PINUS RADIATA IN CALIFORNIA

MARGOT B. FORDE*

SYNOPSIS

The restricted natural stands of Pinus radiata in California are described as they exist today, with special reference to the ecological factors controlling their limits and the past and future effect of European occupation.

INTRODUCTION

The natural forests of Monterey pine (Pinus radiata D. Don) in California command an interest out of proportion to their size. To the ecologist they are important as living relics of an association known as the closed-cone pine forest, which is believed to have been widespread along the coast of California in prehistoric times. To the forester, they are the source of an extremely important commercial timber tree which is now grown over large areas in the Southern Hemisphere.

With the exception of two small state reserves and some municipal land at Monterey, all the Californian P. radiata forest is in the hands of private owners. In the two centuries of European occupation, it has been considerably modified by logging and cattle ranching, and in recent years has felt increasing pressure for residential and recreational development. Lindsay (1932) prepared a valuable detailed account of the ecology and condition of the modern forests three decades ago, which forms the basis of the recent review by Scott (1960). In addition, Chaney and Mason (1933) and Mason (1934) have given a vivid description of the physical surroundings and floristic composition of the stands at Monterey and Ano Nuevo Point at that time. Because of the likelihood of increasing and permanent changes in the future, the opportunity is taken now of recording a fresh impression of the extent and condition of the forests as they exist today, and the factors controlling their growth and spread.

THE CLOSED-CONE PINE FOREST

Pinus radiata, known in California as Monterey pine, is one of a small group of closely-related species called the coastal closed-cone pines. The other principal members of the group, all of which are centred in California, are P. muricata (bishop pine) and P. attenuata (knobcone pine). The most distinctive characteristic of these species is their hard, long-persistent, asymmetric cones which may remain closed for many years after maturity. They are small to medium-sized bushy trees which grow quickly, bear cones at an early age, and can act as pioneers on burnt or cleared ground, but are relatively short-lived.

* Forest Research Institute, Rotorua. (MS received 16 July, 1964.)
Knobcone pine grows in inland areas, usually in dry, open scrub, but the other species are entirely coastal in distribution and form a distinctive type of forest known as the closed-cone pine forest (Mason, 1934). This occurs in discontinuous patches all along the coast of California to northern Mexico, and on several islands in the southern part of this area. In northern and southern California, the closed-cone pine forest is dominated by bishop pine, and in central California by Monterey pine. No mixed forests of the two species occur, and they come into contact only on the Monterey Peninsula, where there is a small enclave of bishop pine in the centre of the *P. radiata* forest. The forests on Santa Cruz and Santa Rosa islands contain variant forms of bishop pine which are sometimes treated as a separate species (*P. remorata*), while the pines on Cedros and Guadalupe islands, Mexico, are taxonomically difficult forms having characteristics in common with mainland *P. radiata*.

Regional climatic variation, particularly a lower rainfall in southern California as compared with the north, is reflected in floristic differences which led Mason (1934) to classify the closed-cone pine forest into three regional types: northern, southern and insular. The southern stands are mostly small and seem in rather critical balance with the surrounding grassland or oak woodland, whereas in northern California the closed-cone pine forest is more extensive, frequently bordering redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) stands, and may be an aggressive colonizer. In both regions, however, the pines are restricted to the coastal summer fog belt.

But although the dominant species of pine and the detailed composition of the forest vary from one stand to the next, the general aspect remains the same. As well as the Douglas fir and various cypresses which are often associated with the pines in the north, there is a two-layered understorey of broad-leaved trees and shrubs in which the coast live oak (*Quercus agrifolia*) is particularly prominent. Depending on the nature of the site, the shrub layer may be of a hard “chaparral” type dominated by species of *Arctostaphylos* and *Ceanothus*, or a more mesophytic type containing soft-leaved plants such as *Corylus*, *Baccharis* and *Rubus*. As a whole, the floristic association is very distinctive; according to Mason (1934), 58% of the species are endemic to California and 29% to the closed-cone pine forests alone.

Rich fossil deposits found in several localities (Chaney and Mason, 1930, 1933; Mason, 1934) show that closed-cone pine forest very similar to that of modern times existed in the Pleistocene era, and that it occurred on other parts of the coast (or islands) at that time. In particular, many species extended farther to the south than they do today. Increasing dryness since the close of the last ice-age apparently caused these forests to contract and fragment, resulting in the existing series of highly disjunct relic stands. Monterey pine and bishop pine, which usually occur together in fossil deposits, became almost completely separated in distribution, and the range of Monterey pine contracted both from the north (Tomales Bay) and the south (Carpinteria). The critical environmental factors which have allowed this species to persist in its present locations but not in other apparently suitable habitats are not entirely understood.
DISTRIBUTION AND CLIMATE OF THE MONTEREY PINE STANDS

