide gate on old Salinas R. channel. 6. Salt ponds. 7. Jetties at Moss Landing harbor. 8. Tide gate at Jetty Road.

> ... has been crowding the mouth of the river northward until it is now in comparatively close proximity to that of the Pajaro. It is conceivable that this same movement may continue until a union of the two streams takes place, and moreover one should not entirely overlook the possibility that such a union may have occurred before. (Snyder, 1913, p. 54.)

A geologist who visited the area in 1854 stated that he saw physiographic evidence that the two rivers had once reached the bay in a single mouth, although he gave no details (Johnson, 1855, p. 31).

In the 19th century, during winter floods, the river sometimes broke through the dunes. Old editions of *Sailing Directions* refer to such breakthroughs near the "Big Bend of the Salinas"—that is near Mulligan Hill where the river turned abruptly northward.

It seems that during the recent geologic past the river mouth has shifted back and forth between the two positions, and that when the mouth was in the more northerly position, or midway between the two, its sediments disappeared into the submarine canyon.

Although it has been claimed (Fisher, 1945, pp. 15-16) that the displacement of the river's mouth southward to its present site was caused by the April 18, 1906 earthquake, there is little evidence of a connection between the two events. As indicated by the following notes, the shift actually occurred some time later.

An ichthyologist's detailed account of the streams tributary to Monterey Bay based upon field observations in the summer of 1909 described the Salinas as emptying into the bay to the north of Moss Landing:

> The mouths of the Pajaro and Salinas are in close proximity, less than 3 miles of land separating them.... (Snyder, 1913, pp. 50-51.)

In 1910, the river emptied through the Rincon de las Salinas before making a 1300 m northward adjustment and emptying in its present position by Mulligan Hill (Westdahl, 1910, p. 2; G. C. Jones, 1933, p. 2). No reference to the event has been found in local newspapers but it appears that the Salinas changed its outlet from north of Moss Landing to south of Mulligan Hill in the winter of 1909 or the spring of 1910.

Local residents may have directed the flooding river to the sea in 1908-1910 by excavating a channel for it through the sand—as they still do, with county assistance, almost every year nowadays because bar and dune sand builds up at the river's mouth during summers. A great expansion of agricultural land was underway at the time and deflecting the river through the dunes made its bed northward available for crops and helped protect the site of Moss Landing from flood.

The river still shows a strong tendency to flow northward into its pre-1908 bed:

> The mouth of the river is opened in the winter either by the river itself or by *artificial means.* Sometimes during this process the water is high enough that some of the water escapes into Elkhorn Slough by way of the old channel. (Beard, 1941, p. 8.)

This overflow of the Salinas into its old bed and into Elkhorn Slough has occurred a number of times. Within the nine-year period 1926-1935, it spilled over in 1929, 1930, 1931, and 1934 (MacGinitie, 1935, p. 635), and this despite the earthen dike placed between Mulligan Hill and the beach, to block such northward flow.

In the last century, the Salinas sometimes flooded violently in winters: "Its usual width, at the entrance to the bay, is about four hundred and fifty feet [137 m]. In 1862, during the wet season, it exceeded a mile [1610 m]." (Cronise, 1868, p. 83.) "Exceeded a mile!" That means that a large part of the dunes between Moss Landing and Zmudowsky Beach were swept away. In the upper part of the valley the Salinas Dam was built in 1941, the Nacimiento in 1957, and the San Antonio in 1966. By reducing flooding, these dams have helped confine the river to its present outlet and made the present site of Moss Landing habitable.

Before 1908, the dunes separating the lower course of the Salinas River from the bay were breached not only by the river but by ocean waves: "A natural dam has been formed across the Salinas River near Moss Landing by cutting of the surf through the sand hills separating the river from the ocean." (*Salinas City Index*, March 7, 1878). Duflot de Mofras' early 19th century map of Monterey Bay shows a peculiar, delta-like protrusion of shoreline in the same vicinity, possibly made by a break-through of the river in the opposite direction. The protrusion has since disappeared.

The vulnerability of the dunes immediately south of Moss Landing has been much reduced during the last half a century. With the Salinas River emptying to the south of the submarine canyon, the beach there has been supplied with additional sand, and broadened.

According to contemporary accounts, in 1859 the mouth of the Salinas River was some 137 m (150 yards) wide and at low tide in late summer the water depth on the bar at the river mouth was about 1.2 m (4 feet). Inside the entrance a small bay, deep enough for oceangoing sloops and schooners, covered the area where the Salinas River and Elkhorn

Slough joined. Commercial agriculture began in the Pajaro Valley in the middle of the last century. Within a few years produce was shipped to San Francisco, ships were loaded by surfboats off the mouth of the Pajaro River, and development of port facilities in the lower Salinas and Elkhorn Slough was being considered. The following note was written in Santa Cruz in the fall of 1859:

> ... we again call the attention of the residents of Pajaro to the project of rendering navigable the mouth of the Salinas.... By inquiry, on our recent visit, we ascertained, beyond a doubt, that *there is four feet of water on the bar at low tide, the depth of water is sufficient for the entrance of vessels* without deepening the channel at all. *The harbor inside the bar is perfectly calm, and of ample dimensions, and the slough will admit the passage of boats to a point within two miles of Watsonville. (The Santa Cruz News,* September 28, 1859.)

Another report on the subject was written at Watsonville on March 16, 1860:

> The passage of a sloop across the bar at the mouth of the Salinas river, on Saturday last, and its arrival *in the little bay* inside, created a great excitement in our town ... this being the first time a vessel has ever entered the channel.... Captain Williams says ... there is no doubt of the perfect safety of the channel for the entrance of *schooners*.... Warehouses will be built on the margins of the river, at its junction with the slough or, *perhaps on the slough itself much nearer town,* and soon the glory of the surf-boats will have departed.... About sixty of us went aboard the sloop and sailed down to the entrance and back to the bay again. The captain offered to take us out to sea and return, saying he had sailed out and in with ease. *(The Santa Cruz News,* April 20, 1860.)

In the 1870's, the port for Watsonville was located at the head of Elkhorn Slough and in the winter of 1876, an oceangoing steamer was plying its waters:

> The stern-wheel steamer, Vaquero, has arrived from San Francisco, and is making regular trips up and down Elk Horn Slough, taking grain out of the Watsonville warehouse and freighting it to Moss Landing. *(The Salinas City Index,* Dec. 21, 1876.)

This ship is further identified elsewhere: "The stern-wheel steamer Vaquero drawing about three feet [1 m] of water and of one hundred tons [90 metric tons] register...." (Elliott and Moss, 1881, p. 114.)

Some old pilings at a spot called Hudson's Landing still stand at the head of the slough but today it is impossible to reach them except in the smallest of boats and at high tide.

Thus Elkhorn Slough has been subjected to many recent changes, the greatest of which, ecologically speaking, took place when the connection between the slough and the Salinas River was severed between 1908 and 1910. Although the slough is now a saltwater estuary there is no question that its character has changed remarkably since that time. Before, when the slough was an arm of the lower Salinas, its water must have been seasonally almost fresh. In winter the slough was probably often a lake of the river's impounded flood waters. The author of the most thorough study of the slough's ecology (G. E. MacGinitie) clearly had this in mind when he made the following statement:

> ... the connection between the Salinas River and the Slough is disestablished. To all intents and purposes, therefore, Elkhorn Slough *at the present time* may be considered strictly a salt water estuary. (MacGinitie, 1935, p. 635.)

Hence, many of the ecological conditions described by MacGinitie in his excellent monograph were clearly brought into existence by human action: namely, by the diking of the channel of the Salinas near Mulligan Hill, thus preventing the river from flowing northward into the lower part of Elkhorn Slough.

The curious absence of cord grass, a characteristic species of California's coastal salt marshes, from Elkhorn Slough may be explained by the slough's history of repeated freshwater incursions. (There is also an old theory, never completely discounted, that the Sacramento and San Joaquin Valleys were once drained by a Pleistocene drainage system emptying into Monterey Bay at the site of Elkhorn Slough; cf. Beard, 1941; Snyder, 1913.)

The above comments on seasonally fresh water in the slough are confined to the historical period, that is to conditions which have existed since European settlement began: The presence of an archaeological site, mentioned earlier, near the bend in the slough in which the native olympia oyster is a principal shell indicates that at least some periods in the past (possibly when the Salinas River emptied near Mulligan Hill) Elkhorn Slough was a marine, that is saline, estuary.

