Diseases of Monterey pine

in Native Stands of California and in Plantations of Western North America

Harold R. Offord

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The Author

Harold R. Offord has been investigating the problems of plant diseases and their control for nearly 40 years. A native of Toronto, Canada, he earned bachelor's and master's degrees at the University of British Columbia, majoring in biochemistry. In 1926 he joined the U.S. Department of Agriculture's Bureau of Plant Industry staff in Berkeley, California, and worked on methods of controlling white pine blister rust and other diseases. He served as pathologist in the Department's Bureau of Entomology and Plant Quarantine from 1935 to 1952, and in the Forest Service's California Region from 1953 to 1955. In 1956 he became chief of the division of forest disease research at the Forest Service Experiment Station in Berkeley. Since mid-1962, he has been in charge of the Station's research on heart rots of conifers, mistletoes, and white-pine blister rust.

Monterey pine (*Pinus radiata* D. Don) is without doubt the best known expatriate of the North American conifers. More than 1½ million acres of plantations in Australia, Chile, New Zealand, South Africa, and Spain attest its economic importance and adaptability (Scott 1960).

Forest biologists have studied Monterey pine intensively as an exotic (Scott 1960; Rawlings 1957), but have given much less attention to native stands of this conifer in California.[1] Botanists have described the species and its distribution (Howell 1941; Jepson 1910; Mason 1934; Shaw 1914). Geneticists have reported on Monterey pine hybrids (Stockwell and Righter 1946), on California plantings of progenies from Australia (Righter and Callaham 1958), and on the ecology and variation of the species (Forde[2]), and entomologists have recorded insects from native stands (Burke 1937; Keen 1952; Struble 1961). Mechanical and other properties of California-grown Monterey pine were described by Cockrell (1959) and Haasis (1932) and the gum turpentines identified by Mirov (1961) . Foresters have not entirely overlooked native forest stands (Larsen 1915; Lindsay 1937; .U.S. Forest Service 1908; Dunning[3]; McDonald[4]), but their reports are outdated now or are not readily available in libraries. Contributions from forest pathologists and mycologists are widely scattered in lists of host and fungi, or deal with a specific problem or fungus such as "repeating pine rusts" (Meinecke 1929) without recognizing Monterey pine in the title of the publication.

It is surprising that so little has been published about *P. radiata* in California. The pine forests of the Monterey Peninsula were among the first in the state to attract the attention of explorers, botanists, foresters, and recreationists. Cabrillo in 1542 noted the attractive pine forests and called Monterey Bay "the bay of the pines." The first settlers of the area in 1770 cut and used the trees. Artists and recreationists have long glorified the pine and cypress in their sea-coast setting, and in central coastal counties of California, Monterey pine has been widely and successfully planted in home lots, parks, and wildland areas since the turn of the century.

More recently Monterey pine has become a favored Christmas tree (Metcalf 1955), and now has vastly greater potential for afforestation through its frost-resistant hybrid *Pinus* X *attenuradiata* Stockwell and Righter (*P. attenuata* X *radiata*).

E. P. Meinecke, the pioneer and recognized authority on forest pathology for the western United States, collected and observed diseases in the Monterey area as early as 1909. From about 1881 until the late 1920's other eminent patholo-

[1]I acknowledge with thanks the help given by Dr. Lee Bonar, professor of botany emeritus, and Dr. Isabelle Tavares, senior herbarium botanist, University of California, Berkeley, in working with host and fungi specimens in the U.C. herbarium. For many years Dr. Bonar has been compiling records of fungi attacking native plants of California and has identified numerous specimens collected by U.S. Forest Service personnel. Thanks are also due Drs. Josiah L. Lowe and R. L. Gilbertson of State University College of Forestry at Syracuse, New York, and Dr. L. K. Weresub, Central Experimental Farms, Ottawa, Canada, for naming some previously unidentified polypores from the pathology herbarium of this Station. Personnel of Del Monte Properties, the California Division of Forestry, and U.S. Forest Service pathologist D. R. Miller and consultant W. W. Wagener expedited disease surveys in Monterey pine areas.

[2]Forde, Margot Bernice. Variation in the natural populations of Monterey pine (*Pinus radiata* D. Don) in California. 1962 (Unpublished doctor's thesis on file at Botany Dept., Univ. Calif., Berkeley.)

[3]Dunning, Duncan. A working plan for the Del Monte Forest of the Pacific Improvement Company. 1916 (Unpublished master's thesis on file at School of Forestry, Univ. Calif., Berkeley.)

[4]McDonald, J. B. An ecological study of Monterey pine in Monterey County. 1959. (Unpublished master's thesis on file at School of Forestry, Univ. Calif., Berkeley.)

gists (Bethel, Boyce, Cooke, Gravatt, Harkness, Rhoads, and Wagener) inspected native stands around Monterey Bay and plantations around the San Francisco Bay area. But their findings have never been published.

Researchers in Australia, Chile, New Zealand, South Africa, Spain, and the United Kingdom have provided an extensive and useful literature on the ecology, management, and protection of *P. radiata* as an exotic. Some of the more comprehensive reports on diseases of Monterey pine have come from pathologists working in New Zealand (Cunningham 1948 to 1955; De Gryse 1955; Rawlings 1957; and Hepting[5]). Scott (1960) has summarized world-wide information (including available data on Monterey pine in California) for a bulletin of the Food and Agriculture Organization of the United Nations. In appendix 6 of the Scott report, Rawlings has listed fungi and insects associated with native and exotic *P. radiata.* Of the 99 fungi recorded by Rawlings only 16 are from California, and only one of these California citations bears a dateline as recent as 1938.

In published host-fungi lists many of the fungi reported on *P. radiata* for California go back to collections made by Harkness from 1881 to 1886, which were described in Grevillea and in California Academy of Science bulletins of that time. Saccardo (1882—1931, 13: 849) listed nine fungi on *P. insignis* Dougl. (*P. radiata*) and seven of these appear to be Harkness collections. Seymour (1929) lists 20 fungi for *P. radiata* in North America, but does not provide any source data. Other lists of fungi with *P. radiata* as host appear in publications by the U.S. Department of Agriculture (1960) and those of Spaulding (1956, 1961).

Evidence of increased world-wide interest in Monterey pine is shown not only by the recent publications of Pert (1963), Scott (1960), and Streets (1962), but also by the 1961 recommendation of the Forest Protection Section of the International Union of Forestry Research Organizations that the diseases of native stands of Monterey pine should be inventoried and appraised. To a major extent, this report is the result of that recommendation. Its objectives are to collate previously published records of diseases of Monterey pine in native stands of California and in plantations of western North America, and to augment this record with unpublished information from the forest pathology files of the Pacific Southwest Station. Included are findings from 1961—63 surveys of native stands, and from a study of specimens of fungi in California herbaria.

The Host and Its Environment

The climatic and edaphic environment of native Monterey pine stands in California and of West Coast plantations will be discussed here only to the extent that they bear upon the nature and impact of diseases. More detailed information on the ecology and silvics of native Monterey pine is given by Forde,[2] Lindsay (1937), Scott (1960) and Roy.[6]

Pinus radiata belongs to the hard pine section and to the *Insignes* or closed cone sub-section of the genus *Pinus* (Shaw 1914). The species name is derived from the radiate or rayed markings on the cone scales. Needles occur in groups of three or two per bundle, with three predominating and considered as characteristic. Cones are first produced at 6 to 10 years of age; they persist for many years, shedding viable seed intermittently. The tree normally makes rapid growth in the first 30 to 40 years, slowing down considerably after 50 or 60 years. It is a relatively short-lived conifer.

Native Stands

Native stands of Monterey pine are restricted to three separate pockets in a narrow strip of central coastal California about 6 miles wide and 130 miles long between sea level and 800 to 1,000 feet elevation (fig. 1). Throughout this report these three areas will be referred to as Swanton (the most northerly at 37° N.), Monterey (the central at 36½ ° N.), and Cambria (the most southerly at 35½ °N.).

Estimates of the acreage of native Monterey pine vary, depending on the definition of type, and

[5]Hepting, George H. A report on the condition of the Radiata pine forests of N. Z. Forest Products Limited. 1960. (Unpublished report to New Zealand Forest Products, Ltd., Auckland, N.Z.)

[6]Roy, Douglass F. Silvics of Monterey pine. 1964. (In preparation for publication, Pacific SW. Forest & Range Expt. Sta., U.S. Forest Serv., Berkeley, Calif.)