At present, the typical form of Monterey pine occurs in three separate places on the coast of central California, spanning a range of about 120 miles (Fig. 1). The total area of these stands is approximately 16,000 acres. The northernmost and smallest area

Fig. 1: Coast of central California, including natural distribution areas of Monterey pine on the mainland.
of forest, often referred to as the Swanton stand, extends for about six miles in a narrow belt along the seaward flank of the Santa Cruz Mountains near Año Nuevo Point, lat. 37°N. About 40 miles to the south across Monterey Bay lies the central and main stand on the Monterey Peninsula, lat. 36° 35'N, with a small southward extension across the Carmel River on to the northern tip of the Santa Lucia Range. Some 70 miles of the precipitous seaward slopes of this range come between the Monterey forest and the southern stand, which stretches discontinuously for about nine miles along the grassy coastal plain round the town of Cambria, lat. 35° 35'N. In all these areas the pines are never more than four miles from the sea and mostly much less, and are found almost entirely on gently-sloping land lower than 1,000 ft above sea-level.

Broadly speaking, the Monterey and Cambria forests are ecologically similar. Both are well-defined, pure stands, surrounded by grassland or oak woodland. Their inland limits are controlled mainly by the extent of summer fog, and in both regions the main body of forest is centred on local occurrences of particular light-textured soils in areas of gentle relief. The pines seem to regenerate successfully within the forest limits but are not tending to extend beyond them. By contrast, the *P. radiata* forest at Año Nuevo Point is small in extent and poorly defined, intergrading with the adjoining forest of Douglas fir and redwood. The pines are not associated with any particular soil type but are usually found on the poorer marginal sites. They will, however, invade clearings where stands of Douglas fir have been disturbed. On the hot, dry inland slopes, the pine and Douglas fir forests are abruptly replaced by scattered knobcone pine and scrub. Because of the steep, broken topography, the different associations form a complex mosaic, and much of the vegetation is ecotonal and difficult to interpret. As pointed out by Mason (1934), floristically and ecologically this stand of *P. radiata* is more closely related to the *P. muricata* forests of Northern California than to the southern stands of Monterey pine.

The climate of the central California coast is characterized by relatively uniform, moderate temperatures throughout the year, rather a low rainfall concentrated in the winter months, and rainless summers with fog at nights and sometimes throughout the day. Extensive meteorological data relating to the areas of *P. radiata* forest were compiled by Lindsay (1932), and have recently been reviewed and extended by Scott (1960). It is difficult to obtain accurate information on local climatic conditions in the three stands because available records mostly come from stations outside the forest limits, sometimes many miles away or separated by major topographic features. The only important variation between them suggested by existing data is in the amount of rainfall, and these figures will be examined in detail.

**Monterey**

Mean annual rainfall for the town of Monterey over the period 1847–1915 was 16.71 in., with extremes ranging from 7 to almost 30 in. (Lindsay, 1932). The average figure for the years 1948–57 at a station close to the edge of the Monterey forest is given by Scott (1960) as 19.01 in., which agrees well with the figure of
18.75 in. quoted for the town of Carmel by Chaney and Mason (1933). The latter authors, working on a basis of an increase in precipitation of 8½ in. for every thousand feet of elevation, calculated that the highest point on the Monterey Peninsula (815 ft above sea-level) would receive over 25 in. a year, but this amount has not actually been measured.

Cambria

For the Cambria stand, the nearest station quoted by Lindsay (1932) was that inland at San Luis Obispo, which over the period 1870-1922 received an average of 20.38 in. of rain a year, with extremes of about 10 and 40 in. Carpenter and Storie (1933) give a mean figure of 20.61 in. and range from 7 to 50 in. for the same station, but comment that the coastal plain adjacent to the ocean receives slightly less precipitation. This is borne out by the mean annual value of 17.14 in. for Point Piedras Blancas (Scott, 1960), on the plain about eight miles northwest of the forest.

Año Nuevo Point

Records quoted by various authors for the station at Santa Cruz, some 15 miles south-east of Año Nuevo Point, indicate a mean annual rainfall of between 26 and 28 in., while the isohyetal map provided by Wagner and Nelson (1961) shows the northern part of the pine forest as receiving between 25 and 30 in., the pattern being described as locally complex. Private records kept at Coastways Ranch, at the seaward edge of the forest, show a mean annual fall of about 30 in. with extremes of 15 and 48 in. (H. Bradley, pers. comm.). It appears, therefore, that, on the average, the Año Nuevo Point forest receives about 50% more rainfall than the two southern stands, possibly excluding the higher parts of the Monterey Peninsula. This discrepancy is large enough to explain its different characteristics.