An oyster industry developed in the slough in the 1920's and 1930's. This industry (like the salt industry) would have been impossible before the deflection of the Salinas River. Consider as an example of the strong influence of fresh water on estuarine faunas an even smaller decrease in salinity which occurred at a later date. In 1931, as has been noted earlier,

flood waters of the Salinas reentered the slough briefly and in 1932, it was reported that as a result "... of last winter's storms ... the native oysters were nearly all killed off ... by seepage of freshwater into the Elkhorn Slough where the beds are located." (*Pacific Fisherman*, Oct. 1932, p. 70.)

The slough was changed, too, by the many dikes, some still standing, built within the slough itself in establishing the oyster industry. Dikes have also been built along the north edge of the slough to keep its salt water from spilling over into fresh well water, etc. In places the banks along the lower course of the slough have been protected with riprap.

Before 1908, Elkhorn Slough (formerly known as Estero Grande and Roadhouse Slough) joined the Salinas River and emptied into the bay north of Moss Landing. Between 1908 and 1946, the slough continued to drain into the bay through the old mouth of the Salinas. In 1946, a private firm under contract with the U.S. Army Corps of Engineers cut through the dune barrier: thus, Elkhorn Slough now empties into the bay almost directly at the head of the submarine canyon at Moss Landing. Jetties were built to protect the new entrance to the slough. The old mouth, about 1.6 km (1 mile) north of Moss Landing, began to fill with sand immediately. Dunes, now partly stabilized with Holland dune grass and native dune vegetation, have built up almost to the level of the older dunes on either side and have hidden the old mouth of the river and the old opening of the slough. A harbor has been built in the old river channel north of the present entrance.

Accounts differ as to whether Elkhorn Slough as a whole is being shoaled or scoured. Since no large streams drain into the slough, it shoals very slowly under natural conditions. There can be little doubt that shoaling was the tendency during the period of intensive agricultural use of its watershed. For example in 1910, it was noted that "... the principal changes [in Elkhorn Slough since the last years of the 19th century] seem to be a diminution in width and depth of the main slough and its laterals, and a reduction of the marshy area in its vicinity." (Westdahl, 1910, p. 2.) Since 1946, scouring seems to have been the rule (and this despite the accumulation of littoral drift and wind-blown sand in the harbor entrance itself). Since the cut was made through the dunes, the slough is more directly subject to tidal fluctuations. At ebb tide a plume of suspended silt commonly spreads over several acres of the bay outside the harbor mouth. Little of this sediment is carried back into the harbor. One result of this scouring has been a deepening and widening of the channel in the lower part of the slough.

In 1935, it was observed that "Above the highway bridge there are no mudflats...." (MacGinitie, 1935, p. 637.) But since that time erosion above the highway bridge has removed patches of pickleweed and lowered the surface to form mudflats, now covered with *Enteromorpha* and *Gracilaria.* This mudflat area is being extended by undercutting at the edges of the channel. Undercutting and slumping can be seen along the edges of the lower part of the slough, exposing banks honeycombed with crab *(Pachygrapsus)* burrows.

On the other hand, local residents say that because of the 1946 cut through the dunes, and the associated increase in tidal range, pickleweed grows farther inland, having replaced willows in spots along the north side of the slough; that the many small stream courses which meander over the surface of the salt marsh have all been deepened; and that at high tide saltwater flows farther up the arroyos in the low hills north of the slough, spoiling the grazing and necessitating increased diking.

There has been a marked redistribution of plant life near the old mouth of Elkhorn Slough. *Enteromorpha intestinalis,* for example, which formerly grew there, has now filled in the mudflats behind the harbor entrace, while pickleweed grows behind the dunes in the slough mouth.

Behind the dunes at Salinas River State Park, the flatland is covered with native vegetation—but it consists, surprisingly of marsh plants such as salt grass, pickleweed, spear salt bush, and coastal gumplant. Surprisingly, because this land having been the bed of the Salinas River, one would expect a freshwater vegetation. However, since 1908, this whole stretch has been under tidal influence; at high tide saltwater moves up the channel from Moss Landing Harbor to the north. Thus, although these salt marsh species are natives they do not make up the original plant cover here.

In 1932, a tide gate was constructed in Moro Cojo Slough:

> Moro Cojo Slough has been equipped with some form of tide-gate structure since the early years of the Twentieth Century. ... for various reasons ... these gates were more or less ineffective in preventing saltwater action and some tidal fluctuation until 1932, when gates were installed at State Highway No. 1 crossing near Moss Landing. (*Senate Document* No. 50, 1946, p. 22.)

When Moro Cojo and Elkhorn Sloughs were connected by the lower course of the Salinas River, and subject at least seasonally to tidal influence, their mollusk faunas were similar. But since 1932, little seawater

has been able to enter Moro Cojo Slough. Its water is now brackish (with a salt content of about 4 parts per 1000, as compared to seawater which has 34 parts per 1000). The only living mollusk common in the Moro Cojo today is the very small snail, *Assiminea transluscens* (identification, Dustin Chivers). Specimens collected in the vicinity of the Kaiser plant are so coated with some foreign material (a magnesium compound?) that they look more like nodules than shells. The decaying shells of the white sand clam cover the bottom in the shallow water of the lower Moro Cojo Slough, near the tide gate by Highway 1. A few hundred meters eastward, a heap of soil dug from a ditch near the Slough was found to contain shells of dead mollusks, including many bay mussels and many Pacific littleneck clams, as well as bent-nosed clam, Washington clam, and soft-shell clam. The materials in the heap cannot have been very old; the soft-shell clam was introduced here only within the last century. The installation of the tide gate plainly changed the entire character of the molluskan fauna of the Moro Cojo; all five mollusks now live in Elkhorn Slough. Probably further dredging in Moro Cojo would turn up dead specimens of most other mollusks common in Elkhorn Slough.

D. ALTERED LITTORAL DRIFT AND THE MONTEREY BAY SAND BUDGET

Beaches, already a major economic resource of the Monterey Bay area, will become increasingly valuable in the future. Below are some general remarks on the natural conditions of sand supply and the effects upon them of man-made physiographic alterations.

Littoral drift refers to the net movement of sand parallel to the shoreline during any given period. Because the prevailing winds along the California coast are from the northwest, most ocean waves arrive from a northwesterly direction. Accordingly, the predominant movement of sand is southward, or down coast.

Over a long period of time Monterey Bay has acted as a great trap for sand moved southward along the coast by littoral drift. This is because of the configuration of the southern half of the bay, with Monterey Peninsula jutting sharply northward. Losses of sand out of the bay around Point Pinos appear to be negligible.

The Monterey Bay submarine canyon is a major depository for sand moving into the bay. Not only for sand moving down coast: westerly and southwesterly waves approaching the shore in winter produce an

upcoast movement in the southern half of the bay, and the sand is lost into the submarine canyon (Wong, 1970, p. 37).

Although sand moves into the Monterey Bay from the north, local streams supply most of the sand kept in motion by littoral drift along the bay's shoreline: The largest streams entering the bay are the Salinas, Pajaro, and San Lorenzo Rivers. All deposit quantities of sediment in the surf zone, part of which accumulates in beaches. The Salinas River is the largest of the three, its flow averaging three times that of the Pajaro; the San Lorenzo is the smallest. Next to streams, erosion of coastal cliffs yields the principal supply of sediment (Wong, 1970, p. 39).

Probably the greatest single man-made change in natural littoral sand movement began after 1908, when the Salinas River was prevented from returning to its old effluent, north of Moss Landing. Before 1908, the sediment carried by the Salinas was deposited in the northern half of the bay; since that time it has been deposited in the southern half. Although littoral drift can move some sand past the head of Monterey submarine canyon (Yancey, 1968, p. 23), it is likely that the canyon now divides the bay into two rather distinct sand provinces. Thus, the supply of sand to the northern part of the bay has been reduced and the supply to the southern part increased.

Between Moss Landing and the present mouth of the Salinas there is a slight seaward bow in the shoreline, marking the above-mentioned offshore fan-shaped lens (see U.S.C. and G. Charts 5402 and 5403). There is no corresponding bow to the north of Moss Landing, around the pre-1908 mouth of the Salinas—very likely because much of the material deposited upcoast from the submarine canyon was soon transported southward by littoral drift into the canyon itself. On the other hand, emptying south of the canyon as it now does, the river appears to be feeding sediment to the lens. In a study of shoreline made through comparison of historical maps, the U.S. Army Corps of Engineers concluded that:

> From the ... Monterey Submarine Canyon south to the vicinity of the mouth of the Salinas River, the offshore area shoaled.... The most extensive seaward advance of the shoreline during the period of record occurred at the mouth of the Salinas River. (*House Document No. 179,* 1958, pp. 61 and 68.)