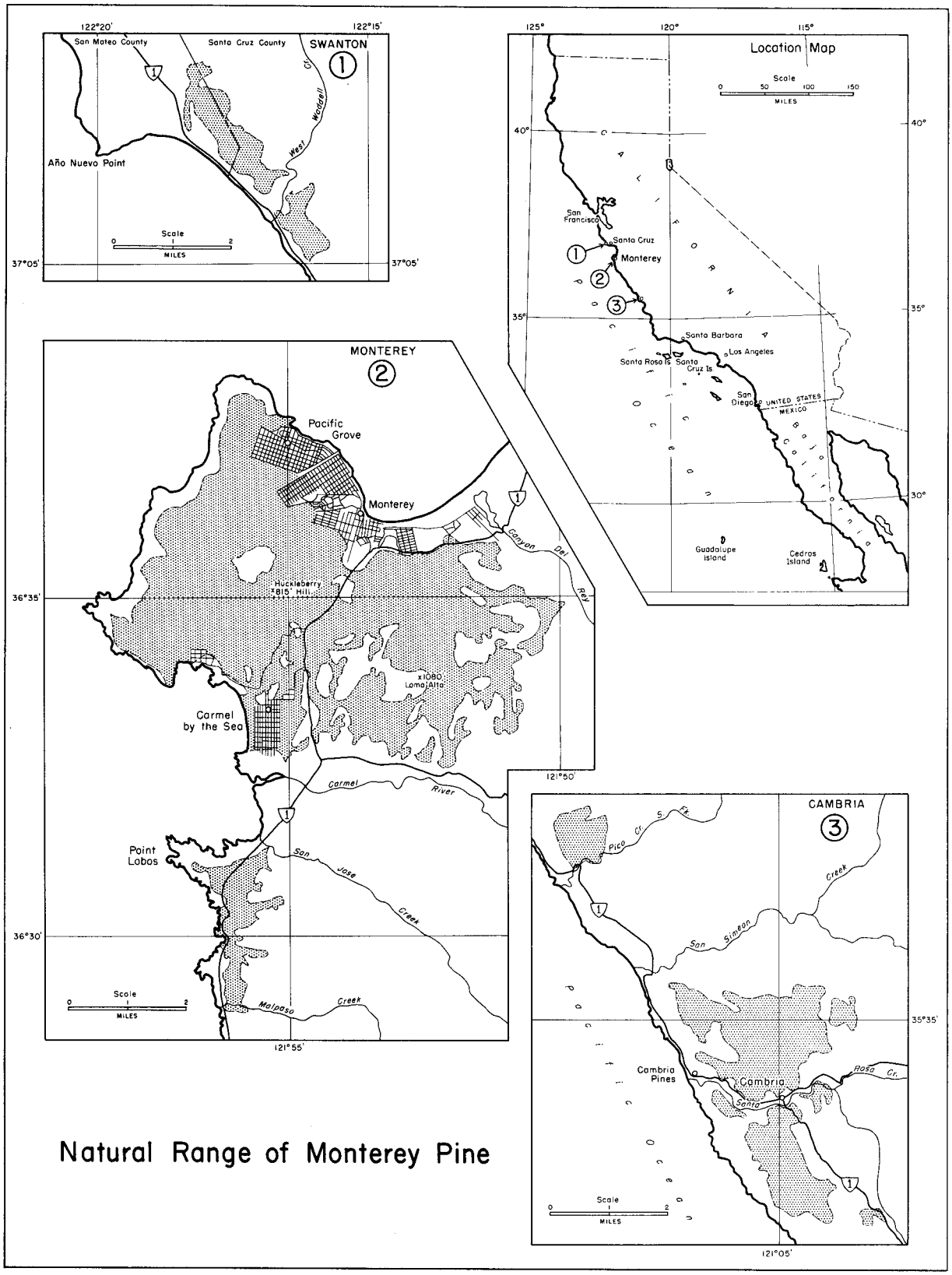


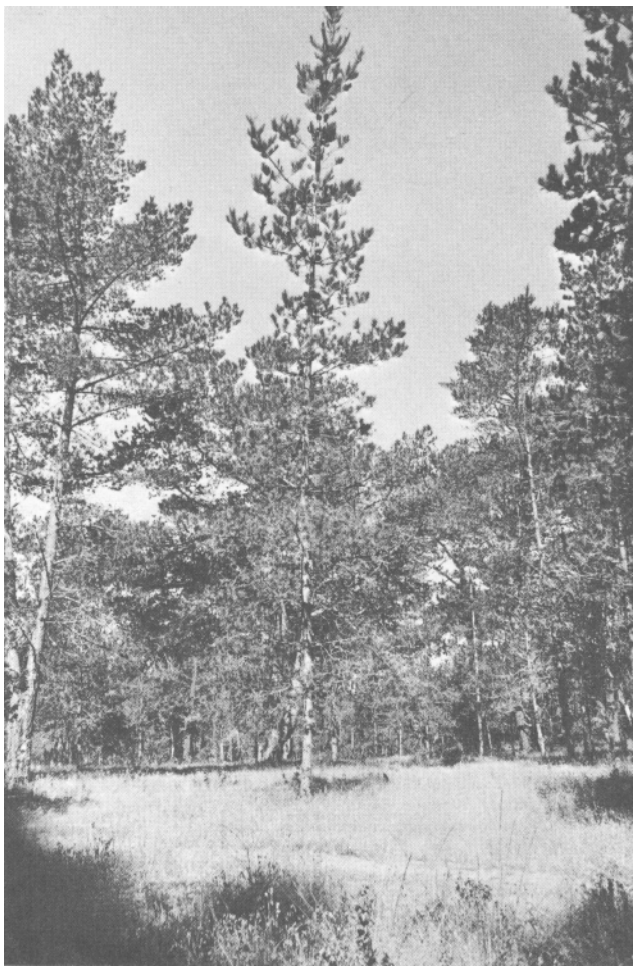
Figure 1.—Native stands of Monterey pine *(Pinus radiata)* in California.

Figure 2.—Natural reproduction of Monterey pine:

***(A)*, on thin clay soil near Pacific Grove.**

***(B)*, on sandy soil in Point Lobos State Park near Carmel.**

***(C)*, on deep clay loam near Swanton.**



A

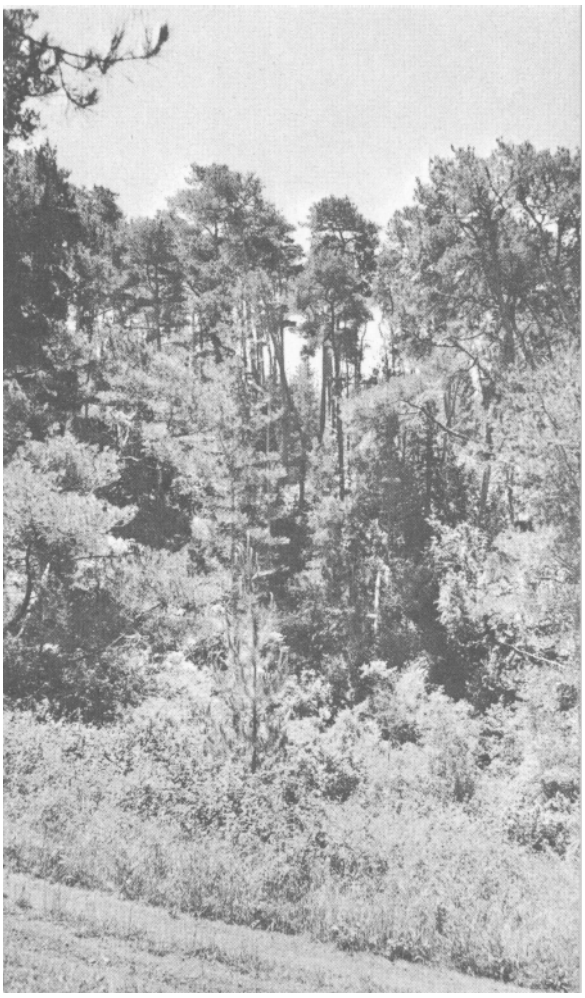


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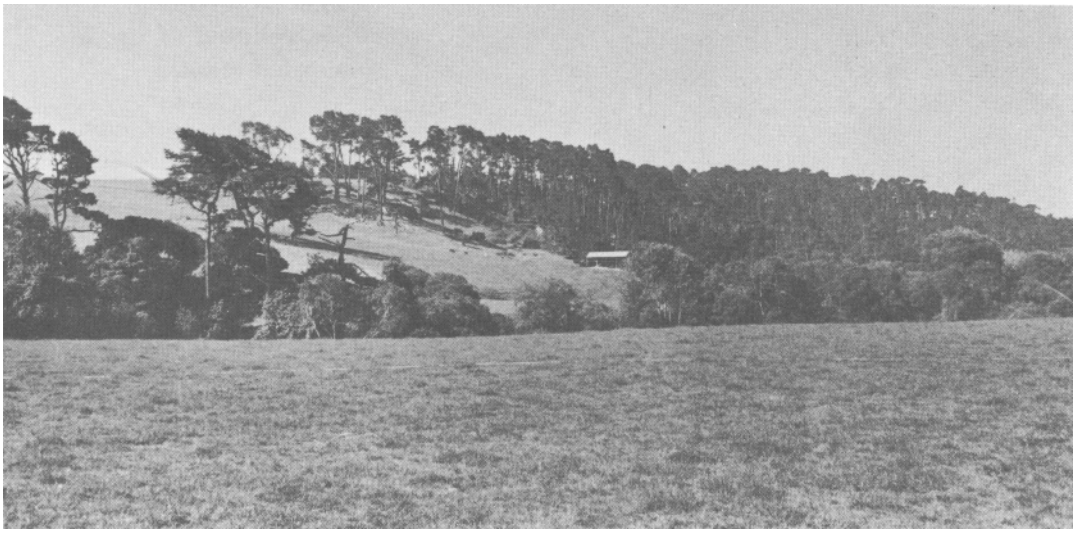
Figure 3.—Forest types in the Cambria area where Monterey pine is the only conifer present in the forest stand. *(A)*, light stocking dominates the upper ridges of Santa Rosa Creek. *(B)*, at the southern limit of Monterey pine merging into grassland. *(C)*, vigorous stand on a 200-foot ridge near the ocean.



B

A

B

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Figure 4.—Forest types in the Swanton area.

(A), **from sea level looking east into the central part of the Swanton stand where Monterey pine (as the elevation increases) is associated with redwood, Douglas-fir, and a mixture of knobcone and ponderosa pine.**

(B), **poison oak dominates the brush associates of this nearly pure stand of Monterey pine.**

(C), **all-age class stand makes vigorous growth when relieved of the impact of disease.**

A

B

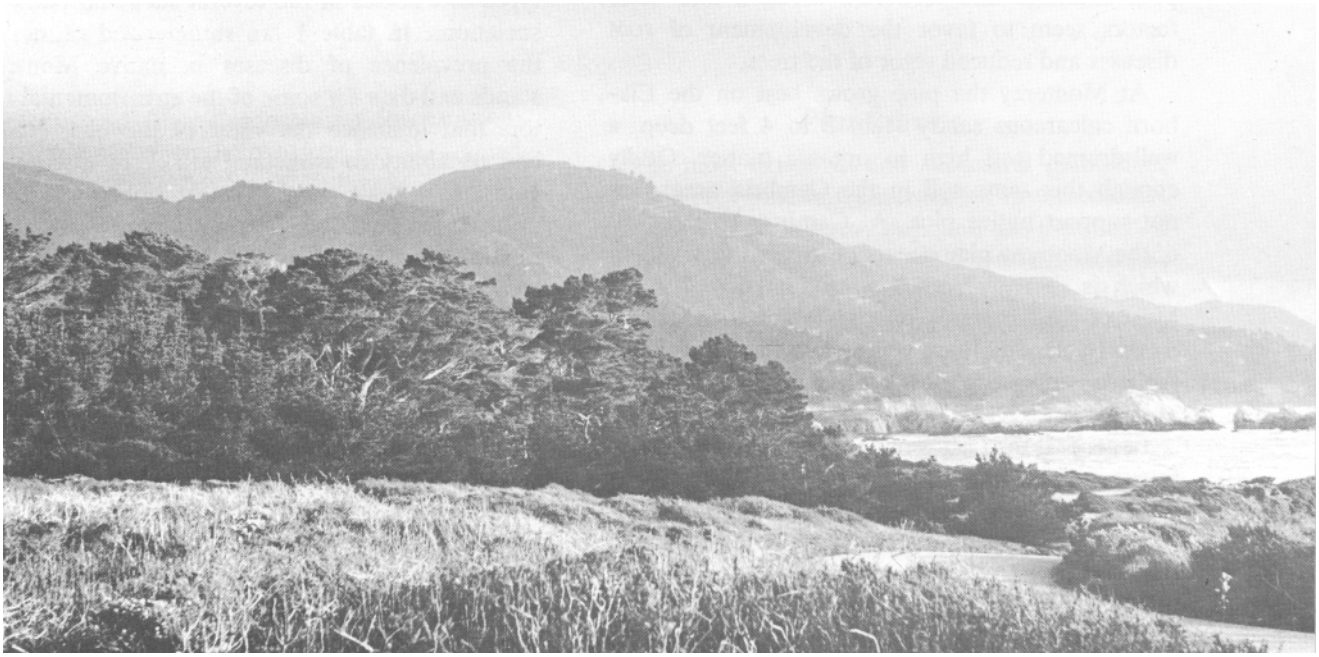

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Figure 5.—Natural stands of Monterey pine on Monterey peninsula.