It should be emphasized that in all the stands, appreciable additional moisture becomes available to the trees from condensation of the heavy summer fogs. Fog “drip” amounting to more than half-an-inch a week has been measured on the higher parts of the Monterey Peninsula (cf., e.g., McDonald, 1959). Monterey pine is not found growing naturally outside the fog belt, and this source of summer moisture seems essential for its survival under present conditions, at least in the southern stands.

DESCRIPTION OF THE MONTEREY STAND

Topography and Limits

The stand of _P. radiata_ at Monterey is the largest and by far the best known of the three. Lindsay (1932) gives the area as 6,000 acres, but McDonald’s (1959) figure of 12,000 acres is a better estimate if areas of mixed pine and oak forest are included. The location and approximate limits of the forest (excluding the extreme inland edge) are shown in Fig. 2. About half the total area occurs on the Monterey Peninsula, a blunt, low extension of the ridge which forms the divide between the Carmel and Salinas Valleys. From Huckleberry Hill, the highest point on the peninsula (815 ft elev.),

24
Fig. 2: Map of the Monterey area, showing major part of pine forest.
gentle, basin-like slopes covered with a pure stand of pines descend to the sea on three sides. Across the neck of the peninsula the forest extends discontinuously inland along Loma Alta ridge on the north side of Carmel Valley for about four miles (approximately one mile beyond the eastern limit of Fig. 7), becoming progressively more broken up by grassland and scrub, especially on the dry southern slopes, and seldom reaching an altitude of more than 900 ft. Eventually it passes into an open woodland of evergreen oaks. South of the Carmel River there is a further area of forest behind Point Lobos and on adjacent seaward slopes of the Santa Lucia Range as far south as Malpaño Creek. The forest proper terminates rather abruptly on the south side of Malpaño Canyon, but scattered trees and small groves can be found in coastal grassland for some distance beyond this point.

Soils

According to Carpenter and Cosby (1929), the chief soils of the Monterey Peninsula and Point Lobos, accounting for the major part of the forested area, are Elkhorn sand and M'Clusky sandy loam. These are both formed from marine terrace deposits two to five feet thick which overlie planed-off bedrock of granite or shale. They are well-drained, light-textured soils, differing mainly in the heavier subsoil of the M'Clusky series. On the ridge east of the peninsula, these give way to residual soils, chiefly Santa Lucia clay loam, which are very thin and stony on the steep upper slopes. Similar soils occur on the Santa Lucia Range south of Point Lobos. In their heavier texture and shallowness these soils seem less favourable to the growth of the pines than the sandy loams of the Elkhorn and M'Clusky series, and may be an important factor limiting extension of the forest inland and southwards from the peninsula. To the north, a large area of Marina sand lies behind Monterey Bay and around the mouth of the Salinas River. This is dry and rather infertile, and is said to have supported a carpet of grass with windblown oak trees and shrubs in virgin conditions. Although Mason (1934) reports that pine roots have been found in this area, it seems doubtful that the forest ever extended to the mouth of the Salinas River as he suggests.

Floristic Composition

The structure and composition of the forest vary considerably depending on soil and aspect. On favourable sites where the pines are large and form a canopy, the forest is fairly open beneath, with a sparse understory of coast live oak (Quercus agrifolia) and shrubs, and a ground cover of grass, ferns, brambles, poison oak (Rhus diversiloba), and various herbaceous plants. Where this sort of forest has been disturbed, there is a much thicker shrubby undergrowth made up largely of poison oak, chaparral broom (Baccharis pilularis sp. consanguinea), coffeeberry (Rhamnus californica), wild lilac (Ceanothus thyrsiflorus) and a mesophytic type of sagebrush (Artemisia douglasiana). In particularly moist shady parts, poison oak may be extremely luxuriant both as a shrub and a climber, and constitute almost the entire undergrowth. Willows and other moisture-loving species occur locally along streamsides.
Fig. 3: Remains of good mature stand of pine forest behind beach near Asilomar, on the west coast of the Monterey Peninsula. Note dense regeneration at right.

Fig. 4: Open forest of pine and coast live oak on lower northern slopes of Loma Alta ridge, Monterey.
This type of stand is found on the gentle, lower slopes of the peninsula (Fig. 3) and the northern side of Loma Alta ridge (Fig. 4). Passing inland along the ridge and out of the influence of fog, the forest becomes more open and oaks gradually larger and more abundant, until finally the pines disappear entirely and the mixed forest gives way to grassland with patches of oak forest. In some marginal sites, numbers of pine seedlings are sometimes found under mature oaks, as if the latter can act as nurse trees when environmental conditions are critical.