The building of the jetties at the Elkhorn Slough-Moss Landing Harbor entrance has probably had the effect of deflecting sand more strongly into the head of the submarine canyon. A study made of the effects of the

jetties' construction on littoral drift over an eight-month period in 1946-47, predicted that a sand bar would develop between the jetties (Bascom, 1947, pp. 1-3), similar to the one that seasonally blocks the entrance to Santa Cruz Small Craft Harbor. However, at Moss Landing it appears that a larger portion of the drift sand than anticipated falls into one feeder branch of the submarine canyon which extends shoreward toward a point between the jetties. Some of the dredging to keep the harbor entrance clear is necessary, not to remove actual littoral deposit, but rather to remove sand which has been blown from beach and dunes adjoining the jetties and settled in inland parts of the entrance.

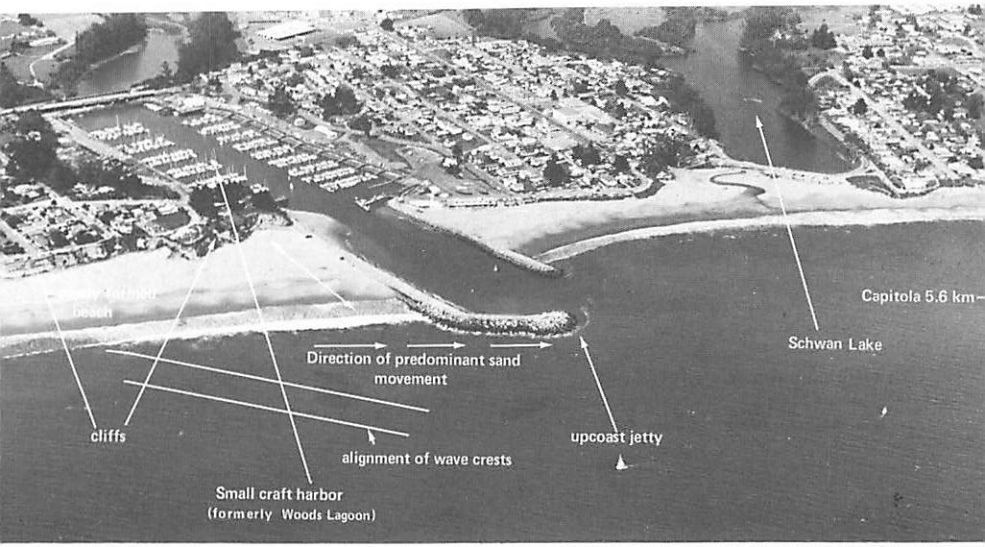
In the late 19th and early 20th centuries, agricultural activities like clearing, grazing, and ploughing increased erosion throughout the area, with a corresponding increase in stream loads. But this was soon counterbalanced by the damming of streams. The reduction of beach sand supply as a result of damming is likely to become increasingly critical for the Monterey Bay area, since streams are the largest source of sand. For example, the building of the Salinas Dam and Reservoir in 1941, the Nacimiento Dam in 1957, and the San Antonio Dam in 1965, have reduced the Salinas River's sediment load. Other dams are being planned.

Cliff erosion has been severe in the northern part of the bay, for instance, between Capitola and Santa Cruz, and on westward along West Cliff Drive. There riprap has been dumped along the bases of the cliffs, reducing the rate of erosion, but at the same time reducing the amount of sand supplied to the beaches.

At both Santa Cruz Small Craft Harbor and at Moss Landing, dredge spoil taken from between the jetties has been distributed elsewhere. The spoil from Santa Cruz Small Craft Harbor has been pumped onto the beach immediately southward. At Moss Landing, dredge spoil has been transported from between the jetties and distributed in the vicinity of Moss Landing pier.

The effects of the old iron-sand workings near Aptos at Rob Roy were probably small, at least in terms of volume of sand displaced but the evidence has been obscured by real estate development. Other real estate projects, like Rio del Mar have disturbed sand and influenced its movement along the shore. At Pajaro Dunes, particularly, large amounts of sand have recently been scooped from the mouth of the Pajaro River and piled up as foundation for a housing development.

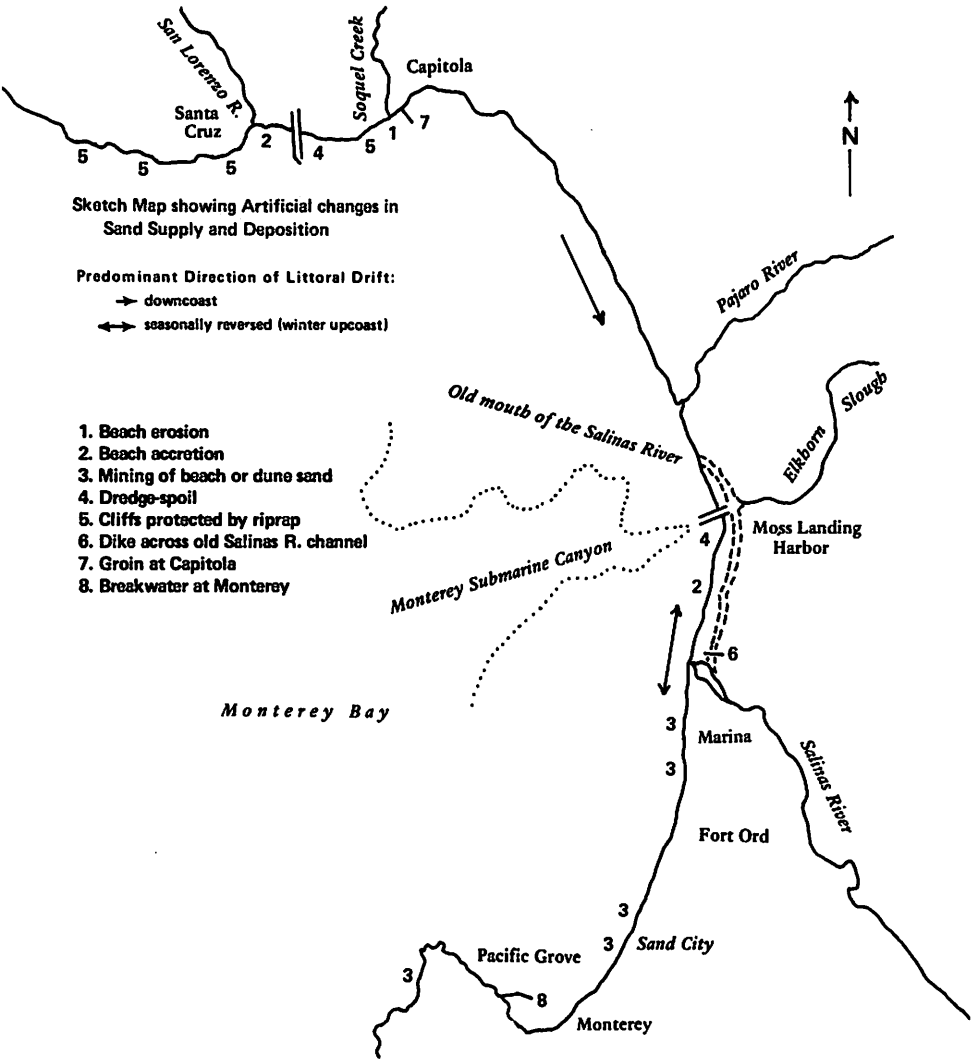
Road-surfacing and building materials are being quarried on the Pajaro River, near Aromas. Tailings dumped into the river have thoroughly changed its sediment-transport regimen.

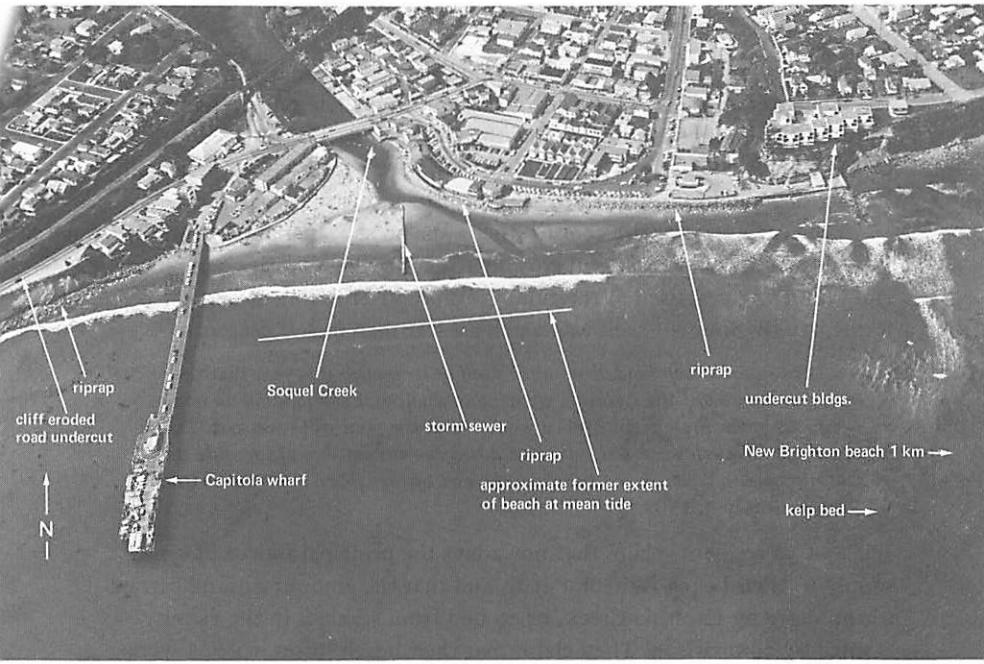


Ebbtide shoreline at Santa Cruz Small Craft Harbor on April 11, 1968, showing the cliffs along East Cliff Drive protected from wave-erosion by a broad, newly-formed beach. (Photo, B. Gordon and D. Hawley).