(A), **densely stocked all-age stand on Huckleberry Hill.**

(B), **lightly thinned two age-class forest on the coastal plain.**

(C), **windswept stand at ocean edge.**

how lines are drawn around intermingled pine, grazing, and brush land. Some estimates have been as high as 20,000 acres and some as low as 8,000. Vegetation type maps of the Pacific Southwest Station suggest that the total acreage of native Monterey pine in these three localities is closer to 14,000 acres—distributed as follows: 1,000 (Swanton) in San Mateo and Santa Cruz counties, 8,000 to 12,000 (Monterey) in Monterey county, and 3,000 (Cambria) in San Luis Obispo county. The Cambria acreage includes about 400 acres of Monterey pine at Pico Creek some 6 miles north of the main body of pine at Cambria.

The climate in all three localities of the natural stands can be briefly described as Mediterranean and is quite similar in respect to seasonal distribution of 15 to 35 inches rainfall, the prevalence of summer fog, the rarity of frost, the absence of snow or hail, and moderate summer temperatures. About 75 percent of the annual rainfall occurs from December through March.

There is considerable variation in the soils at Swanton, Monterey, and Cambria (Lindsay 1937). Shales and marine sandstones intermixed with calcareous material from underlying rocks predominate at Swanton (Jensen 1939); granite, siliceous shales, and sandstones at Monterey (Carpenter and Cosby 1929); and slates, sandstones, and limestones at Cambria (Carpenter and Storie 1933). Monterey pine does well on soil derived from these rocks if the soil is not too shallow or too poorly drained. Heavy clay soils usually mean poor drainage and restricted aeration and these factors seem to favor the development of root diseases and reduced vigor of the trees.

At Monterey the pine grows best on the Elkhorn calcareous sandy loam 3 to 4 feet deep, a well-drained soil high in organic matter. Oddly enough this same soil in the Cambria area does not support native pine. At Cambria virtually all of the Monterey pine occurs on Arnold sandy loam which is derived from a consolidated sandstone. Most of the Monterey pine at Swanton occurs on Santa Lucia clay loam where growth and vigor of the tree is noticeably better than on the same soils at Monterey.

In general the best growth and the most disease-free conditions in Monterey pine stands will be found in sites where the soils are well drained, deep, and are made up of sandy loam. Although Monterey pine often makes excellent growth on light sandy soils, it seems probable that mycorrhizal formers may be contributing to nutrient assimulation under these conditions. Monterey pine reproduces vigorously (fig. 2) under a wide variety of soil and climatic conditions. Restrictions of environment and disease appear later in their impact on growth and longevity.

Important differences among the three areas in terrain, exposure, and vegetation seem to be reflected in the kind and prevalence of diseases. To a pathologist's eye, the stands at Cambria seem less vigorous than those at Swanton and less vigorous than many of the segments of the forest in the Monterey Peninsula. Perhaps this situation is a reflection of a single-species coniferous stand compared with a mixed-species forest.

California live oak (*Quercus agrifolia* Née) is an associate of Monterey pine in the three locations. In the single-species coniferous stand at Cambria (fig. 3), the coastal form of the western gall rust (*Peridermium harknessii*)[7] and the western dwarfmistletoe (*Arceuthobium campylopodum*) are prevalent and damaging on all age classes of trees. In the mixed coniferous forest at Swanton (fig. 4) where *P. radiata* is associated on lower slopes with redwood (*Sequoia sempervirens* [D. Don] Endl.), on mid-slopes with Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), and on upper slopes with knobcone pine (*Pinus attenuata* Lemm.), there is a widely distributed but light infection of gall rust and no known dwarfmistletoe. At Monterey both gall rust and dwarfmistletoe cause important losses, but there is considerable variation in the prevalence of all types of diseases in the several sites and plant associations. In table 1 are summarized ratings on the prevalence of diseases in native Monterey stands and data for some of the environmental factors that influence the vigor of the host conifer and its ability to withstand attack of disease organisms.

Botanists have long been interested in the interrelationship of the mainland *P. radiata* and similar closed-cone pines of the islands off the shores of

[7]Authors for scientific names of all pathogens are given later in the lists of fungi and parasitic plants for native stands and plantations and in the Appendix for exotic Monterey pine. Names and authors of fungi have been verified by C. R. Benjamin and John A. Stevenson, mycologists, U.S. Department of Agriculture, using their preferred style of omitting prestarting-point authors. Abbreviations of authors are those given in U.S. Department of Agriculture Handbook 165 (1960).

Table 1. Ratings on prevalence of five types of diseases on Monterey pine at Swanton, Monterey, and Cambria, and some related data on climatic and ecologic factors affecting host vigor

Disease and factor as listed	PREVALENCE[1] Swanton	Monterey	Cambria
Gall rust	1	2	3
Root diseases	2	3	1
Heart rots and other decays	1	3	2
Foliage diseases	1	3	2
Dwarfmistletoe	[2]1	2	3
CLIMATIC AND ECOLOGIC DATA			
Rainfall, mean annual (inches)	27.7	16.7	20.4
Av. abs. max. temp. °F. (May-Oct.)	102.7°	90.3°	105.0[0]
Av. abs. min. temp. °F. (Nov.-Apr.)	24.9°	26.3°	25.5°
Av. length of growing season (frostless days)	270	307	284
Soil variability	Intermed-late	Greatest	Least
Diversity of forest stand	Greatest	Intermediate	Least

[1]*1 - disease least prevalent; 2 - intermediate; and 3 - disease most prevalent.*

[2]*None found.*

California and Baja California.[8] Consensus now describes the pine on the Mexican island of Guadalupe as *P. radiata* var. *binata* and those on Cedros (Mexico), Santa Rosa (U.S.A.), and Santa Cruz (U.S.A.) as being most closely related to *Pinus muricata* D. Don. No information is available on pathogens associated with the closed-cone pines on any of these islands. Bannister (1958) reported an unidentified "rust fungus" on one herbarium specimen of pine from Guadalupe Island. A disease survey of these island stands Of the closed-cone pines would be of considerable interest to pathologists, especially in respect to tree improvement work.

[8]Bannister (1958), Howell (1941), Jepson (1910), Mason, (1943), and Newcomb (1959).

Plantations

The most extensive and successful plantations of Monterey pine in California are in the counties around San Francisco Bay and in portions of those counties near the ocean where the modified Mediterranean climate prevails (fig. 6). Recent data from Farm Advisors of these central California counties show about 1,200 acres of Monterey pines in larger plantations and numerous small plantings in windbreaks, parks, and home gardens. Trees have been planted as far south as San Diego in California and as far north as British Columbia.

At Placerville, California, in a climatic and soil environment quite different from native stands, planted Monterey pine made excellent growth until it encountered *Fomes annosus* (Bega 1962).

Figure 6.-Successful plantings of Monterey pine in the Berkeley hills, right foreground, and left and center on farther slopes.

Gall rust occurs in a 30-acre plantation of Monterey pine in Jackson State Forest near Fort Bragg, California (Sindel 1963). Some 14,000 seedlings (1-0 age class) were planted there in 1951-52. The number of infested trees and mortality have not yet been determined. Plantings of Monterey pine near Tahkenitch Lake near the coast of southern Oregon[9] and at Coombs, Vancouver Island, B. C.,[10] were successfully established but later became infected with *Peridermium harknessii*. At Tahkenitch 80 percent of the trees were attacked and at Coombs about 5 percent. Molnar (1961) reported a severe outbreak of the sweetfern blister rust (*Cronartium comptoniae*) in several plantations of Monterey pine on Vancouver Island, British Columbia, and warned of the need to guard against the introduction of this rust into other parts of the world.

Some of the oldest and most frequently examined plantations of Monterey pine in California are those in Old Sutro Forest, Golden Gate Park, and the Presidio, in the San Francisco area, and on the University of California campus at Berkeley. The first planting of Monterey pine on the U.C. campus was made about 1870. The Sutro Forest was established about 1880; plantings in Golden Gate Park and the Presidio were started about 1892 and continued on an intermittent schedule for 20 to 30 years. Many of the earliest herbarium collections of gall rust, and of foliage diseases such as the needle rust (*Coleosporium madiae*) (fig. 7), came from plantings in and near San Francisco. From these plantings comes evidence of heavy gall rust infection in young trees that does not continue at this high level as the trees grow older. As trees get taller and, older, environmental conditions in the live crown apparently become less favorable for infection. Then, as new infections diminish, there is a commensurate reduction in the amount of local inoculum.

In summary, successful planting of Monterey pine in west coast areas of North America is definitely limited by frost, midsummer heat, disease, and other pests. The most generally suitable sites for planting of Monterey pine in western North America are the coastal counties of central California. To date the western gall rust and the sweetfern blister rust have placed some limitations on the desirability of planting Monterey pine outside of its optimum range in California. Dwarfmistletoe has not yet been a limiting factor in plantations.

Major Diseases

Seventy-two pathogens are listed in a later section as associates of *P. radiata* in native stands of California and in plantations of western North America. The appendix records 86 fungi reported on exotic *P. radiata* but does not duplicate a pathogen if it has already been named for California and West Coast plantations. Mycorrhiza of exotic Monterey pine are not listed in the appendix, but are briefly reviewed later under the heading "Mycorrhiza." Of these 72 native pathogens, 17 are briefly discussed here because of their common occurrence or their potential for damage in natural stands or plantations. Highlights of the behavior of these pathogens are given by categories of so-called major diseases: seed and seedling, foliage, stem, and root diseases, and decays and stains. A more critical appraisal of the damage factor would restrict major diseases in native

[9]Personal correspondence with D. P. Graham, U.S. Forest Service, Portland, Ore. Jan. 3, 1963.

[10]Personal correspondence with A. C. Molnar, Canadian Forest Entomology and Pathology Laboratory, Victoria, B.C. Feb. 19, 1963.

stands and West Coast plantations to those caused by: *Arceuthobium campylopodum, Armillaria mellea, Cronartium comptoniae, Fomes annosus, Fomes pini, Peridermium harknessii* (*Peridermium cerebroides* nomen nudum), and *Polyporus schweinitzii.*

Seed and Seedling Diseases

No disease problems of any significance have affected the production and germination of Monterey pine seed and the natural or nursery establishment of seedlings under California conditions.

At Swanton, Monterey, and Cambria *P. radiata* flowers in early spring, and produces some fertile cones at 6 to 8 years of age. From the age of 15 to 20 years while trees are in good vigor they produce seed in abundance. Cones shed seed annually and remain on trees for many years. Mirov (1946) states that the seed of Monterey pine has excellent keeping quality in cold storage and Schubert (1952) reports that cold-stored seed retained a viability of 71 to 87 percent after 16 to 17 years. The quality of seed, however, may be impaired by improper treatment during collection, extraction, storage, and other pre-planting procedures.