In sites where the soil is shallow and the pines tend to be stunted and more widely spaced, oaks are small and bushy or absent, and the undergrowth consists of a thick shrub layer dominated by manzanita (*Arctostaphylos tomentosa* var. *tomentosiformis*) and huckleberry (*Vaccinium ovatum*). This type of association is found chiefly on the higher parts of the peninsula, the south side of Loma Alta ridge above Carmel Valley, and in the Carmel Highlands area south of Point Lobos (Fig. 5). It occurs in most extreme form on the upper western slopes of Huckleberry Hill, where the Monterey pine forest is replaced locally by an enclave of bishop pine and the endemic Gowen cypress (*Cupressus goveniana*) (see below). This dry, open type of forest is connected with the better stands described above by broad transitional zones, where manzanita gradually vanishes from the undergrowth and oaks become larger.

Round the coast of the peninsula, the forest adjoins a coastal scrub in which chaparral broom, sagebrush (*Artemisia californica*), bush monkeyflower (*Mimulus aurantiacus*), *Eriophyllum staechadi- folium*, and *Eriogonum parvifolium* are prominent. Gnarled, semi-

Fig. 5: Dry, open pine forest in Carmel Highlands, Monterey, with shrubby undergrowth consisting largely of manzanita.
prostrate pines extend out into this scrub, and occur even on poorly consolidated dunes. A very similar type of scrub, lacking only the extreme coastal and dune plants, is present along the borders of the forest in dry, open places on Loma Alta ridge and the Santa Lucia Range.

At Cypress Point and Point Lobos, the northern and southern headlands of Carmel Bay, the endemic Monterey cypress (*Cupressus macrocarpa*) occurs on rocky points. The cypresses mingle with the pines on the fringe of the forest, but do not penetrate to any depth. The total number of individuals in these populations, the only natural occurrence of the species, is very small. Monterey cypress is only one of several species endemic to the Monterey region which help make the flora of this area rich and distinctive.

*Bishop Pine at Monterey*

The population of *P. muricata* on Huckleberry Hill is especially interesting because of its small size and isolation from other stands of the species to the north and south, and also because Monterey is now the only place where bishop pine and Monterey pine come into contact, though they were associated in the two largest Pleistocene fossil deposits of the closed-cone pine forest. The area concerned is one of shallow, sandy soil and heavy fog on the upper western slopes of the peninsula, and is about 200 acres in extent. Rather small stunted trees of bishop pine and Gowen cypress occur in a scrub of manzanita (*A. tomentosa* and *A. hookeri*), huckleberry, coffeeberry, wild lilac (*Ceanothus dentatus* and *C. rigidus*), chamise (*Adenostoma fasciculatum*), golden chinquapin (*Castanopsis chrysophylla* var. *minor*) and other species. A mesic Monterey pine forest persists in the gullies which cross the enclave, and the repeated transition between this and the bishop pine association on the slopes is very abrupt. At the edges, however, there is a gradual transition to a stunted *P. radiata* forest. Essentially, therefore, the two pines occupy different habitats and mingle only in the ecotones. They do not appear to hybridize. Gowen cypress occurs again in a restricted area of the pine forest behind Point Lobos, but bishop pine is not present in this locality.

*Settlement and Land Use*

The Monterey forest has a long history of European occupation. Because of the good anchorage for ships and the availability of pines for masts, Monterey Bay was a frequent port of call for Spanish explorers of the 16th, 17th and 18th centuries, and permanent settlements were established in the latter part of the 18th century. The first settlers were pastoralists and farmers, and marginal areas of forest were probably cleared at an early stage for grazing land and crops. From the beginning, a certain amount of timber was cut for local construction, and by the middle of the 19th century considerable amounts were being cut at sawmills and shipped out by schooner. Wood was also used to fuel brick kilns in the area (McDonald, 1959). A number of extensive forest fires were recorded during the early settlement period, some of which were attributed to mining operations (McDonald, 1959), and these have continued to occur periodically even up to the pre-
sent day. Early this century all the southwest part of the Monterey Peninsula, then used for cattle ranching, was acquired by a private land development company and has since been managed as an exclusive residential and recreational estate. The towns of Monterey and Carmel have been tourist attractions for a long period, and the permanent population of the area has grown tremendously in recent decades, particularly during the period when the nearby military camp was an important troop-training centre for the second world war. With the population still increasing rapidly throughout the whole state, pressure on these attractive forested areas, both for tourism and permanent settlement, will become even heavier.

There is little ranching or logging in the forest today, but scarcely any of it is being left undisturbed. To begin with, the towns of Monterey and Pacific Grove in the north and Carmel in the south occupy approximately 2,500 acres of the original forested area, and apart from these actual urban areas, there are extensive peripheral settlements where houses are scattered sparsely in the forest. The lower slopes of the peninsula on the south and west sides are also fairly extensively settled, and the marine drive along the coast, known as the 17-mile drive, is a famous scenic attraction. The higher, central parts where the forest is rather stunted are still mostly unoccupied, but are criss-crossed by numerous roads and tracks. The best remaining areas of forest on the peninsula are on the steep north-east slopes overlooking Monterey Bay; much of this belongs to the city of Monterey.