(1) Santa Cruz Small Craft Harbor and the Depletion of Capitola Beach

Following a feasibility study made by the U.S. Army Corps of Engineers, the Santa Cruz Small Craft Harbor was completed in 1963. Although the preliminary study did not indicate strong littoral drift, it was hoped that the jetty protecting the west side of the harbor entrance would trap enough downcoast drift to extend the beach west of the entrance, thus causing the waves to break well away from the cliffs which were subject there to wave erosion. The desired effect was attained: a fine broad beach, at times as much as 180 m (200 yards) in width, developed west of the harbor; purple-flowered ice plant now grows down the face of the cliffs. However, in the fall of 1964, the year after the harbor was completed, Capitola, about 5.6 km (3.5 miles) to the east, began losing its beach. Such a loss is normal during the winter but the beach did not return the following summer. Waves began to undercut the foundations of buildings behind the beach and a storm sewer was exposed by removal of beach sand. Riprap was placed along the cliff at the west end of the beach to protect it from wave erosion. Between


San Lorenzo R.
Santa Cruz
Soquel Creek
Capitola
5
5
5
2
4
5
1
7
N
Sketch Map showing Artificial changes in Sand Supply and Deposition
Predominant Direction of Littoral Drift:
downcoast
seasonally reversed (winter upcoast)
1. Beach erosion
2. Beach accretion
3. Mining of beach or dune sand
4. Dredge-spoil
5. Cliffs protected by riprap
6. Dike across old Salinas R. channel
7. Groin at Capitola
8. Breakwater at Monterey
Pajaro River
Old mouth of the Salinas River
Elkhorn Slough
Moss Landing Harbor
Monterey Submarine Canyon
Monterey Bay
Marina
Salinas River
Fort Ord
Sand City
Pacific Grove
Monterey



Ebbtide shoreline at Capitola on April 11, 1968, showing eroded beach, exposed storm sewer, and riprap placed to prevent waves from undercutting cliffs, roadway, and buildings. (Photo, B. Gordon and D. Hawley)

Capitola groin in April, 1971 (completed in July, 1970). Capitola beach is replenished by littoral drift trapped on the upcoast side of the groin. (Photo, U.S. Army Corps of Engineers)

Santa Cruz Small Craft Harbor and Capitola, part of the beach at 26th Avenue also disappeared, and cliffs in the intermediate stretch had to be protected from increased erosion with riprap.

Capitola is one of the state's oldest seaside resort towns, economically heavily dependent upon the attractions of its beach for vacationers.

In the early part of the century there was no shortage of sand supply. Probably because of increased erosion attending the intensive agriculture and lumbering practised at the time the amount of sediment deposited in the bay by Soquel Creek was much greater than it is at present:

> *The Soquel Creek landed so much sand at its mouth* this year that the water at the end of the Capitola wharf is so shallow *that a landing on boats is impossible* at present, but it is probable that the sand will wash out. *Two years ago so much sand and soil came down the stream that at low tide it was possible to walk on the beach to the end of the wharf. (The Santa Cruz Surf,* February 4, 1909.)

Capitola residents claim that nowadays the principal source of sand supply to their beach is littoral drift, and that the amount of sand carried to the shore by Capitola Creek, or eroded from seacliffs in the vicinity, is small by comparison. They claim that their beach losses in 1964 were a consequence of the erection of the jetties at Santa Cruz Small Craft Harbor, and blame the U.S. Army Corps of Engineers for deciding mistakenly that there was too little littoral movement of sand at the Santa Cruz Small Craft Harbor to justify a sand bypass across the entrance. (A sand bypass is a continuous dredging operation which would supply sand continuously to the downcoast side of the harbor entrance where it could be carried on down the coast by littoral drift.)

In 1966, the city of Capitola even trucked in sand to replenish its beach, at considerable expense; but the sand was quickly swept away. As a solution to the problem Capitola has built a groin of its own to trap littoral drift. (Will this affect New Brighton Beach, the next large beach downcoast?) *House Document No. 179,* 1958, evaluates earlier shoreline changes in this vicinity.

(2) Sand Mining

Within the bay sand mining is concentrated in two stretches of shoreline in the southeast, one near Marina and the other near Sand City. A third area is along the western shore of Monterey Peninsula (Hart, 1966, pp. 84-92).

From the dunes at Lapis Siding (near Marina), sand is pumped in suspension to a processing plant, in a year-round operation. During the winter season when the grains are largest, hence more desirable commercially, sand is collected from the surf zone. Large water-filled pits mark the source of the mined dune and beach sand.

Sand-mining operation near Marina. (Photo, J. Christenson and D. Hawley)

Around Sand City dune landscape has been greatly altered by sand mining operations. Aside from the open pits and an area of shifting dune, disturbance is small-scale around Marina. On the other hand, on Monterey Peninsula, several hundred acres of beautiful white dunes and a large part of their associated biota have been eliminated. And there the dune and beach sand resources can be considered "essentially non-renewable, sand replenishment by wave and wind action being much less than the excavation rate." (Hart, 1966, p. 91.)

Within the bay, the coarsest dune sand appears to be in the vicinity of Fort Ord, grain size diminishing both to the north and south. Were its extent not restricted by Fort Ord, sand mining would likely be practised along the whole stretch of shoreline from Marina to Sand City.

According to local sand mine operators the shoreline near Sand City has moved landward in recent years, and the average sand grain size has been reduced. One estimate puts the shoreline back 53 m (175 feet) in the last 20 years. Some attribute these changes to effects of the building of Santa Cruz Small Craft Harbor. This seems rather unlikely because the harbor is separated from this part of the bay by the submarine canyon. The following report was written in 1966: "The Beach Erosion Board, U.S. Army Corps of Engineers, *considers shore erosion in the Fort Ord vicinity to be severe* and currently is studying the situation to determine the causes of erosion." (Jack Stirton, cited in Hart, 1966, p. 86.) This erosion of shoreline has apparently taken place despite the increased supply of sand provided by the Salinas after 1908. Sand mining at Lapis began about this time—in 1906. Perhaps sand mining operations themselves account for some landward movement of shoreline. Or perhaps it is the result of Monterey Harbor alterations. The mining of sand from higher parts of the dunes may have little effect on beach equilibrium, but the effects of dredging the surf zone, even taking relatively small amounts of sand, could be considerable. The stripping of the coarser sand from the surf zone probably influences sand grain size on neighboring beaches, too.

Obviously a sand budget is needed for the embayment as a whole.

(3) Littoral Drift, Artificial Reefs, and Planning in the Offshore Zone

That sand accumulations form a special habitat is well known—the fact is even proclaimed in the common names of several species, sanderling, sandpiper, sanddab, sand dollar, sand crab, etc. When artificial changes cause the erosion or accretion of beaches this characteristic sand fauna is redistributed, too. Artificial changes in littoral drift may redistribute offshore kelp beds, as well: kelp is only found where rock is exposed for its holdfasts; if these rocky surfaces are buried in sand, the kelp beds soon disappear, and their large associated fauna disappears also.

The effects of artificial reefs on the ecology of sandy areas offshore have been studied along the coast of southern California (Carlisle, *et al*, 1964); the results may be significant for planning in the Monterey Bay area.

These studies were primarily concerned with the improvement of sport fishing in the coastal waters. Sites for artificial reefs were selected in flat sandy areas where fishing for kelp bass, sand bass, and sheephead

(sport fish species which favor rocky areas and kelp beds) is generally poor. There are broad expanses of such bottom in Monterey Bay, e.g., offshore from the Salinas River mouth and Fort Ord. In southern California, the reefs were placed at depths of not more than 15 to 18 m (50 to 60 feet) (kelp does not flourish at greater depths) yet deep enough that they posed no hazard for navigation. Naturally-seeded giant kelp beds became established within a few months after the reefs were placed and marine life, including fish populations in the vicinity of the reefs, built up rapidly. There can be no doubt that kelp beds provide a new habitat, rich in more than fish species alone: "A separate sublittoral faunal group [in Monterey Bay] is *the giant kelp assemblage which includes about one hundred and forty five mollusks and one brachiopod.*" (Smith and Gordon, 1948, p. 154.)