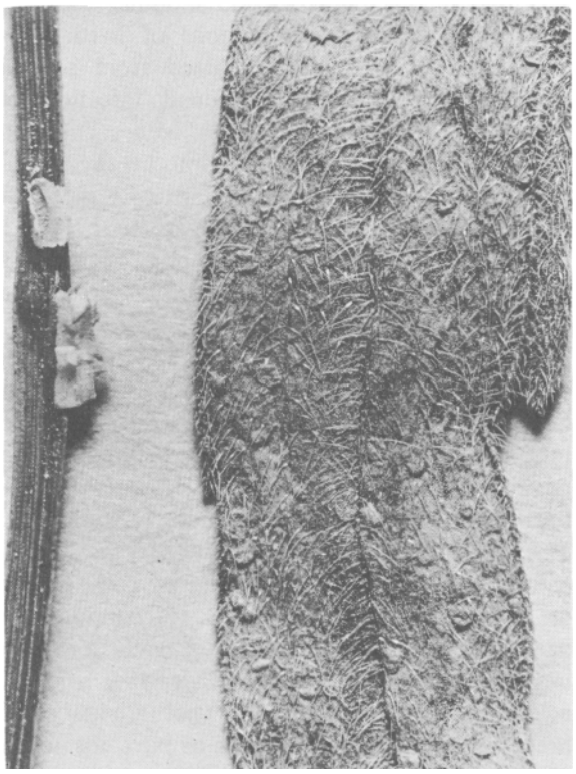


Figure *7.—Coleosporium madiae,* needle rust showing, left, the ruptured aecial pustules on Monterey pine needles, and right, the uredial stage on the leaves of tarweed. Alternate host, in this case, is *Madia saliva.*

No special disease research has been directed to seed of Monterey pine in California, but the role of fungi on coniferous seed in West Coast areas is suggested by reports from Schubert (1960) for sugar pine and Shea (1960) for Douglas-fir. Not all of the fungi listed by Schubert and Shea were believed to be pathogenic on the embryo or to carry over into the post-emergence period of development. Among the suspect genera of fungi isolated were: *Aspergillus, Gliocladium, Monilia, Mucor, Penicillium, Pullularia, Rhizopus,* and unidentified bacteria.

In California most of the Monterey pine nursery stock is grown in the State Division of Forestry Ben Lomond nursery near Santa Cruz. Production of *P. radiata* there is scheduled for about one-half million seedlings per year. In 1962 a modest start was made in production of Monterey pine nursery stock at the Forest Service nursery at Arcata, California. A few commercial nurseries in other parts of the State grow a small amount of stock for home garden supply.

The performance of Monterey pine seedlings in California nurseries has generally been excellent. In fact, nurserymen have to guard against excessive growth for field planting stock. At the Ben Lomond nursery seedlings may grow to an average size of 16 inches from the normal seeding time, in April, until the preferred lifting date, the following January or February.

P. radiata is not immune to damping-off and to some of the later developing root diseases, but little trouble has been experienced to date in well-designed nursery procedures. Although *Pythium, Rhizoctonia, Fusarium,* and *Macrophomina* have been isolated from soils at Ben Lomond nursery, no major losses have occurred in beds of Monterey pine. *Pythium* in particular, as well as *Rhizoctonia,* appears to have an impact on root regeneration of Monterey pine seedlings and this problem is being studied by forest scientists from the University of California and the Forest Service.

The stocking and persistence of Monterey pine reproduction in both natural stands (fig. 2) and plantations (fig. 6) attest the vigor of this species even though gall rust and dwarfmistletoe often take a substantial toll of young age-class trees.

Foliage Diseases

Judging from collections and reports of the past 50 years, the most prevalent or potentially damaging foliage diseases are: *Coleosporium madiae, Hypodermella limitata, Hypoderma pedatum, Lophodermium pinastri,* and *Naemacyclus niveus.* Of these fungi *N. niveus* is probably the most widespread and damaging in the three areas of native pine. *Diplodia pinea,* a much-studied foliage and twig blight of exotic Monterey pine, occurs but rarely on native pine and has not been a serious pathogen under California conditions. The absence of hailstorms in coastal areas of California may be one of the important environmental factors that has curtailed the buildup of *D. pinea,* a wound parasite, in native stands. In exotic stands, *D. pinea* is often troublesome in localities persistently subjected to hailstorms.

The damage caused by foliage diseases varies considerably from year to year depending on climatic conditions. For a heteroecious rust such as *Coleosporium madiae* (fig. 7) close association of host plants as well as locally favorable climatic conditions are essential to rust intensification. Since the host *Madia* spp. are intolerant plants, they are suppressed with increased age and density of plantations or natural regeneration. *C. madiae* is most apt to occur in young open stands of pine during years when spring rains are above normal.

It is worth noting that *Elytroderma deformans* (Weir) Darker, a prevalent and damaging foliage and twig blight of hard pines in California, is not known to occur on Monterey pines.

Personal communications from pathologists I. A. S. Gibson, L. S. Gill, and J. O. Whiteside, and a report by Gibson (1963) call attention to the occurrence of a damaging needle blight (*Dothistroma pini*) in Monterey pine plantations of East Africa. This pathogen has not been found in western North America, or not reported under that name. A further report on the situation in East Africa by I. A. S. Gibson, P. S. Christensen, and F. M. Munga is in preparation.

Stem Diseases

Gall Rust

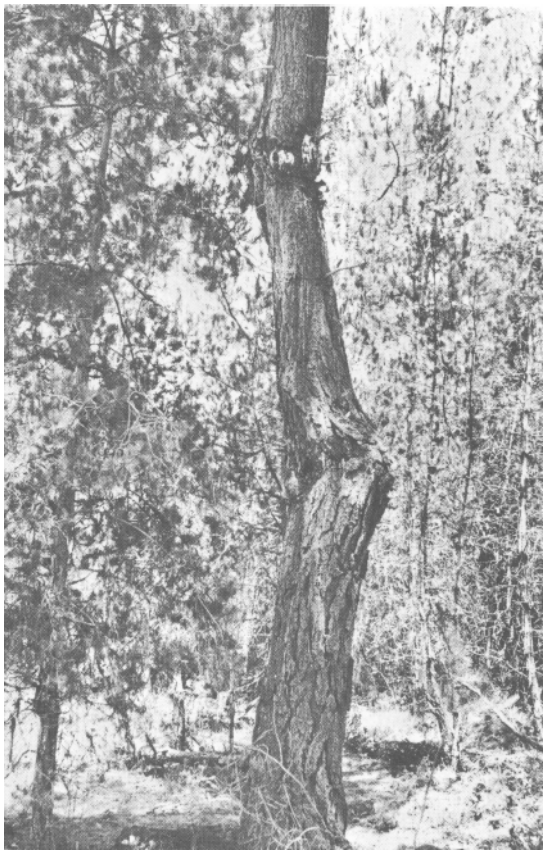
The western gall rust in its coastal form of *Peridermium cerebroides* occurs at damaging levels in Cambria, Monterey, and Swanton stands of Monterey pine and in plantations throughout central coastal California (fig. 8). *Peridermium cerebroides,* a nomen nudum as described by Meinecke (1929), has not yet been described validly as a species. The *Peridermium harknessii* form of the gall rust is found in some plantations in California, and in Oregon, Washington, and British Columbia wherever natural inoculum of this form of the rust is locally prevalent. Introduced into exotic plantations in regions where native gall rust does not occur, this fungus might seriously impair the productivity of Monterey pine as a forest species. Experience in North America shows clearly that the gall rusts may be vigorous and damaging diseases under a wide range of climatic conditions.

Both forms of the western gall rust have been transmitted to Monterey pine seedlings by artificial inoculation (Meinecke 1916, 1920, 1929). Successful inoculations were made by the spore shower method on intact stems and foliage, thus showing that artificial wounding of tissue is not necessary. Galls produced by inoculation retained characteristics typical of *Peridermium cerebroides* or *Peridermium harknessii.* Swelling and typical infection spots occurred in 5 to 20 months and sporulation in about 20 to 35 months.

From a series of inoculations of hard pines with aecia of gall rusts obtained from several sources, Boyce (1957) obtained infection of Scotch pine (*Pinus sylvestris* L.), with aecia from Monterey pine. Boyce's tests did not include inoculation of Monterey pine seedlings with gall rust aecia from other hard pines. Nevertheless, he did confirm in the case of the Scotch pine, Meinecke's (1920) descriptions of the distinctive appearance of the *P. cerebroides* galls on Monterey pine.

Both *Peridermium harknessii* and *P. cerebroides* stimulate the formation of witches'-brooms and both retard the growth of the infected stem; where infection of the main stem occurs they can cause death of a small tree. Mycelium is invariably confined to the gall and its immediate surroundings. The galls of *P. cerebroides* tend to become spherical and seldom show exfoliation of bark during or after sporulation (fig. 9A). By contrast the bark that overlays *P. harknessii* galls tends to break and scale off, showing underlying smooth, naked wood (figs. 9B and 9C) well in advance of branch killing. The exfoliation of bark results in the formation of a collar of dead bark on *P. harknessii* galls that stands out most clearly at the proximal end of the swelling (fig. 9B). This collar seldom if ever is seen on the *P. cerebroides* galls on Monterey pine or on other coastal hard pines (*Pinus muricata* and *Pinus attenuata*) attacked by

A

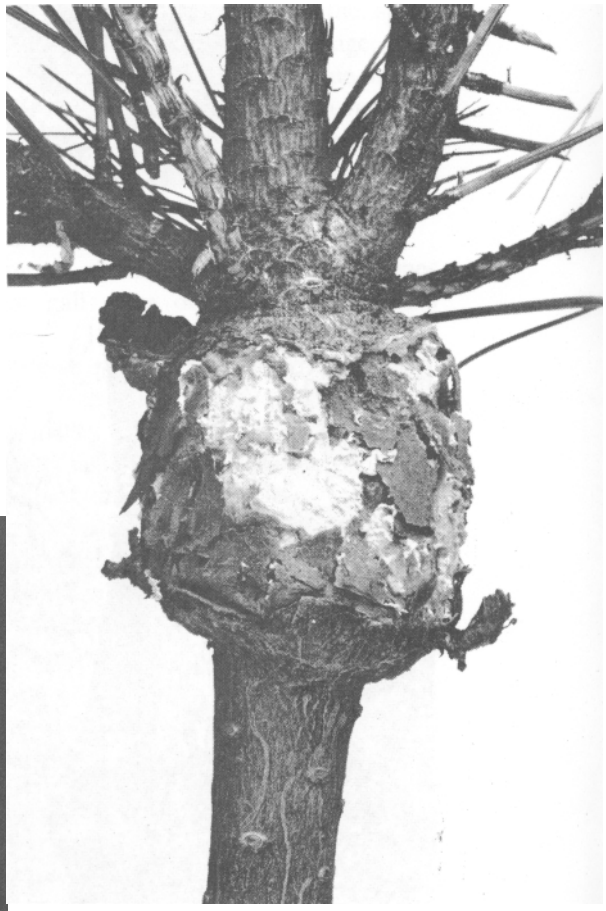


B

C

Figure 8.—Bole defects to mature *(A)* and *(B)* and pole and sapling *(C)* Monterey pine by gall rust *(Peridermium cerebroides)*. Trees shown in *(A)* and *(B)* were also attacked by dwarf mistletoe.