Some large areas of good mature forest also exist on the north side of Loma Alta ridge, east of the coast highway. A little cattle ranching is still continued on the upper eastern slopes where the forest is patchy, but both sides of the ridge are traversed by numerous roads and for the most part the forested areas are being used for housing developments or large private estates.

All the hilly upland south of the Carmel Valley is still used for cattle ranching, but the forest here was always confined to the slopes immediately above the sea. The entire area of Point Lobos west of the highway, which used to form part of the Point Lobos dairy farm, is now a state reserve, and quite an extensive area of mature forest belonging to private owners remains intact on the gentle lower slopes behind the point. The forest south of Gibson Creek is occupied by the settlement of Carmel Highlands, and even former ranchland on the north side of Malpaso Creek has been subdivided in recent years (Fig. 6).

Two centuries of grazing, logging, and sporadic fires have left the forest in greatly altered and often debased condition, but natural regeneration is usually good, and, apart from the considerable areas now occupied by urban settlements, there is little evidence that the original limits have been substantially altered by man's activities. Because of both favourable soil and heavy fog, the forest on the peninsula can be considered the core of the whole stand, with extensions into rather less favourable areas. The natural northern limit appears to be the foot of Loma Alta ridge, where the hillside soils give way to windblown sand behind Monterey Bay. There appears to have been local clearing along the margins here, and regeneration can be seen in abandoned pasture above Monterey city. Lack of summer fog is probably chiefly re-
sponsible for the increasing patchiness and eventual disappearance of the pines passing inland along this ridge, but soil depth is probably also a critical factor. McDonald (1959) found that pines rarely occur where there is less than 13 in. of soil, and never where there is less than 9 in. The forest may have extended farther down to the Carmel River at one time, but Monterey pine will not tolerate poor drainage and the fertile soils of the valley flats were probably too wet in winter to support a continuous stand of forest connecting that to the north and south such as McDonald (1959) envisages. As Lindsay (1932) comments, there was probably a larger and more continuous area south of the river at one time than exists at present; the pastures to the north and south of San
Jose Creek, for instance, show traces of the original forest cover. The sharpness of the forest boundary on the south side of Malpas Canyon may be artificial to some extent, but there is no record of continuous stands of forest farther south in historic times, although Langenheim and Durham (1963) have shown that about 10,000 years ago Monterey pine was growing at Little Sur, ten miles south of the present southern limit of the main forest.

DESCRIPTION OF THE CAMBRIA STAND

Topography and Limits

The southernmost forest of Monterey pine at Cambria is the most isolated and sharply delimited. As shown in Fig. 7, the main stand of approximately 2,500 acres extends for about four miles along the coast on gently sloping land to the north and south of Santa Rosa Creek. The highest point at which trees occur is 660 ft at Scott Rock, but most of the forest is between 200 and 300 ft above sea-level and the inland edge is not more than three miles from the ocean. A separate grove of some 500 acres (not shown in Fig. 7) occurs on the north side of Pico Creek, about three miles north of the main stand. Grazing lands surround the forested areas.

Soils

The limits of the Cambria forest show a rather striking correspondence with the boundaries of a type of soil called Arnold sandy loam. This is a light-textured, residual soil developed from sandstone on gently rolling slopes (Carpenter and Storie, 1933). The pines are confined almost entirely to this soil, and occupy nearly all this particular local occurrence, the most extensive exceptions being the area between Pico Creek and Van Gordon Creek (the westernmost tributary of San Simeon Creek), and that between San Simeon Creek and Leffingwell Creek. To the north and south, Arnold sandy loam is replaced by Los Osos fine sandy loam, on to which the pines extend to a limited extent, and at the seaward edge by narrow strips of M'Clusky fine sandy loam and Elkhorn sand. Soils of the latter two series are very favourable for the growth of pines at Monterey, yet they do not seem to carry forest in this district, even where they occur over appreciable areas near San Simeon (north of Pico Creek) and at Piedras Blancas Point. On the inland edge, the Arnold series adjoins Cayucos clay adobe, a much heavier soil carrying grassland and scattered oak forest.

Floristic Composition

Floristically, the Cambria forest is rather uniform and resembles the better stands at Monterey, though it is neither as diverse in habitats nor as rich in species as that area. The pine is the dominant tree at all times, with coast live oak in the understorey. On drier sites where the forest is open there is often quite a dense layer of oaks and shrubs, but where it is moist and shady, the oaks are sparse and the ground cover consists mainly of ferns, grasses, and soft-leaved shrubs like poison oak and brambles.
Fig. 7: Map of the Cambria area, showing main stand of pine forest.