Although reefs built of old cars quickly attracted fish and produced kelp in the southern California study area, the car bodies disintegrated into low mounds of rubble within three or four years, at which time kelp and fish life again diminished. (Furthermore, although no chemical studies were made, chemical alterations of the seawater, which very likely accompanies disintegration of the cars, may well have harmful effects as yet undescribed. It appears that artificial reefs will not make suitable graveyards for the unwanted bodies of our old cars.)

Quarry rock turned out to be the best (though most expensive) material for the construction of durable reefs. Properly located, such artificial reefs might be of considerable value for dissipating wave action and reducing erosion, as well as for maintaining a varied littoral flora and fauna.

E. MOSS LANDING SALT PONDS

Salt is manufactured on the Elkhorn Slough at Moss Landing by the Monterey Bay Salt Company. The special physical conditions necessary for commercial production of salt from ponds, namely, a tidal flat which is protected from the surf and underlain by a relatively impermeable layer, and which is not subject to flooding by fresh water, are not common along the coast. Two of these three conditions are now to be found in Elkhorn Slough but before the 1908 displacement of the Salinas River mouth the slough was frequently flooded with fresh water, precluding a successful salt industry. Commercial salt production on the slough began in 1916, that is well after the displacement of the River mouth.

The property of the Monterey Bay Salt Company consists of approximately 324 hectares (800 acres), some 162 of which are used in the production of salt. About 3 hectares are in rectangular crystallizing ponds, ranging in size between 0.2 and 0.4 hectares (0.5 and 1 acre). "Seawater pumped from Elkhorn Slough circulates through the concentrating pond system and returns as pickle saturated with sodium chloride in the vicinity of the crystallizing ponds...." (Ver Planck, 1968, pp. 68, 71). The whole cycle requires several years for completion.

The various colors in the ponds depict an ecological succession: as the salinity of the ponds increases, they are inhabited by different species of blue-green algae, the metabolic products of which color the water (Carpelan, 1957). The colors are most intense, and their range is greatest, in the fall. When harvested, the salt crystals are washed to remove a red covering produced by dinoflagellates concentrated in the ponds. Most of the mollusks of adjacent tidal flats are absent from the ponds, probably because their waters are too saline for these animals.

On the other hand, the ponds swarm with brine shrimp, not common in the neighboring slough. Phalaropes feed heavily on these shrimp and the ponds have become important to other estuarine birds, as well.

Salt has long been manufactured in this area. Indeed, the name of the Salinas River is derived from *salinas*, the Spanish word for salt ponds. However, the original salt manufacturing sites, which gave the river its name, were located somewhat farther south, probably near Marina. In Spanish times salt was brought from:

> ... the Salinas lagoons, or salt ponds, situated between the ocean sand dunes and the Monterey River ['Monterey' is one of several names applied to the Salinas River in the days before salt manufacturing began here] .... The commander of the guard [at Monterey Presidio] would bring Indians from Soledad and Carmelo and gathering all the salt from *the three lagoons* into one pile, covered it with sticks and branches, to which they set fire, so as to melt over the surface and form a crust over the mass, which would protect it from the dampness.... (Bancroft, 1888, p. 486.)

The "three lagoons" used as *salinas* were probably located at Marina, where several low, very saline ponds still exist just behind the dunes, or near the present mouth of the Salinas where, despite scouring by the river, physiographic evidence indicates former presence of similar ponds.

Chapter 7

CUSTODIAL PLANNING FOR THE MONTEREY BAY AREA: BIOTA AND LAND USE

A. RECENTLY PROLIFIC SPECIES AND THE CULTURAL LANDSCAPE

THE REMARKS made earlier on faunal change and animal numbers are barely an introduction to a large, poorly documented but important subject. Many species and much complicated biogeographical detail are involved even in the relatively small Monterey Bay area. There exist few censuses for the area, except those made by the Department of Fish and Game and the Audubon Society. The need for such information becomes ever more obvious.

The ecological effects of industrial people are now felt on a global scale and virtually all species are affected. People will have to take responsibility for the condition of many species, both those with increasing and those with decreasing populations—a responsibility that will entail more than mere "game laws" and "wilderness areas." In fact conservational responsibility may ultimately require a global inventory and the apportionment of biomass and range, species by species.

In few cases can the present distributions of species native to the Monterey Bay area be explained in terms of climatic and edaphic factors alone. Ranges and population numbers are mainly an expression of historical land use. The majority of the plant, and many of the animal, species living in rural-urban biocommunities are adventive immigrants, long since adapted to human presence. Native species, too, have adjusted to human activities.

This adjustment of plants and animals to human presence is an important evolutionary factor, determining as it must the biota of the future. Several recent books list endangered species (e.g., J. Fisher, *et al*, 1969)—that is, animals unable to make such adjustment. For planning, a complementary book is needed listing those species which have adapted most successfully. (The foregoing pages have attempted such a list for the Monterey Bay area alone.)

Despite its importance for practical ecological planning, no theoretical statement has been published describing an optimum balance in numbers for species resident in the Monterey Bay area. Nor do such statements appear for comparable areas. Although there is an important literature on "wildlife management" only the most general of statements are available on what constitutes balanced animal populations. Except for models so abstract that they have little value for planning purposes, writings on the subject appear to be confined to determining suitable populations of game animals. True, there has been much argument over the meaning, and even the value, of the term "balance of nature" (Ehrlich and Birch, 1967, p. 106). Much of this disagreement stems from misunderstandings over the time intervals under consideration. Granted all environments and populations are subject to constant change in the long-term, and even to drastic short-term fluctuations. Nevertheless, most studies evidence a natural balance in the sense of "... the persistence of ecological systems as a result of their tendency to compensate for perturbations." (Slobodkin, *et al*, 1967, p. 119.) Examples of such persistence and compensation, acting at least over the time spans involved in the history and plannable future of the Monterey Bay area, may be found in the natural plant associations.

In rural and urban surroundings human custom is the controlling factor. Within broad environmental limits, cultural practises (land use, food habits, pest control methods, quarantine procedures, game laws, etc.) will determine which species are present and control their fluctuations in number. Here one can speak of no natural balance. Species content and numerical ratios in these surroundings will increasingly be a response to optional human actions, planned or unplanned. A mosaic of natural plant communities scattered throughout the area will be invaluable as a reference base in decision making.

B. DEPLETED AREAS AND THEIR REPLENISHMENT

Doubtless the establishment of "wilderness areas" has been a great step forward in the conservation movement. For example, Los Padres National Forest, just to the south of the Monterey Bay area, was converted into the Ventana Wilderness Area in 1969. But future wilderness areas should include more than broad expanses of coniferous forest in rough, high country, ecologically neither the most complex of plant associations nor in the most danger of extermination. Most of the

public parks of the area are located in such vegetation—with the notable exceptions of Toro Regional Park and Royal Oaks County Park. The wilderness area idea should be extended to include many small tracts of various natural plant formations—riparian forest, oak woodland, coniferous forest, chaparral, freshwater marsh, etc. Remnants of these original formations should be located and extended in a patchwork of whichever patterns best fit the terrain. Such tracts, scattered over their natural areas of growth throughout the cultural landscape, would serve as seedbeds for redirecting ecological change and as habitats for native animal species. They would, in a sense, be living historical records and invaluable as controls in studying changing land use. The ribbons of ecotone vegetation at their edges would be greatly elongated by such a distribution of plant cover; and since the ecotone is the site of greatest successional potential, rapid changes in plant cover would be facilitated as later needs arose. Studies elsewhere have shown that the population density of most nesting birds "... varies as a direct function of the *amount of edge per unit area.*" (Beecher, 1942, p. 39), and increases with the diversity of the plant cover. General observations suggest that the same relationship holds in the Monterey Bay area and that it applies as well to various animals other than birds. Within the overall mosaic of plant cover, the animal species present will change sequentially as successional phases trend toward climax.

Considering the Monterey Bay area as a whole, the comprehensive management of vegetation has an unrealized potential for regulating terrestrial animal numbers, plant cover's being the basic "biological control." Although the greatest present need is for what might be called "wilderness renewal districts" and for replanting programs, there will continue to be a need for selective clearing as well—and for the use, under appropriate weather conditions, of low-intensity fires. Where woody cover is heavy enough to supply valuable fuels, mechanical methods of clearing may be used, followed on some sites—depending upon the kind of succession desired—by the controlled burning of slash.