A



C

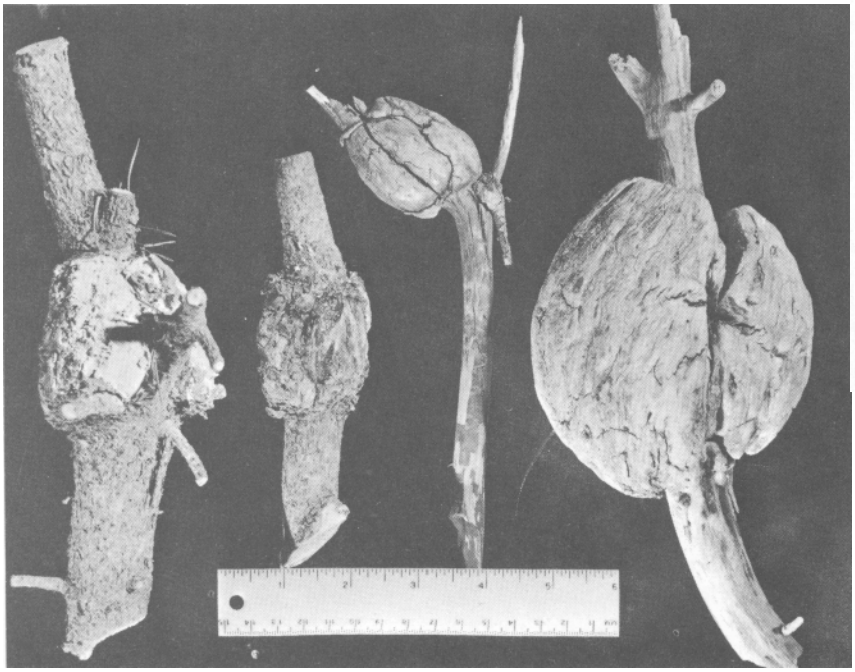
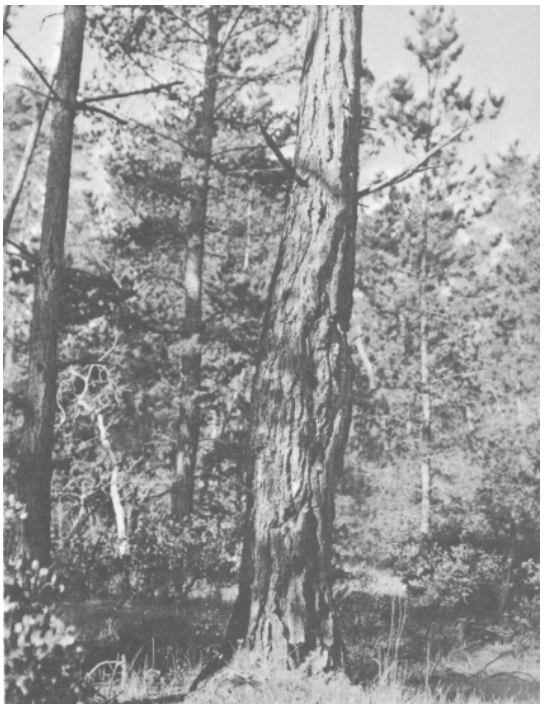


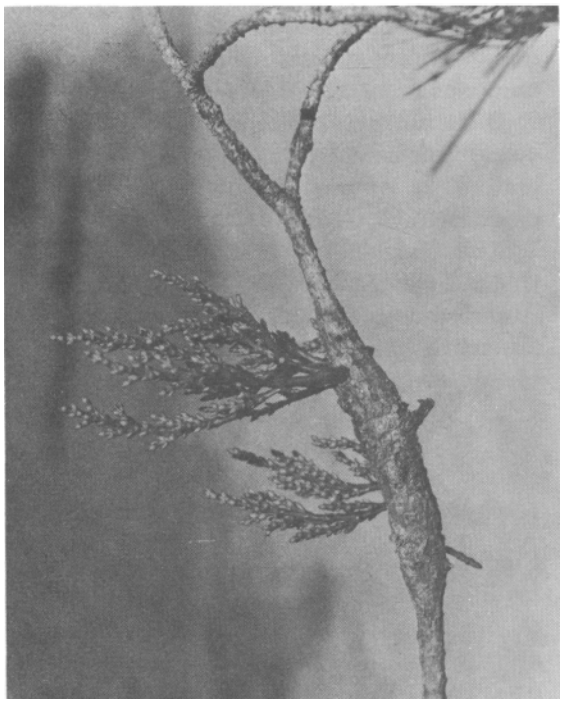
Figure 9.—Galls formed by *Peridermium cerebroides* and *P. harknessii. (A)* On Monterey pine *P. cerebroides* forms a globose gall that retains bark scales and does not form the bark collar shown in *(B)*. *P. harknessii* on *Pinus sabiniana (B)* causes early exfoliation of bark, induces the formation of a bark collar, and progresses towards the bare wood galls as shown in *(C)* well in advance of branch suppression. Note also in *(B)* and in *(C)* on left, the mass of confluent aecia.

A



B

Figure 10.—Bole defects caused by long-established dwarfmistletoe infections. *(A)* Swelling and cavity. *(B)* Long fusiform swelling.



A

Figure 11.—Western dwarfmistletoe *(Arceuthobium campylopodum* f. *typicum)* on Monterey pine. *(A)* Seed-hearing (female) plant on a small branch. *(B)* Pollen-bearing (male) plant on the trunk of a pole-size tree.

B

this form of the rust. Meinecke (1920) states that aecia of *P. harknessii* are larger and more definitely confluent than those of *P. cerebroides,* but these characteristics by themselves do not always help the field man to identify the fungus.

As with other Peridermia of conifers the pycnia of *Peridermium cerebroides* are rarely seen in the field. Although Meinecke (1929) never observed pycnia on natural or artificially induced infections of *P. cerebroides,* he believed that the production of pycnia is merely repressed and that internal pycnia should be found. Gill (1932) reported seeing pycnia on native *P. attenuate* in the Santa Cruz Mountains of California in February and on a collection made in January from planted *P. radiata* near Palo Alto, California, after infected tissue had been sectioned in the laboratory. Production of aecia extends over several months in coastal regions of California, the period depending on the ecologic niche in which the host is growing. Usually peak production of aecia takes place in February and March.

Sweetfern Blister Rust

Sweetfern blister rust (*Cronartium comptoniae*), a well-known and widely distributed rust of hard pines (Anderson 1963; Boyce 1961), does not occur in native stands of Monterey pine. Experience in plantations of British Columbia (Molnar 1961), however, clearly shows that this rust is a dangerous disease of Monterey pine. Sweetgale (*Myrica gale* L.), known in British Columbia, Washington, and Oregon, is a confirmed alternate host. *Myrica californica* Cham., widely distributed in coastal areas of California, Oregon, and Washington, and *Myrica hartwegii* Wats. from the Central Sierra Nevada of California are unproven but suspect hosts. In the West, known susceptible native pines are lodgepole, ponderosa, bishop, Jeffrey, and Monterey. Thus, both hosts and the rust are widely distributed in West Coast areas.

Molnar (1961) recorded damage to 9,000 Monterey pine in 12 British Columbia plantations. He found 2, 5, 1, and 3 plantations falling respectively into five designated classes of 0, 1-10, 11-50, 51-75, and 76-100 percent of pine infected. Molnar (1961) concluded that Monterey pine is a high risk species for planting in the coastal regions of British Columbia.

Dwarfmistletoe

Arceuthobium campylopodum f. *typicum,* the western dwarfmistletoe, is a parasitic seed-bearing plant that attacks and damages the hard pines. This parasite, native to Monterey pine stands in California, finds a highly susceptible host in *P. radiata* (fig. 10). In the Cambria and Monterey areas dwarfmistletoe and the gall rust are the most prevalent and destructive pathogens of Monterey pine.

There are no special features of the western dwarfmistletoe on Monterey pine to distinguish it from the dwarfmistletoe found on other hard pines (fig. 11). Gill (1935, pp. 185, 190, and 221) in his publication on dwarfmistletoes in the United States states that "On *Pinus radiata* the (dwarfmistletoe) shoots are characteristically a distinctive olive green shade"—and "The large

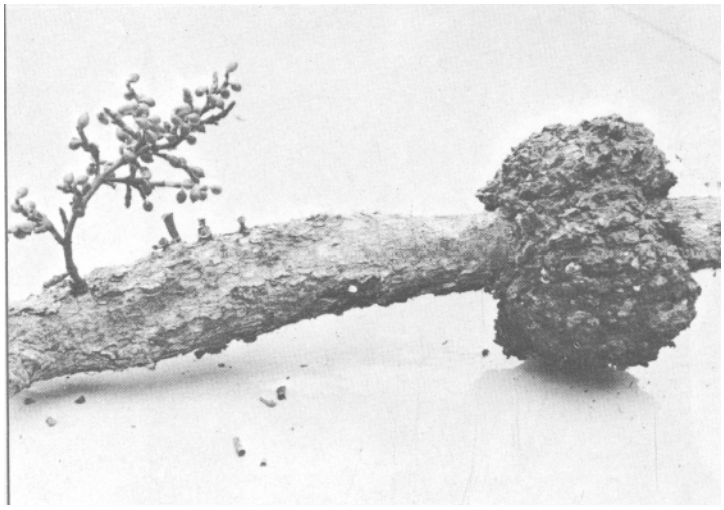


Figure 12.—Gall rust *(Peridermium cerebroides)* and western dwarfmistletoe *(Arceuthobium campylopodum)* often combine their attacks on Monterey pine. Mature seeds of dwarfmistletoe were ripe and being discharged in November at Cambria when this picture was taken.

dense clusters of shoots characteristic of old infections—seem especially to attract spittle insects (Cercopidae) which mine out the stems causing the death of branches or entire shoots." Kuijt (1960) includes Monterey pine as host for the western dwarfmistletoe in California but does not go into detail on this host-parasite combination. A comprehensive review of the literature of the mistletoes has been made by Gill and Hawksworth (1961).

Observations on the host strongly suggest that trees weakened by dwarfmistletoe are often attacked by insects.

Dwarfmistletoe is most prevalent on trees of young pole class or larger though occasionally it will occur on reproduction under 10 feet in height. All sizes of trees are damaged, deformed, or, in multiple heavy infections, killed by this parasite. The pathogen often causes fusiform swellings on twigs and branches. Older infections on the main stem may cause little or no swelling; here the dwarfmistletoe breaks out between cracks in the bark. Witches'-brooms caused by dwarfmistletoe are common.

Decayed and sunken faces of older branches or the trunk of Monterey pine may be associated with gall rust, dwarfmistletoe, or mechanical or animal damage. In many locations within the Cambria and Monterey pine areas dwarfmistletoe and gall rust may occur in multiple infections on the same tree (figs. 8 and 12). Both pathogens apparently find an ideal environment for spread and intensification in coastal areas of central California.

Linder (1938) reported the occurrence of *Metasphaeria wheeleri* Linder sp. nov. a natural parasite on scales and stems of *Arceuthobium campylopodum* on Monterey pine, Point Lobos State Park, California.

Control of dwarfmistletoe in Monterey pine is through removal of infected branches or trees in accordance with silvicultural objectives as outlined by Kimmey (1957) and by Kimmey and Mielke (1959). There are no special elements in the control of dwarfmistletoe on Monterey pine that require different methods from those recommended for other hard pines.

Cankers

There are no parasitic canker fungi of any significance occurring in native stands of California or in West Coast plantations. Mention should be made, however, of the susceptibility of Monterey pine to pitch canker *Fusarium lateritium pini* as reported by Hepting (1961). This fungus is primarily a wound parasite. It is pathogenic and destructive to Monterey pine seedlings and should be regarded as potentially dangerous to Monterey pine both native and exotic. Nothing comparable to the smothering fungus, the so-called "Glenburvie fungus" from New Zealand or its reported equivalent of *Peniphora sacrata* (Gilmour 1959), has been found in California.