(Fig. 8). In heavily cut-over parts of the forest open to cattle, the undergrowth consists of shrubby oaks, bracken, poison oak, coffeeberry, chaparral broom, and bush monkeyflower scattered throughout pasture. *Arctostaphylos tomentosa*, which dominates the undergrowth in large areas of hilly forest at Monterey, seems to be absent, nor was any other species of manzanita seen though Mason (1934) refers to *A. pechoensis* in this region. The apparent absence
of *Ceanothus thrysiflorus* is also interesting, as this species is prominent in disturbed parts of the northern stands. A number of introduced plants are now common along roadsides and in damaged parts of the forest.

Mason (1934) refers to the occurrence of bishop pine at Cambria, but it was not seen during this study. This species re-appears on the San Luis Range, however, about 20 miles farther south along the coast.

**Settlement and Land Use**

The Cambria area has a much shorter history of settlement than has Monterey. The sheer coastal face of the Santa Lucia Range was impassable to early settlers, and the main route between Monterey and San Luis Obispo passed inland through the Salinas Valley. Access to the rolling coastal plain about Cambria was obtained by way of Morro Bay, to the south, or else by a long and difficult pass across the hills from Paso Robles. The first botanist to describe the Cambria pine forest was Theodore Hartweg, who in 1847 observed “a small pine wood... like an oasis in the desert” (Hartweg, 1848). The abruptness with which this forest rises from the surrounding grassland was evidently as noticeable then as it is today.

Cattle ranching and logging were begun in the latter part of the 19th century, and the forest was repeatedly worked-over for timber and partly burnt and cleared for grazing. In recent decades, with the development of the scenic coastal highway from Monterey and also of a better road across the hills between Morro Bay and the
Fig. 9: Two-layered forest in southern part of Cambria stand. Lower storey contains many bushy oak trees.

Salinas Valley, it has become a thriving seaside resort, and large numbers of summer homes have been built in parts of the forest. The pines in this area differ from those at Monterey in having larger cones, and are known locally as "Cambria pine".

North of Santa Rosa Creek the land is still used for cattle grazing, and the forest is greatly damaged and interspersed with areas of pasture. One small sawmill is still working in the centre of the forest. The town of Cambria is expanding into the fringes of the forest on both sides of the creek, and there are settlements at the mouth of the valley, both to the north and the south. South of Santa Rosa Creek the forest is in rather better condition, but a two-layered structure in parts bears evidence of early logging or other disturbances (Fig. 9). There are cattle ranches in the north and south parts of this stand, but the central portion has been roaded and subdivided into residential sections and there are numerous houses among the trees in some parts, particularly overlooking the sea.

Early burning and clearing have undoubtedly reduced the original area of forest, particularly on the seaward edge to the north and south of Leffingwell Creek. Where they are not checked, young trees are spreading out into grazing land in many parts of this area. The large area of pasture which interrupts the seaward side of the forest south of Santa Rosa Creek was clearly also forested at one time; the grass ends abruptly at a line of mature forest and a few islands of trees remain as evidence of the original cover. There was also probably marginal clearing at the southern edge of the forest, and along the inner margin. It is more difficult to find evidence that the isolated grove of forest north of Pico Creek
was ever connected to the main stand south of Leffingwell Creek, though the intervening area of grassland is similar in soil and topography to that occupied by the forest farther south. This northern grove is still used as a cattle run, and is almost devoid of shrubby undergrowth. While there are clumps of mature trees, most of the grove consists of fairly well-spaced young trees, as if it might be at least partly an artificial plantation. As Lindsay (1932) suggests, however, this could also be a result of early burning by graziers to open up the canopy and obtain more grass. The mature forest on the steep slopes above the creek certainly appears natural.

DESCRIPTION OF THE ANO NUEVO POINT STAND

Topography and Limits

On the slopes of the Ben Lomond Range in the vicinity of Año Nuevo Point, *P. radiata* exists under conditions very different from those at Monterey and Cambria. The coastal ranges in this area are very steep, sometimes rising almost to 1,000 ft within a mile of the sea, and cut by deep narrow canyons. Because of this rugged topography, the area is ecologically diverse and contains a complex mosaic of vegetation types. A belt of forest consisting mainly of Monterey pine occurs on the lower seaward slopes, and in general in drier and more exposed sites, often facing south. In areas such as valley bottoms and north-facing slopes where there is more shelter and moisture, the pine forest tends to be replaced by a moister Douglas fir and redwood forest. The boundary between these two forest types is indistinct, however, and often Monterey pine and Douglas fir are found growing together in a mixed forest, the predominance of one or the other varying with the site. On dry, inland ridgetops and steep slopes where the soil is shallow and very stony, these mesophytic forests are replaced abruptly by an open scrub with scattered knobcone pine.