As mentioned earlier, maximum diversity in plant cover will be favored by maintaining existing areas of natural vegetation, by allowing natural successional trends to proceed unchecked on a variety of available sites, by partially replanting tracts from which natural associations have been long cleared, and by keeping all possible phases of plant succession in existence simultaneously through selectively disturbing localized portions of climax vegetation. These conditions are prerequisites for a varied and balanced fauna.

Several parts of the Monterey Bay area come to mind as being in need both of replanting programs and of protected tracts in which successional trends may proceed without interruption.

The coastal area along the present route of Highway 1, northward from Santa Cruz past Davenport and Año Nuevo, has been deservedly much acclaimed for its beauty. As the population is small, it is sometimes even pointed to, mistakenly, as a remnant of untrammeled California nature. But, as noted earlier, natural plant associations have long since been largely eliminated there. Foreign annuals grow along the road and dominate neighboring pastures. The area could be made even more attractive than it is at present, and much more varied, by reviving tracts of the natural vegetation.

Another promising area for revegetation is the surface of the Aromas Red Sands, lying between Moro Cojo Slough and the Pajaro Valley and including much of the Prunedale and Hall districts. Although this land has long been used agriculturally, especially during the depression of the 1930's, its soils are not very fertile. Numerous patches of oak woodland still exist on the upper slopes; in fact since agricultural use has lessened, many new oak stands have appeared and more can be easily generated. A fine example of oak woodland can be seen in the recently established Royal Oaks Park.

Oak woodland makes an attractive setting for homesites. Surfaces in the Aromas Red Sands area are mainly sloping, the soils are well-drained, and the land is some of the least expensive in the bay area. Certainly it is more reasonable to build homes here than on the productive alluvium of the Pajaro and Salinas Valleys. With appropriate care of the plant cover in this area, an actual increase in wildlife can accompany increased human settlement.

A third area, the lower Salinas Valley, is particularly in need of a renewal program. Drainage, field levelling, and other operations for the purposes of commercial agriculture have largely eliminated the native plant cover; for example, the floodplain marshes, oak woodland, and parts of the riparian forest.

Although it is economically impractical to use large parcels of prime agricultural land for the growth of native plants, many tracts scattered throughout the rural area are available. These include the following lands which are publicly owned, or in which the public has a stake:

Parts of the lands supervised by the Bureau of Land Management should be made available for such use. For example, the Bureau's map

of the Monterey Planning Unit (dated April 1, 1973) shows tracts of "vacant public domain" in the foothills both on the east and west sides of the Chualar-Gonzales stretch of the Salinas Valley.

Within the network of state and county roads there are many small patches of roadside, median, and roadcut well-suited for replanting efforts.

The beds and banks of the lower courses of the Salinas and Pajaro Rivers are privately owned but have long been maintained by the local counties and the U.S. Army Corps of Engineers; the artificial levees along the streams were built with public funds.

Because of clearing operations and tillage, riparian forest in the lower Salinas and Pajaro Valleys is now confined to narrow strips along the river banks, where the principal tree growth is made up of sandbar willow, arroyo willow, Fremont cottonwood, box elder, sycamore, and blue elderberry. Under undisturbed conditions, the forest would be more extensive and varied than now. But hydrologic circumstances here have been thoroughly altered. Since the time when flood control dams were built in the upper Salinas Valley, water has been payed into the river channel more evenly throughout the year than previously. Thus, the bed does not dry so completely in summer as it once did. With this regulation of water supply, conditions for creating and maintaining a complex riparian forest may actually have been improved. Stretches of this riparian land can be made into valuable educational parks. Roads along the level tops of the artificial levees are ideal for bicycling and well suited for use by conducted excursions of school children.

With increased popular interest, various tracts of privately owned land might also become available for planning an improved plant cover:

Golf courses cover a large area. Portions of the courses can easily be developed to function also as parks and arboretums. Where possible, native vegetation should be used in landscaping unused grounds. This is not to say that alien ornamentals should be excluded, but surviving native plants should be preserved and, wherever practicable, more planted.

Cemetery owners can probably be interested in developing burial grounds with the preservation of plant and bird life in mind. To many, this use will seem appropriate for purely sentimental reasons. Devoting productive land to cemeteries and golf courses will be increasingly criticized in the future unless such multiple uses are found. Several cemeteries in the area are already favorite sites for bird watchers.

Railroad rights-of-way are almost unused for planting nowadays. At one time the Southern Pacific Railway Company had a program which included seeding the tracksides with poppies and lupines. But interest in such beautification has waned for the time being. Today roadside vegetation is often killed with sprays.

Tailing heaps and old mine pits do not cover a large part of the area but such barren and constantly growing surfaces are a real challenge for reclamation by plants. Some of the most conspicuous are those of Kaiser Refractories at Natividad and Moss Landing. The quarrying scars made by the Davenport Cement Company in the Santa Cruz Mountains are more extensive, but are better hidden, being generally surrounded by well-wooded slopes. Parts of the sand-mining properties in coastal dunes along the southern part of the bay are also in need of revegetation. One of the plants which may have promise in replanting dunes is a prostrate variety of the coyote bush, native on the dunes at Año Nuevo and northward along Highway 1. Perhaps this especially attractive form can be established in other dune areas. It is already used horticulturally in the southern part of the state.

In hilly country near the coast, gullies and erosion scars have sometimes been planted to coyote bush in their drier, upper courses; and to willows in their lower, wetter parts. (The WPA made such use of these plants.) Woody vegetation should be encouraged on such sites and generally all slopes too steep to withstand grazing, kept well-wooded.

Because of the cover and food they provide, fence rows, hedges, and windbreaks are potentially important in the regulation of animal numbers, particularly in areas where the original vegetation has been cleared. In parts of the eastern United States, the importance of contour hedges to agriculture and wildlife management is well recognized. The multiflora rose and Osage orange have been widely planted as hedge. In Britain, where they have been maintained for centuries, hedges have developed a distinctive and stable animal community. Hedges and fence rows might well be a beneficial addition in the Monterey Bay area, replacing, where practical, barbwire fences.

Hedges and fence rows made up of small trees and shrubs are especially attractive to wildlife, because cover is most effective where it is close to the ground (Pedrides, 1942, p. 279). Existing windbreaks consisting of tall eucalyptus and cypress trees will support more animal life if an understory can be added, preferably made up of native shrubs. The following are good prospects for hedge and fence row plants because

their fruits are eaten by both mammals and birds: The islay prune besides being an uncommonly attractive plant will grow on a variety of terrains—as a shrub on thinner soils and as a small tree on more fertile sites. The toyon, usually seen as a shrub, may, like the islay prune, grow to tree size, thriving on both dry ridges and stream banks. The blue elderberry has a wide distribution. Although especially common along streams and roadsides, it is also found on hilltops, for example, on Fremont Peak—where its seeds were no doubt carried by birds. The coffee berry and red berry are two attractive, closely-related, easily-planted shrubs. The red berry is better suited to drier parts of the area. Western creek dogwood will likely prove especially valuable on moister soils. Because their fruits are eaten and their seeds disseminated by birds, poison oak and California blackberry will appear spontaneously in many hedge sites.

A few patches of freshwater marsh still survive because draining them has been impractical; for instance, parts of Harkins and Struve Slough near Watsonville, and several of the old lake beds between Castroville and Salinas—where the banks of numerous drainage ditches extend this type of habitat. Rebuilding patches of marsh vegetation on such sites will be of great importance to wildlife.

Ideally residents and gardeners will know both the successional trends and potential natural vegetation of the properties they care for. Using this information, and principles and methods such as those stated by Ian McHarg in his *Design with Nature*, landscape architects can gradually shape residential surroundings which are distinctively Californian—outlined by the forms of native trees and shrubs which authentically express the area's varied natural growth potentials: coast live oak, sycamore, bay, digger pine, black oak, madrone, tanbark oak, etc., each growing within its appropriate environment and having its own distinctive configuration may partly replace the collage of exotic tree species now favored in residential areas.

Native plants, adapted as they are to local environment and reproducing themselves untended, can often be maintained at less expense than can aliens (for example, without costly summer irrigation). Thus, the horticulturist will use the total growth potential of the area to economic advantage by allowing the forces of nature to operate for him—practising wherever possible an accommodating action within the natural plant cover, rather than destructive action against it.

By regulating successional development on his property and, in places, reconstructing the climax vegetation natural to his area, the resident will at the same time encourage reestablishment of the original fauna. To name only a few examples, the acorn woodpecker will reappear with the regrowth of oak woodland, the yellow warbler with strips of riparian forest, wren tits with chaparral, the pygmy nuthatch in closed-cone pine forest, winter wrens in dense redwood groves, etc. The replanting of oak woodland and riparian forest will be especially important to bird life in the Monterey Bay area because these are the plant associations which are richest in numbers of bird species (Miller, 1951, p. 554), and at the same time those that have suffered most from clearing operations.