Root Diseases

The most prevalent and damaging or potentially damaging root diseases associated with Monterey pine in native stands or West Coast plantations are: *Armillaria mellea, Fomes annosus,* and *Polyporus schweinitzii.*

Of these, *Fomes annosus is* unquestionably the most important. It was reported about 1909 in some of the earliest surveys by Meinecke and others in the Monterey peninsula. Experience at the Eddy Arboretum of the Institute of Forest Genetics at Placerville (Bega 1962) attests to the high susceptibility of Monterey pine to *F. annosus* in plantations. Most of the tree killing by *F. annosus* in the Monterey area seems to be associated with shallow, poorly drained, heavy soils where the trees have not been making average growth.

E. P. Meinecke, in an unpublished report in the forest pathology files of the Pacific Southwest Station, provides a detailed description of the annosus rot in wood and bark, and of the sporophores and mycelium of the fungus. In herbarium records supporting these descriptions, he noted that "40 to 70 percent of trees over 40 years of age in the grounds of the Del Monte Hotel property a little above sea level" were affected.

The prevalence of oaks in natural stands of Monterey pine at Cambria and Monterey suggests that *Armillaria mellea* should be of fairly common occurrence. It is. Losses from *A. mellea,* however, are not alarming and generally appear to be contained by natural biologic agents.

Although *Phytophthora cinnamomi* has been found only once on nursery stock from southern California (Zentmyer and Munnecke 1952), experience in New Zealand (Newhook 1959, 1960) provides ample evidence of the aggressiveness of *Phytophthora* spp. to Monterey pine. Great care should be exercised to prevent *Phytophthora* spp. from being introduced into forest nurseries or native stands of Monterey pine. Sutherland et al.

Figure 13.—Fomes *pini* conks on Monterey pine in Huckleberry Hill, Monterey area. For Monterey pine these are unusually large and conspicuous conks of this heart rot fungus.

(1959) observed increased susceptibility to *Phytophthora* spp. and a slower recovery rate of affected Monterey pine growing in poorly drained soils.

Polyporus schweinitzii is widely distributed in the three areas of native Monterey pine, where it often is associated with the mortality of fast growing and apparently vigorous pole-sized or young mature trees. It seems likely that in addition to its well-known role in causing decay of root and butt, *P. schweinitzii* can actually be a root pathogen as described by Boyce (1961). Not infrequently *P. schweinitzii* conks occur on the main stem about 15 to 25 feet from the base of a standing tree. At Swanton and Monterey, *P. schweinitzii* conks were found in association with insects on recently killed trees that had been making excellent growth in deep, seemingly fertile soils.

Decays and Stains

Native and exotic Monterey pines are attacked by a broad spectrum of organisms causing decay of heartwood and sapwood, staining of sapwood, and deterioration of wood. Of the rot fungi causing significant losses of Monterey pine timber in California, *Fomes pini* (fig. 13), *Polyporus schweinitzii, Armillaria mellea,* and *Polyporus tomentosus* are especially noteworthy. *F. pini* and *P. schweinitzii* both occur at Cambria, Monterey, and Swanton, but occurrence is spotty within these areas. Heart rot losses in Monterey pine are generally low, probably on the order of 2 or 3 percent of the total volume of merchantable timber. *Polyporus anceps* has been found on native Monterey pine but it is not common. The most prevalent saprophyte found on dead trees or down logs and slash is *Polyporus abietinus.* Under favorable conditions blue stain and other sapstain fungi will develop in windblown or felled trees in the woods and in log decks.

Other Diseases, Disorders, and Protection Problems

Mycorrhiza

No published information is available on mycorrhizal symbionts of Monterey pine in native stands of California. Several of the well-known mycorrhizal formers are native to California and others listed for Monterey pine from other parts of the world will doubtless be found here. Sporophores of *Boletus* sp. and *Amanita* sp. were often seen in Monterey pine stands of the Cambria, Monterey, and Swanton areas, during recent surveys by Forest Service personnel.

Trappe (1961) observed sporophores of *Inocybe lacera* associated with Monterey pine seedlings grown in jars of soil inoculated with freshly gathered mycorrhiza of Douglas-fir and ponderosa pine. MacDougal and Dufrenoy (1944a, 1944b) made histological studies of the ectendotrophic symbionts of *P. radiata,* and reported that the association did not seem to be connected with any morphological alterations. They described the anatomy of the pine symbiont and also the biochemistry of phenolic compounds in the root peri-

cycle and endodermis. Wallis (1959) studied the effects of chlordane, allyl alcohol, dieldrin, and other biocides on mycorrhizal fungi associated with *P. radiata,* which seemed generally to be little affected by these chemicals in dosages used.

Zak and Bryan (1963) have properly emphasized the difficulties of extrapolating from data on mycorrhizal synthesis to conditions as they exist in the forest. Several workers have reported the role of mycorrhiza in the culture of *P. radiata* as an exotic.[11] In a recent review Trappe (1962) listed the following fungus associates of the ectotrophic mycorrhiza for *P. radiata:*

- *Amanita muscaria* (L. ex Fr.) Pers. ex Hooker
- *Cenococcum graniforme* (Sow.) Ferd. & Winge
- *Gomphidius rutilus* (Schaeff. ex Fr.) Lund & Nannf.
- *G. vinicolor* Peck
- *Inocybe lacera* (Fr.) Kumm.
- *Laccaria laccata* (Scop. ex Fr.) Berk. & Br.
- *Lactarius deliciosus* (L. ex Fr.) S. F. Gray
- *Rhizopogon luteolus* Fr. & Nordh.
- *R. roseolus* (Corda) Hollos
- *R. rubescens* Tul.
- *Scleroderma aurantium* (Vaill.) Pers.
- *S. bovista* Fr.
- *Suillus granulatus* (L. ex Fr.) O. Kuntze
- *S. luteus* (L. ex Fr.) S. F. Gray
- *S. piperatus* (Bull. ex Fr.) O. Kuntze
- *S. subaureus* (Peck) Snell

Martinez[12] has reported *Amanita muscaria, Cantharellus cibarkus* Fr., and *Marasmius oreades* Fr. as mycorrhizal symbionts of Monterey pine in Spain. Of all these only C. *graniforme, I. lacera, R. rubescens,* and *S. luteus* have been established for Monterey pine by pure culture technique (Rawlings 1951, Trappe 1961).

Physiogenic Disorders

In recent years planted Monterey pine in the San Francisco Bay counties has shown an increasing amount of needle cast and chlorosis of foliage. No fungus or insect of a primary nature is involved in this damage. It is suggested that physiogenic needle cast from drought, nutrient deficiencies, and occasional , spells of low temperature plus some added impact from air pollutants are responsible. Monterey pine may be one of the more sensitive of the pines to air pollutants.

Large brooms (fig. 14) that resemble those associated with dwarfmistletoe infections have been observed occasionally on scattered Monterey pine in the Cambria, Monterey, and Swanton areas. Close examination of these brooms discloses no evidence of the causal agent. They are presumed to be the result of some physiogenic disorder.

In field trials at Tahkenitch Tree Farm in southern Oregon (Austin and Strand 1960) *P. radiata* and *Pinus* X *attenuradiata* hybrid showed increased response in height growth to phosphorus fertilizers. Increased phosphorus uptake has been credited to mycorrhizal symbionts (Morrison 1957). Neither the native stands of California nor West Coast plantations have produced unusual symptoms such as needle fusion, rosette disease or the obvious symptoms of zinc, potassium, phosphorus,

Figure 14.—Physiogenic brooming in Monterey pine. Note large brooms in upper crown of tree at left side of mill. The mill shown is in Carmel Valley and is one of two small mills in California cutting Monterey pine lumber for local sale.

[11]Azevedo 1959; Clements 1938; Cromer 1935; Morrison 1957; Rawlings 1951, 1960.

[12]Martinez, Jose Benito. Third annual report of progress of research sponsored by P. L. 480. 1963 (Unpublished report to Inst. Forest. de Invest. y Exper., Madrid.)

and boron deficiencies such as have been reported in exotic stands from Australia and other countries.[13]

Insect, Animal, and Fire Damage

Keen (1952) lists 50 species or genera of insects occurring on Monterey pine in California. Of these, three species of ips and the red turpentine beetle (*Dendroctonus valens* Lec.) are marked as tree killers. Burke (1937) reports 26 insects as important enemies of native Monterey pine. Struble (1961) in discussing the Monterey pine ips (*Ips radiatae* Hopk.) states that maturing trees may be attacked when weakened by competition from drought, mistletoe infection, or fungus infection by *Peridermium.* Similarly the red turpentine beetle seems to be unusually aggressive in plantings located in hot, dry sites that might be considered as marginal for growth of Monterey pine. Pathologists .have remarked on the prevalence of the spittle bug *Aphrophora permutata* Uhl. in trees and stands where *Peridermium cerebroides* or *P. harknessii* infections are common.

The sequoia pitch moth *Vespamima sequoiae* (Hy. Edw.) causes the formation of large amounts of a greyish resin on the bark. Old dwarfmistletoe bole infections also contribute to copious resin flow that often combines with that produced by the pitch moth. Associated with this external body of resin there may be a wedge-shaped intrusion of pitch in the sapwood that closely resembles the pitching caused by pitch canker *Fusarium lateritium pini* on Virginia pine (*Pinus virginiana* Mill.). Attempts to isolate this fungus from these pitch wedges of Monterey pine wood have failed.

Beetles, of course, are involved in the introduction of blue-stain fungi (*Ceratocystis* spp.) into the sapwood of Monterey pine, and a sooty mold (*Epicoccum* sp.) is often seen in association with scale insects.

In California the low level of incidence of *Diplodia pinea* on Monterey pine may be attributed to the nature of injuries caused by some of the aphids, mites, and scale insects as well as to the absence of hailstorms. Native stands of Monterey pine have not been subject to outbreaks of wood wasps and associated fungi similar to the *Sirex noctilio* Fabr. outbreaks reported from New Zealand (Rawlings 1955).

Native stands of Monterey pine at Cambria and Monterey were subjected to considerable grazing and burning until the late 1920's when land managers became active in protecting the timbered areas. Monterey pine produces seed in such abundance, and it regenerates so aggressively that depredations by cone and seed insects, ants, rodents, and deer are not often serious problems to the forest manager. Schaefer (1962) describes *Conophthorus radiatae* Hopkins as a major pest of Monterey pine cones in central California. This cone beetle is reported to have killed 90 percent of the cones in some stands of the Monterey area but is not known to occur in the Cambria and Swanton areas. There seems to be no special disease problems correlated with animal damage, though damage by deer and rodents has been observed in plantations (Sindel 1963).

A relatively thin-barked pine, *P. radiata* has been rated in Australia (Pryor 1940) as more susceptible to fire damage than *Pinus ponderosa* Laws. or *Pinus jeffreyi* Grev. & Balf. In native stands, fire-wounds are frequently associated with the presence of heart or butt rots and almost always with many saprophytic fungi. Extensive patches of even-age Monterey pine that have come in after fire tend to be free of dwarfmistletoe, but may be heavily infected with gall rust.