Because the Monterey pine forest is not a well-defined entity in this region, it is difficult to map (Fig. 10), and even the northern and southern limits of the species are hard to determine precisely. The northernmost substantial occurrence is at Green Oaks Creek, but scattered individuals occur near Cascade Creek and possibly in stands of Douglas fir beyond this. (A small clump near Gazos Creek arose from a planted tree.) From here there is a fairly continuous belt of pine forest south to about a mile beyond the mouth of Waddell Creek, where the old county highway turns inland and crosses the coastal terrace before descending into Scott Creek. Scattered outliers can be found in grassland and coastal scrub on the seaward slopes of this terrace for a little distance further south. Inland, in the valley of Scott Creek, pines occur rather sparingly among Douglas fir and redwood on the seaward-facing slopes from north of Mill Creek to Little Creek, Swanton, and possibly even beyond this. A few trees that seemed to be wild were seen near the Bonny Doon road on the hills behind Davenport, but there are many in the Santa Cruz area which were planted or which have seeded-out from planted trees, so that it is difficult now to be sure of the natural southern limit. Because the distribution is so diffuse, it is hard to estimate the total area of Monterey pine in this district but it is probably less than 1,000 acres, and

36
Fig. 10: *Map of the Año Nuevo Point area, showing distribution of pine forest.*

only part of this is occupied by pure stands of pine. Throughout the area, pines are not found more than a mile-and-a-half from the sea, and mostly less than a mile, and do not extend higher than 800 ft above sea-level.

**Soils**

A study of the soils of the Año Nuevo Point pine forest is complicated by the fact that it lies across the border between two countries. A regional soil survey of the Santa Cruz area, which includes the southern part of the pine forest, was published in 1944 (Storie *et al.*), and one of the San Mateo area, which takes in the forest from Elliot Creek north, in 1961 (Wagner and Nelson), but the two differ considerably in style and detail of mapping and it is difficult to integrate the information provided.

Most of the soils on which Monterey pine occurs belong to the steep and shallow phases of the Santa Lucia series of clay
loams, which are also found in the Monterey area. These are residual soils developed from the decomposition of siliceous shales in rolling-to-steep country. They are high in organic matter, acid in reaction, permeable, well drained, and subject to severe erosion. Often the soil is very shallow and contains many angular shale fragments, forming the so-called shale barrens (McMillan, 1956). On the gentle slopes between Año Nuevo Creek and Elliot Creek, soils of the Colma series occur. These have been formed from weakly-consolidated marine sediments and are slightly acid, well-drained loams. Small areas of other coastal terrace soils, mainly Tierra loam, Lockwood loam and Watsonville loam, also occur within the forested area. The principal edaphic factor affecting the distribution of Monterey pine in this region appears to be soil depth, as there is no obvious correlation with soil type.

**Floristic Composition**

The structure of the pine forest is similar on the whole to that at Monterey and Cambria, but the undergrowth is often more mesophytic, particularly where the pines are mixed with Douglas fir. Coast live oak is still common in the understorey, but other trees such as madrone (*Arbutus menziesii*), tanbark oak (*Lithocarpus densiflora*), horse chestnut (*Aesculus californica*) and California laurel (*Umbellularia californica*) are also prominent. Disturbed parts of the forest have a thick, shrubby undergrowth containing much poison oak and wild lilac (*Ceanothus thyrsiflorus*), but in older stands the forest is more open with scattered shrubs and a ground cover of ferns, grasses, brambles and poison oak. Except along ecotones where the forest adjoins dry scrub, manzanita does not regularly form part of the undergrowth, as it does in large areas of the Monterey forest. At the coastal margins of the forest, the undergrowth consists of a coastal scrub similar to that on the Monterey Peninsula.