Chapter 8

CONCLUDING REMARKS

IN THE SETTLEMENT of the Monterey Bay area, peoples of contrasting cultures with varying levels of technology have modified the natural setting and affected the biota differently. Imprints of early changes are still discernible in the countryside. They have been inspected as evidence, as have historical records, in order to illustrate such interrelationships between man and nature, culture and landscape.

My reason for describing these differences in custom and subsistence is not solely to judge their relative merits for purposes of benefitting environmental quality, but also to emphasize that styles of land use, food habits, economic goals, aesthetic preferences and the like (each with its potential ecological effects) differ according to tradition among peoples who have used the California coastlands. Such traits are optional cultural expressions. They stem from personal choices which have been made at various times and places and which have been established in folk custom by consensus. Although one hears much about irresistible socio-economic forces, no good reasons appear for supposing that the Monterey Bay area's future character is prescribed by a specific 'natural and inevitable economic development'—for example, by a development under which all resources, including the biota, must be expendable.

Land use options abound. Some lead to biotic enrichment and diversification. In the long run, these will likely be the soundest economically. As knowledge of past relationships between people and nature in the area improves, retrospect will become increasingly useful in planning.

COMMON AND SCIENTIFIC NAMES FOR ANIMALS

MOLLUSKS

Basket cockle	*Clinocardium nutalli*
Bay mussel	*Mytilus edulis*
Bent-nosed clam	*Macoma nasuta*
Black abalone	*Haliotis cracherodii*
Black dog whelk	*Hyanassa obsoleta*
Black turban	*Tegula funebralis*
Blue top shell	*Calliostoma ligatum*
Brown garden snail	*Helix aspersa*
California oyster	*Ostrea lurida*
Cockle	*Cardium*
Eastern oyster	*Crassostrea virginica*
Gaper (horse) clam	*Tresus nutalli*
Gumboot chiton	*Cryptochiton stelleri*
Jackknife clam	*Stolen sicarius*
Japanese horn snail	*Batillaria zonalis*
Japanese littleneck clam	*Protothaca semidecussata*
Japanese (Pacific) oyster	*Crassostrea gigas*
Littleneck clam	*Protothaca staminea*
Mexican oyster	*Ostrea irridescens*
Mossy chiton	*Mopalia muscosa*
Olympia oyster	*Ostrea lurida*
Oyster drill	*Urosalpinx cinereus*
Pacific littleneck clam (Rock cockle)	*Protothaca staminea*
Pismo clam	*Tivela stultorum*
Purple-hinged scallop	*Hinnites giganteus*
Red abalone	*Haliotis rufescens*
Red turban	*Astraea gibberosa*
Ribbed horsemussel	*Volsella demissa*
Sea hare	*Aplysia californica*
Sea mussel	*Mytilus californianus*
Shell limpet	*Acmaea pelta*
Shipworm (teredo)	*Teredo navalis*
Slipper shell	*Crepidula adunca*

Soft-shell (mud) clam	*Mya arenaria*
Washington clam	*Saxidomus nuttalli*
White sand clam	*Macoma secta*

INSECTS

American cockroach	*Periplaneta americana*
Argentine ant	*Iridomyrmex humilis*
Artichoke plume moth	*Platyptilia carduidactyla*
Asiatic (black) cockroach	*Blatta orientalis*
Australian cockroach	*Periplaneta australasiae*
Bedbug	*Cimex lectularius*
Black scale	*Saissetia oleae*
Body louse	*Pediculus corporis*
Brown powder post beetle	*Lyctus brunneus*
Cabbage butterfly	*Pieris rapae*
Citrophilus mealybug	*Pseudococcus gahani*
Citrus mealybug	*Pseudococcus citri*
Coddling moth	*Carpocapsa pomonella*
Corn earworm	*Heliothis zea*
Cottony cushion scale	*Icerya purchasi*
Crab louse	*Phthirius pubis*
European earwig	*Forficula auricularia*
European lyctus	*Lyctus linearis*
German (common) cockroach	*Blattella germanica*
Green apple aphis	*Aphis pomi*
Ground squirrel flea	*Ceratophyllus acutus*
Head louse	*Pediculus capitis*
Hen louse	*Menopon gallinae*
Honeybee	*Apis mellifica*
Horse bot fly	*Gastrophilus intestinalis*
Housefly	*Musca domestica*
Human flea	*Pulex irritans*
Ladybird (vedalia)	*Rodolia cardinalis*
Lesser housefly	*Fannia canicularis*
Mediterranean flour moth	*Ephestia kuehniella*
Monarch butterfly	*Danaus plexippus*
Monterey pine scale	*Physokermes insignicola*

Mourning cloak butterfly	*Aglais antiopa*
Oak moth	*Phryganidia californica*
Oystershell scale	*Lepidosaphes ulmi*
Pear slug	*Caliora cerasi*
Plume moth	*Platyptilia carduidactyla*
San Jose scale	*Aspidiotus perniciousus*
Sulphur (alfalfa) butterfly	*Colias eurytheme*
Yellow jacket	*Vespula diabolica*

OTHER INVERTEBRATES

European red mite	*Paratetranychus pilosus*
Goose barnacle	*Mitella polymerus*
Japanese anemone	*Diadumene luciae*
Mussel worm	*Nereis sp.*
Purple sea urchin	*Strongylocentrotus purpuratus*
Red poultry mite	*Dermanyssus gallinae*
Red sea urchin	*Strongylocentrotus franciscanus*

FISH

Bluegill	*Lepomis macrochirus*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Carp	*Cyprinus carpio*
Common shad	*Alosa sapidissima*
Eastern brook (speckled) trout	*Salvelinus fontinalis*
Goldfish	*Carassius auratus*
Grunion	*Leuresthes tenuis*
Largemouth bass	*Micropterus salmoides*
Monterey sucker	*Catostomus occidentalis*
Mosquito fish (top minnow)	*Gambusia affinis*
Onespot fringehead	*Neoclinus uninotatus*
Rainbow trout	*Salmo gairdneri*
Redear sunfish	*Lepomis microlphus*
Smallmouth bass	*Micropterus dolomieui*
Steelhead salmon	*Salmo gairdnerii*
Stickleback fish	*Gasterosteus aculeatus*
Striped bass	*Roccus saxatilis*
Threadfin shad	*Dorosoma petenense*
White catfish	*Ictalurus catus*

AMPHIBIANS AND REPTILES

Bullfrog	*Rana catesbiana*
Santa Cruz long-toed salamander	*Ambystoma macrodactylum croceum*
Western pond turtle	*Clemmys marmorata*

BIRDS

Acorn woodpecker	*Melanerpes formicivorus*
American barn owl	*Tyto alba*
American golden eagle	*Aquila chrysaetos*
Bald eagle	*Haliaeetus leucocephalus*
Band-tailed pigeon	*Columba fasciata*
Barn (fork-tailed) swallow	*Hirundo rustica*
Black phoebe	*Sayornis nigricans*
Brandt's cormorant	*Phalacrocorax penicillatus*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Molothrus ater*
Burrowing owl	*Speotyto cunicularia*
California clapper rail (marsh hen)	*Rallus longirostris*
California condor	*Gymnogyps californianus*
California gull	*Larus californicus*
California jay	*Aphelocoma californica*
California linnet (house finch)	*Carpodacus mexicanus*
California thrasher	*Toxostoma redivivum*
California towhee	*Pipilo fuscus*
Cedar waxwing	*Bombycilla cedrorum*
China (ring-necked) pheasant	*Phasianus colchicus*
Coot (mudhen)	*Fulica americana*
Dark-eyed junco	*Junco oreganus*
English sparrow	*Passer domesticus*
Mountain quail	*Oreortyx picta*
Northern cliff swallow	*Petrochelidon albifrons*
Pygmy nuthatch	*Sitta pygmaea*
Red-winged blackbird	*Agelaius phoeniceus*
Ruddy duck	*Oxyura jamaicensis*
Sanderling	*Crocethia alba*
Shrike (butcherbird)	*Lanius ludovicianus*
Sooty shearwater	*Puffinus griseus*
Sparrow hawk (American kestrel)	*Falco sparverius*

Starling	*Sturnus vulgaris*
Steller's jay	*Cyanocitta stelleri*
Turkey vulture (buzzard)	*Cathartes aura*
Valley quail	*Lophortyx californica*
Western meadowlark	*Sturnella neglecta*
Western mockingbird	*Mimus polyglottus*
Western mourning dove	*Zenaidura macroura*
Winter wren	*Troglodytes troglodytes*
Wood duck	*Aix sponsa*
Wrentit	*Chamaea fasciata*
Yellow-billed magpie	*Pica nuttalli*
Yellow warbler	*Dendroica petechia*