[13]Hall and Purnell 1961; Herman 1938; Kessell 1943; Ludbrook 1942; Purnell 1958; Smith 1943; Stoate and Bednall 1957; Vail et al. 1961; and Will 1961.

Pathogens Associated with Pinus Radiata in Native Stands of California and Plantations of Western North America

In the list that follows the pathogens are identified by the name used in the supporting publication or as indexed in the California herbarium of record. The symbols for the four herbaria consulted are: PSW for the Pacific Southwest Forest and Range Experiment Station, Berkeley; UC for the University of California (Botany Department), Berkeley; CAS for the California Academy of Science, San Francisco; and PC for Pomona College, Claremont. The collector is named but not the one who identified the fungus. The symbols (X), (XX), and (XXX) that appear next to the name of the pathogen mean saprophyte, wound parasite, or obligate parasite in the sense of Spaulding (1961). As used here, these symbols refer to the behavior of the fungus on Monterey pine in western North America (when known) and do not necessarily categorize the fungus on other hosts.

Well-known fungi are not described unless the characteristics are noteworthy for Monterey pine. No attempt has been made to provide a list of synonyms.

Herbarium records, usually those for the earliest collections, are provided to support previously published listings of fungi marked U.S.A., California, as in Scott (1960) or where origin of collection has been unreported as in Seymour (1929).

Dwarfmistletoes

***Arceuthobium campylopodum* Engelm. forma *typicum* (Engelm.) Gill (XXX)**
(Loranthaceae)

Seed bearing plant parasitic on conifers. PSW 97954 (W. H. Long) from an arboretum near Palo Alto, San Mateo County, California, September 1911. Other collections from native stands in PSW herbarium. Occurs throughout native stands of Monterey pine at Cambria and Monterey but not yet reported from the Swanton area. Not known to occur on Monterey pine outside of central California, U.S.A.

Fungi

***Armillaria mellea* (Fr.) Quél. (XX)**
(Basidiomycetes, Agaricales)

Root rot. PSW 85069 (E. P. Meinecke) Golden Gate Park, San Francisco, May 1923. This collection from a planted tree 22 inches d.b.h. having roots and base of trunk affected, poor foliage throughout and tree declining, mycelium almost girdling the base up to 2 to 3 feet high in places. Recent Forest Service surveys in native stands of Monterey pine confirmed the presence of this fungus and its killing of pines in Monterey, Santa Cruz, and San Mateo counties. A host list for this fungus (Raabe 1962) shows a collection from a planted Monterey pine in California. Parasitic on roots of weakened trees causing decay of roots and death of trees. Characteristics of fungus and decay in Monterey pine similar to those described by Boyce (1961) for other pines. Listed by Scott (1960) for Chile, Kenya, and New Zealand, by Green (1957) for Great Britain, and by Martinez[14] for Spain.

***Botrytis cinerea* Fr. (XX)**
(Fungi Imperfecti, Moniliales)

Mold blight. Collected (G. R. Hoerner) March 1934, from the Peary Arboretum, Corvallis, Oregon, on seedlings of Monterey pine (Hoerner 1938). Listed by Shaw (1958) for Oregon. World-wide distribution as a blight of coniferous and broad-leaved trees. Described by Gibson (1962) as a nursery disease in Kenya causing dieback. Listed by Scott (1960) for New Zealand.

***Cenangium abietis* (Fr.) Rehm (XX)**
(Ascomycetes, Pezizales)

Twig blight. PSW 97700 (E. P. Meinecke) February 1926, Del Monte, Monterey County, California, on foliage and twigs of reproduction 5 to 10 feet tall. UC 469644 (H. E. Parks) Berkeley Hills, Alameda County, California, February 1923, on dead bark of planted Monterey pine. Apothecia small, black, cup-shaped. Listed by

[14]See footnote 12.

Seymour (1929) as similar to *Cenangium ferruginosum* Fr. and now generally called by this name rather than *C. abietis.* Usually associated with and follows injury by gall midge or scale insects. Boyce (1961), referring to *C. ferruginosum,* calls it "pruning disease" which causes intensive flagging injury of ponderosa pine in the Southwest, most prominent in spring and early summer.

***Coleosporium madiae* (Syd.) Arth. (XXX)**
(Basidiomycetes, Uredinales)

Needle rust. PSW 83479, 83480 (E. P. Meinecke) April 1915, near Monterey, California, and indexed as *Peridermium californicum.* Twelve later collections were made, February through early May 1917–1922 (E. P. Meinecke, W. W. Wagener, and E. Bethel) at Monterey and Carmel, along Skyline Boulevard in San Mateo County, and from Golden Gate Park, San Francisco. These collections, indexed as *Coleosporium madiae,* provide both aecial and telial stages of the fungus. The connection of the alternate stages was demonstrated by E. P. Meinecke in 1917 using aeciospores (PSW 85840, 85997) from *P. radiata* on *Madia dissitiflora* Nutt. T. & G. (Rhoades et al. 1918). Jeffrey and Coulter pines have also been reported as aecial hosts in California.

Coleosporium madiae on tarweed hosts has been collected in various parts of the coastal mountains and Sierra Nevada of California. An early report is that of Cooke (1879) who reported the fungus on living foliage of *Madia nuttallii* Gray in the Sierra Nevada; a later collection, UC 538806, on this same host was made near the coast in Humboldt County. Other California collections of the rust-infected *Madia* spp. were on *M. capitata* Nutt., UC 568080, Marin County, September 1922; on *M. congesta* T & G., UC 959786, Presidio, San Francisco, August 1913; on *M. dissitiflora,* UC M64532, Berkeley, Alameda County, July 1923; on *M. elegans* Don, UC 976868, Marin County, June 1926.

Arthur (1962) describes pycnia, aecia, uredia, and telia on host foliage. Aecia may occur on any face of the needle and all belong to the form genus *Peridermium.* Peridium flattened, laterally tongued-shaped; aecia white, large, appear in early spring (February to May) in native stands and central California plantations. Aecia are globoid to broadly ellipsoid. On tarweed leaves uredia are hypophyllous, round, golden-yellow; telia hypophyllous, orange-yellow when fresh; teliospores cylindric or oblong-lanceolate.

***Coniothyrium acuum* (Cke & Ell.) Harkn. (XX)**
(Fungi Imperfecti, Sphaeropsidales)

Needle rot. Collected (Harkness #1591) May 1884, on needles of planted pine at Woodland, California (Harkness 1885). Listed by Seymour (1929) as equivalent to *Phoma acuum* Cke. & Ell. and by Scott (1960) for U.S.A.

***Corticium punctulatum* Cke. (X)**
(Basidiomycetes, Agaricales)

Wood rot. PSW 85763 (E. P. Meinecke) April 1911, near Del Monte, Monterey County, California. On bark of dead tree. Listed by Scott (1960) for New Zealand.

***Cronartium comptoniae* Arth. (XXX)**
(Basidiomycetes, Uredinales)

Stem rust. Molnar (1961) confirmed the identity of the rust on planted Monterey pine from Vancouver Island by aeciospore inoculations on *Myrica* sp. and *Castilleja* sp. to distinguish *C. comptoniae* from *Peridermium stalactiforme* Arth. & Kern. The pathogen and its symptoms are described by Boyce (1961) and Anderson (1963). To date in-fection of Monterey pine with this rust is known only from British Columbia.

***Dasyscypha bicolor* (Fr.) Fckl. (XX)**
(Ascomycetes, Pezizales)

Canker. UC 585683 (Lee Bonar) October 1937, Oakland, California. Forms a canker-like lesion on dead bark. Spaulding (1961) reports *Dasyscypha calyciformis,* a probable synonym for *D. bicolor,* as a wound parasite occasionally causing damage to Monterey pine in New Zealand.

***Dermatea pini* Phill. & Harkn. (XX)**
(Ascomycetes, Pezizales)

Twig blight. CAS 2042 (Harkness #2505) type specimen, February 1881, San Francisco, California, on twigs of planted pine. Reported by Phillips and Harkness (1884) and listed by Seymour (1929) and Scott (1960) as equivalent to *Cenangium pini* (Phill. & Harkn.) Newcomb. U.S.A. only.

***Diplodia pinea* (Desm.) Kickx (XX)**
(Fungi Imperfecti, Sphaeropsidales)

Twig blight. UC 257173 (Lee Bonar) in San Rafael, Marin County, California on cone scales of planted *P. radiata.* UC 209258 (D. R. Miller) in Deer Flat County Park, Monterey County, California, November 1962 on dead needles and some live twigs. In Deer Flat County Park this fungus seems to have contributed to damage of foliage and twigs, but host trees here are in poor vigor and other stem and foliage disease are also present.

Hedgcock (1932) noted *Sphaeropsis ellisii* Sacc. (*D. pinea*) on greenhouse seedlings of *P. radiata* in Washington, D. C. Surprisingly, only two collections of *Diplodia pinea* as noted above have been made from Monterey pine in California.

The nomenclature and morphological and cultural characteristics of *Diplodia pinea* as well as the behavior of this fungus as a saprophyte and parasite are described in detail by Birch (1936) and Waterman (1943). Crandall (1938) reported that *Sphaeropsis ellisii* in nurseries of the United States caused root rot and death of 3- to 5-year-old red pines and of 5- to 6-year-old eastern white pine. Spaulding (1961) refers to *D. pinea* as causing a canker or twig blight. Slagg and Wright (1943) reported that *D. pinea* caused extensive damage to seedlings of *Pinus nigra* Arnold, *P. edulis* Engelm., *P. ponderosa,* and *Pseudotsuga menziesii* in a Kansas nursery, and that the fungus was found on needles, needle bases, bark, and cone scales of damaged branches of mature trees of *P. nigra, P. ponderosa, P. pungens* Lamb., *P. rigida* Mill., and *P. sylvestris L.*

Diplodia pinea on exotic Monterey pine has been the subject of much research and attention by pathologists and foresters.[15] *D. pinea* may be parasitic after injury by wind, hail, insects, birds, or frost and physiogenic disorders.[16] The fungus has been charged (Birch 1936) with damage to unthrifty trees resulting in: Secondary infection of stag-headed trees, red-top, stem infection, bud-wilt of seedlings, and sap stain. It is widespread and common in New Zealand as a saprophyte on foliage, dead bark, wood, and cones. Recently, many pathologists take the position that damage, potential or actual, from *D. pinea* has been greatly overrated.

Diplodia pinea is widely distributed in exotic plantations of Monterey pine in Argentine, Australia, Chile, New Zealand, South Africa, and Spain.

***Eriosphaeria vermicularia* (Fr.) Sacc. (XX)**
(Ascomycetes, Sphaeriales)

Collected (Harkness #1350) circa 1881 on planted pine near San Francisco and Martinez, California. Reported by Harkness (1885) as a stain fungus but collection not available for study. Lister by Seymour (1929) and Scott (1960) for U.S.A.