The ecological relationship between Monterey pine and Douglas fir, and the extent to which the present forest associations are natural, are very difficult to assess. Since habitat conditions change over very small distances, much of the vegetation must always have been ecotonal, and interference by man has further complicated the situation. Because Monterey pine regenerates rapidly in disturbed forest and will colonize grazing land, it may have increased at the expense of Douglas fir since the district was settled. Duffield (1951) went so far as to postulate that in this area Monterey pine was originally only a minor component of the Douglas fir and redwood forest, and that the present pure pine stands on the lower seaward slopes arose after cultivation was relaxed early in the century. A rather different view was taken by Lindsay (1932), who thought that Monterey pine forest might be considered an edaphic climax on the poorer soils, while the climax formation on good sites was the Douglas fir-redwood forest. He interpreted most of the present mixed forest as an unstable association, and noted that nowhere could Monterey pine and Douglas fir be found in intimate mixture as a young pole stand. In his account of the forest on the south bank of Waddell Creek, Mason (1934) similarly suggested that the mixed stand of mature pines and younger firs on the upper slopes might be successional in nature, in contrast
to the forest on the lower slopes where Monterey pine was clearly dominant. It does seem likely that fairly pure stands of pine were always present on the drier, more exposed, and otherwise less favourable sites on the fringe of the Douglas fir forest, but the area of these may have increased as a result of man's activities. Similarly, although the pines probably always acted as opportunists and entered temporary openings in marginal parts of the Douglas fir forest, the mixed forest with large numbers of pines may not be a natural association. Any increase in Monterey pine should theoretically be only temporary, as it is much shorter-lived than Douglas fir and does not regenerate well in heavy shade, but disturbances to these forests are likely to continue.

**Knobcone Pine at Año Nuevo Point**

Unlike the other Californian close-cone pines, *P. attenuata* is normally found in dry inland areas, and this local contact with mesophytic coastal forest close to the sea is very unusual. In this area the species occurs as a small, shrubby tree of poor form, scattered in a dry, open scrub of manzanita (*Arctostaphylos tomentosa* and *A. sensitiva*), chamise, huckleberry, golden chinquapin, tree poppy (*Dendromecon rigida*), canyon oak (*Quercus chrysolepis*), chaparral pea (*Pickeringia montana*), yerba santa (*Eriodictyon californicum*), and other species. This association occurs on steep dry slopes inland from the narrow fog belt, and mostly in very shallow, loose, stony soil (shale barrens). Its junction with the Monterey pine and Douglas fir forest is usually abrupt, but stunted Monterey pines may extend out into the scrub for some distance, while tall, luxuriant knobcone pines are sometimes found in the forest fringe. Where there has been fire or clearing in the ecotonal zones, all the species concerned regenerate in a confused mixture, and sometimes even trees with as diverse ecological requirements as knobcone pine and redwood can be seen growing side by side.

![Seedling pines spreading out from a small forest remnant on terrace south of Waddell Creek, Año Nuevo Point.](image)

Fig. 11: Seedling pines spreading out from a small forest remnant on terrace south of Waddell Creek, Año Nuevo Point.
Monterey pine can readily be crossed with knobcone pine, and vigorous hybrid offspring up to the second generation have been raised in cultivation. A difference of about a month in the time at which the two species begin to shed pollen restricts the amount of natural crossing, but sporadic hybrids do occur where they adjoin, especially where there have been disturbances. Because the two species are adapted to very different habitats, however, and the ecotones between them are narrow, the establishment of intermediate hybrids would not normally be favoured, i.e., the two species are separated by an ecological rather than a genetic barrier. Nevertheless, the potential for introgressive hybridization is there, and over a sufficiently-long period or in altered environmental conditions even a slight gene flow might produce significant alteration to one or both species.
Settlement and Land Use

No township of any size is situated in or near the Año Nuevo Point pine forest, and this area of coast is still given over entirely to farming. Beef cattle are run in many of the areas of pasture at the edge of the forest, and there is a dairy herd in Waddell Valley. Artichokes and brussels sprouts are also grown quite extensively. Nearly all the Monterey pine forest falls within a number of private ranch properties, but in some places it adjoins or overlaps into undeveloped sections of the Big Basin Redwoods State Park, which lies inland and to the north. Although the pines are mostly branchy and of poor form, and the timber is considered very inferior to Douglas fir and redwood which are both available locally, some of the largest and best stands on Coastways Ranch have been roughly logged in recent years.

There are few records of the early settlement of the area, but all or most of the marginal areas of pasture and cropland were probably won from the forest at that stage. Where regeneration is not checked, they are quickly covered by young pines (Fig. 11). There is no evidence that the flat, low terrace forming Año Nuevo Point itself was ever forested, however. There used to be a milling settlement at Swanton, in Scott Creek, and remains of the first hydro-electric plant in California can still be seen on Big Creek. A number of extensive fires occurred in the early part of the century, and even in recent decades, and probably none of the present pine stands is of any great age. A U.S. Geologic Survey photograph published in 1909, for instance, shows only grass and scrub on the ridge south of Elliot Creek, and other early photographs belonging to local residents show only small scattered trees on the north side of Finney Creek (cf. Fig 12), and also between Green Oaks Creek and Año Nuevo Creek, where there are now continuous stands. Although the total area of coastal forest is probably still less than existed originally, Monterey pine, by its ability to colonize abandoned agricultural land and take advantage of disturbances to Douglas fir forest, may actually have become more abundant as discussed above.

REFERENCES