MAMMALS

Black bear	*Euarctos americanus*
Black rat	*Rattus rattus*
Black-tailed deer	*Odocoileus hemionus*
California ground squirrel	*Citellus beecheyi*
California sea lion	*Zalophus californianus*
Cottontail rabbit	*Sylvilagus auduboni*
Deer mouse	*Peromyscus maniculatus*
Eastern fox squirrel	*Sciurus niger*
Eastern gray squirrel	*Sciurus carolinensis*
Elephant seal	*Mirounga angustirostris*
European wild pig	*Sus scrofa*
Golden beaver	*Castor canadensis*
Guadalupe fur seal	*Arctocephalus philippii townsendi*
Harbor seal	*Phoca vitulina*
House mouse	*Mus musculus*
Meadow mouse	*Microtus californicus*
Northern elephant seal	*Mirounga angustirostris*
Norway rat	*Rattus norvegicus*
Pocket gopher	*Thomomys bottae*
Rocky Mountain elk	*Cervus canadensis nelsoni*
Roof rat	*Rattus rattus*
Sea otter	*Enhydra lutris*
Steller sea lion	*Eumetopias jubata*
Tule elk	*Cervus canadensis nannodes*
Western gray squirrel	*Sciurus griseus*
Western harvest mouse	*Reithrodontomys megalotis*

COMMON AND SCIENTIFIC NAMES FOR PLANTS

African brass buttons	*Cotula coronopifolia*
Alder	*Alnus*
Arroyo willow	*Salix lasiolepis*
Bay (California laurel)	*Umbellularia californica*
Beach bur	*Franseria chamissonis*
Beach morning glory	*Convolvulus soldanella*
Beach sagewort	*Artemesia pycnocephala*
Bermuda grass	*Cynodon dactylon*
Bigleaf maple	*Acer macrophyllum*
Bishop pine	*Pinus muricata*
Black cottonwood	*Populus trichocarpa*
Black oak	*Quercus kelloggii*
Blue beach lupine	*Lupinus chamissonis*
Blue blossom	*Ceanothus thyrsiflorus*
Blue elderberry	*Sambucus mexicana*
Blue-eyed grass	*Sisyrinchium bellum*
Blue gum	*Eucalyptus globulus*
Blue oak	*Quercus douglasii*
Bluff lettuce	*Dudleya farinosa*
Box elder	*Acer negundo*
Bracken	*Pteridium aquilinum*
Bristle cone fir (Santa Lucia fir)	*Abies bracteata*
Brittle-leaved manzanita	*Arctostaphylos crustacea*
Broad-leaved cat-tail	*Typha latifolia*
Buckbrush	*Ceanothus cuneatus*
Buckeye	*Aesculus californica*
Bull kelp	*Nereocystis luetkeana*
Bull thistle	*Cirsium lanceolatum*
Bur clover	*Medicago polymorpha*
Bur-reed	*Sparganium eurycarpum*
Bush monkey flower	*Mimulus aurantiacus*
California laurel (bay)	*Umbellularia californica*
California poppy	*Eschscholzia californica*
California sage	*Artemesia californica*
California scrub oak	*Quercus dumosa*
California tule	*Scirpus californicus*
Canyon live oak	*Quercus chrysolepis*
Cape oxalis	*Oxalis pes-caprae*
Cat-tail	*Typha*

Chamise	*Adenostoma fasciculatum*
Chaparral pea	*Pickeringia montana*
Chia	*Salvia columbariae*
Chinquapin	*Castanopsis chrysophylla*
Coast eriogonum	*Eriogonum latifolium*
Coast live oak	*Quercus agrifolia*
Coast redwood	*Sequoia sempervirens*
Coast whitethorn	*Ceanothus incanus*
Coffee berry	*Rhamnus californica*
Common groundsel	*Senecio vulgaris*
Common sand verbena	*Abronia umbellata*
Cord grass	*Spartina foliosa*
Coulter pine	*Pinus coulteri*
Coyote bush (greasewood)	*Baccharis pilularis*
Cutleaf filaree	*Erodium botrys*
Dandelion	*Taraxacum officinale*
Deerweed	*Lotus scoparius*
Digger pine	*Pinus sabiniana*
Douglas fir	*Pseudotsuga menziesii*
Duckweeds	*Lemna*
Dwarf maul oak	*Quercus chrysolepis nana*
Eel grass	*Zostera marina*
Filaree	*Erodium*
Flowering currant	*Ribes glutinosum*
Forget-me-not	*Myosotis latifolia*
Foxtail	*Hordeum leporinum*
Fremont cottonwood	*Populus fremontii*
French broom	*Cytisus monspessulanus*
German ivy	*Senecio mikanoides*
Giant kelp	*Macrocystis angustifolia*
Gowen cypress	*Cupressus goveniana*
Hazelnut	*Corylus californica*
Hoarhound	*Marrubium vulgare*
Holland dune grass (Marram grass)	*Arenaria ammophylla*
Honeysuckle	*Lonicera*
Ice plant	*Mesembryanthemum*
Indian hemp	*Apocynum cannabinum*
Interior live oak	*Quercus wislizeni*
Islay prune	*Prunus ilicifolia*

Jim bush	*Ceanothus sorediatus*
Knobcone pine	*Pinus attenuata*
Lizard tail	*Eriophyllum staechadifolium*
Madrone	*Arbutus menziesii*
Manzanita	*Arctostaphylos*
Marram grass (Holland dune grass)	*Arenaria ammophylla*
Marsh pennywort	*Hydrocotyle ranunculoides*
Maul oak (Gold cup)	*Quercus chrysolepis*
Milkweed	*Asclepias*
Miner's lettuce	*Montia perfoliata*
Mock heather	*Haplopappus ericoides*
Monterey cypress	*Cupressus macrocarpa*
Monterey manzanita	*Arctostaphylos hookeri*
Monterey pine	*Pinus radiata*
Needle grass	*Stipa cernua*
New Zealand spinach	*Tetragonia expansa*
Nodding stipa	*Stipa pulchra*
Pacific blackberry	*Rubus ursinus*
Pampas grass	*Cortaderia selloana*
Pepper tree	*Schinus molle*
Periwinkle	*Vinca major*
Pickleweed	*Salicornia pacifica*
Plantain	*Plantago*
Poison hemlock	*Conium maculatum*
Poison oak	*Rhus diversiloba*
Ponderosa pine	*Pinus ponderosa*
Red berry	*Rhamnus crocea*
Red-stem filaree	*Erodium cicutarium*
Redwood sorrel	*Oxalis oregana*
Ribbon kelp	*Egregia menziesii*
Ripgut grass	*Bromus rigidus*
Rockweed	*Fucus*
Sandbar willow	*Salix hindsiana*
Santa Cruz cypress	*Cupressus abramsiana*
Salt grass	*Distichlis spicata*
Saltrush	*Juncus leseurii*
Scotch broom	*Cytisus scoparius*
Sea fig	*Mesembryanthemum chilensis*
Sea otter cabbage	*Nereocystis luetkeana*

Sea palm	*Postelsia palmaeformis*
Sea rocket	*Cakile edentula*
Seaside daisy	*Erigeron glaucus*
Seaside painted cup	*Castilleia latifolia*
Silky beach pea	*Lathyrus littoralis*
Silver-leaved manzanita	*Arctostaphylos silvicola*
Silver weed	*Potentilla egedei*
Soft chess	*Bromus mollis*
Surfgrass (narrow-leaved eel grass)	*Phyllospadix torreyi*
Sweet fennel	*Foeniculum vulgare*
Sword fern	*Polystichum munitum*
Sycamore (plane tree)	*Platanus racemosa*
Tanbark oak	*Lithocarpus densiflora*
Toyon (Christmas berry)	*Photinia arbutifolia*
Tree lupine	*Lupinus arboreus*
Tule	*Scirpus*
Turkey mullein	*Eremocarpus setigerus*
Umbrella sedge	*Cyperus eragrostis*
Valley oak	*Quercus lobata*
Wax myrtle	*Myrica californica*
Western creek dogwood	*Cornus occidentalis*
Whip-strap kelp	*Pterogophora californica*
Wild oat	*Avena fatua*
Wild radish	*Raphanus sativus*
Willow herb	*Epilobium watsonii*
Willows	*Salix*
Woody chain bladder	*Cystoseira*
Yellow mustard	*Brassica campestris*
Yellow sand verbena	*Abronia latifolia*
Yerba Buena	*Micromeria chamissonis*

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