Fomes annosus* (Fr.) Cke. *(XX)
(Basidiomycetes, Agaricales)

Root rot. Sporophores PSW 10000 (E. P. Meinecke) and rot specimens of bark and wood PSW 85156 (E. P. Meinecke) both collected in December 1909 from Del Monte Properties in Monterey area, Monterey County, California. Other collections in PSW herbarium. *Fomes annosus* often kills Monterey pine rapidly as reported for many other pine species (Bega 1962), first destroying the function of cambial tissue. Pines attacked by this fungus show typical root disease symptoms of reduced growth and thin, chlorotic foliage. Usually the attack of the fungus is associated with copious resin infiltration of wood around the base of the tree at ground level. Most of the roots may be sound at the time of fading and death of the tree. In later stages the fungus causes the typical soft white stringy rot in roots and butt (Boyce 1961). Lowe (1957) and others have described the fungus. Not yet reported on Monterey pine outside of California.

***Fomes pini* (Fr.) Karst. (XX)**
(Basidiomycetes, Agaricales)

White pocket heartrot. PSW 85224 (E. P. Meinecke) April 1911, at Monterey, California; later collections PSW 85228, 85230, 85247, and 85248 (Meinecke and Boyce) from Monterey area of native pines. Observations in 1962 showed that *F. pini* sporophores were common in native stands of pine at Cambria, Monterey, and Swanton on live and dead trees. Causes typical white pocket decay of heartwood with some invasion of sapwood. The perennial conks and pattern of decay in the heartwood for Monterey pine are typical of hard pines. The dark colored conks when sunken somewhat in the bark at branch stubs, are hard to see on the dark bark of Monterey pine. General characteristics of this well-known fungus are described by Boyce (1961) and Lowe (1957).

***Fomes pinicola* (Fr.) Cke. (X)**
(Basidiomycetes, Agaricales)

Brown crumbly rot. PSW 98036 (H. R. Offord), March 1963 from Green Oaks Creek, San Mateo County, California, near northern limit of the Swanton-Año Nuevo stand of pine. Occurred at the base of a 2½ foot stump, a recently cut tree. Rare on Monterey pine in native stands though often found on associated Douglas-fir. Not previously listed for Monterey pine.

[15]Bancroft 1911; Birch 1936; Capretti 1956; DeGryse 1955; Eldridge 1957; Ferreirinha 1953; Gibson 1958; Laughton 1937; Purnell 1956, 1957.

[16]Legal 1930; Ludbrook & White 1940; Poynton 1957; Rawlings 1955; Saravi 1950; Young 1936.

***Fomes roseus* (Fr.) Karst. (X)**

(Basidiomycetes, Agaricales)

Brown cubical rot. PSW 98035 (G. B. Rawlings and W. W. Wagener) October 1956. On down log in exposed location in fog belt near Swanton, Santa Cruz County, California.

***Guepiniopsis tortus* (Fr.) Pat. (X)**

(Basidiomycetes, Tremellales)

Jelly fungus. UC 641049 collected March 1940, Oakland, Alameda County, California, on debris underneath planted pine.

***Hydnum stevensonii* Berk. & Br. (X)**

(Basidiomycetes, Agaricales)

White stringy rot. PSW 85742 (E. P. Meinecke) April 1911, Pacific Grove, Monterey County, California, on dead fallen branch. Yellow conk in small recessed branch stub.

***Hypoderma pedatum* Darker (XX)**

(Ascomycetes, Phacidiales)

Needle cast. PSW 83843 (J. S. Boyce) January 1920, San Francisco, California. Seven other early collections from Monterey and from Golden Gate Park area, San Francisco in PSW herbarium. Collected (D. R. Miller) November 1962, at Cambria, Monterey, and Swanton. Described by Darker (1932) as a new species from a collection made in Golden Gate Park, San Francisco, California, August 1929; specimen in Arnold Arboretume (Pathological Herbarium 655). Darker (1932) states, "The diseased needles occurred in tufted branches on the dead ends of twigs, but there was no evidence to indicate that *Hypoderma pedatum* was the primary cause of the trouble. *H. pedatum* can be easily diagnosed in the field by the small brownish hysterothecia scattered along the stomatal lines." Listed by Scott (1960) for U.S.A.

***Hypodermella limitata* Darker (XX)**

(Ascomycetes, Phacidiales)

Needle cast. PSW 83889 (E. P. Meinecke) April 1915, Monterey County, California. From J. S. Boyce collection #293 of May 1919, Darker (1932) described this fungus as a new species; type locality Golden Gate Park San Francisco. Part of same collection in UC herbarium at Berkeley.

Darker (1932) states that, "*H. limitata* infects only short portions of the needle. Usually restricted to sections a few mm. long located in the center of green needles. In the case of *H. limitata* only four spores mature. Hysterothecia shining black, amphigenous on sordid areas on green or languishing needles." Listed by Scott (1960) for U.S.A.

***Hypodermella montivaga* (Petr.) Dearn. (XX)**

(Ascomycetes, Phacidiales)

Needle cast. PSW 83001 (W. W. Wagener) April 1926, Fort Scott, San Francisco on foliage of planted trees. Darker (1932) says this fungus is similar to *Hypodermella sulcigena,* a destructive parasite in Europe. Described by Dearness (1924) from type collection on *Pinus contorta* Dougl. from Idaho.

***Hysterangium gardneri* E. Fischer (X)**

(Basidiomycetes, Lycoperdales)

Terrestrial fleshy fungus. UC 126142 collected November 1904, under planted Monterey pine on University of California Campus, Berkeley. Listed by Seymour (1929) and Scott (1960) as *Hysterangium juscum* Harkn. for U.S.A.

***Lophium mytilinum* Fr. (XX)**

(Ascomycetes, Hysteriales)

Canker. Collected (Harkness #2682) from planted trees in San Francisco, California, June ca. 1881 and reported by Harkness (1885). In Germany Engler and Prantl (1897) describe this fungus as developing on blackened surfaces of bark and wood of conifers. Reported on Monterey pine only for U.S.A.

***Lophodermium nitens* Darker (XXX)**

(Ascomycetes, Hysteriales)

Needle cast. PSW 83052 (W. W. Wagener) near Monterey, California, March 1930, on foliage and acting as a weak parasite. Appears as shiny black subcuticular bodies on outer face of needles. Boyce (1961) reports *L. nitens* on five-needle pines as a saprophyte.

***Lophodermium pinastri* (Fr.) Chev. (XXX)**

(Ascomycetes, Hysteriales)

Needle cast. PSW 83852 (J. S. Boyce #340) at Golden Gate Park, San Francisco, California, May 1919, on planted pine. Other collections from same area in PSW herbarium. Marked heavy infection and very common on all needles except current year. Collected (Darker #658) Golden Gate Park San Francisco, California and in Pathological Herbarium of Arnold Arboretum. Described by Darker (1932).

Tehon (1935) lists *P. radiata* as host for *Lophodermium pinicolum* Tehon n. nom. for *L. pinastri,* basing his description on a collection by J. S. Boyce made March 1919, at Cisco, California. Mild winters and wet summers may create epidemic outbreaks on Monterey pine (Rawlings 1955). Under favorable conditions this fungus may cause serious injury, especially in nurseries,

but usually is a mild parasite. Listed by Scott (1960) for New Zealand, South Africa, and Spain.

***Macrophoma pinea* (Desm.) Petr. & Syd. (XX)**
(Fungi Imperfecti, Sphaeropsidales)

Needle blight. Collected on seedlings, state of Washington, as reported by Hedgcock (1932). Listed by Shaw (1958). U.S.A. only.

***Merulius confluens* Schw. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. UC 568821 collected February 1937, on burned dead log, Oakland Hills, Alameda County, California.

***Mycosphaerella acicola* (Cke. & Harkn.) Lindau (XX)**
(Ascomycetes, Sphaeriales)

Needle blight. CAS 1849 (H. W. Harkness #2303) type specimen collected April 1881, San Francisco, California on pine needles and called (Cooke and Harkness 1884b) *Sphaerella acicola* Cke. & Harkn. Indexed in UC herbarius as *M. acicola* but no specimen filed. Listed by Seymour (1929) and Scott (1960) for U.S.A. as *S. acicola*.

***Naemacyclus niveus* (Fr.) Sacc. (XXX)**
(Ascomycetes, Phacidiales)

Needle cast. PSW 97988 and UC 756713 (Vera M. Miller) November 1942, and UC 652850 (E. B. Copeland) November 1940, all from the University of California Campus, Berkeley, parasitic on foliage of planted pine. Listed by Darker (1932) as in California on Monterey pine. Collected (D. R. Miller) Deer Flat Park, Monterey County, March 1962, and noted again at Monterey, Cambria, and Swanton, in November 1962.

Darker (1932) states that ascocarps are scattered, somewhat rectangular in appearance when partially open, at first waxy, dark brown, later becoming concolorous with leaf surface, opening along stomatal lines, the two halves of the covering layer becoming widely opened through the tearing of the epidermis. Listed by Scott (1960) for New Zealand and Spain, by Gibson (1962) for Kenya.

***Peniophora burtii* Rom. (X)**
(Basidiomycetes, Agaricales)

Sapwood rot. UC 641021 (Vera M. Miller) March 1940, on down twig of Monterey pine, near Pacific Grove, Monterey County, California.

***Peniophora cinerea* (Fr.) Cke. (X)**
(Basidiomycetes, Agaricales)

Sapwood rot. UC 620883 (Lee Bonar) November 1935, on dead bark and wood of planted Monterey pine near San Rafael, Marin County, California.

***Peniophora gigantea* (Fr.) Mass. (X)**
(Basidiomycetes Agaricales)

Sapwood rot. UC 532368 (Lee Bonar) March 1935, in Oakland Hills, Alameda County, California, on dead bark from a planted tree.

Boyce (1961) says that *P. gigantea* causes a superficial sap rot of both conifer and hardwood slash and wood products in storage. It often appears as a fluffy white mycelial growth on a wood surface. Reported as a major cause of decay of deadwood by the New Zealand Forest Service (1961).

***Peridermium cerebroides* Meinecke nomen nudum (XXX)**
(Basidiomycetes, Uredinales)

Coastal gall rust. PSW 83526 (E. P. Meinecke) April 1912, from vicinity of Monterey, California. Thirty-one collections of gall rust on Monterey pine in California were deposited in the PSW herbarium from 1912 to 1944. Depending on the date of collection these specimens were marked *Peridermium harknessii, Peridermium cerebrum,* or *P. cerebroides.* They come from Monterey, Santa Clara, San Mateo, San Francisco, Marin, and Alameda Counties. *P. cerebroides,* the coastal form of the western gall rust *Peridermium harknessii* J. P. Moore, is prevalent and damaging in native stands of Monterey pine at Swanton, Monterey, and Cambria. It is common also in plantations of central coastal California. In or adjoining these same areas bishop pine (*Pinus muricata*) and knobcone pine (*Pinus attenuata*) may be infected by one or both forms of this rust.

***Peridermium harknessii* J. P. Moore (XXX)**
(Basidiomycetes, Uredinales)

Western gall rust. This widely distributed gall rust occurs in plantations of Monterey pine in California, Oregon, Washington, and British Columbia. Cummins in the Supplement of the 1962 revision of Arthur (1962, p. 4a) leaves both *Peridermium cerebroides* and *P. harknessii* with *Cronartium coleosporioides.*

***Pestalotia funerea* Desm. (XX)**
(Fungi Imperfecti, Melanconiales)

Needle and twig blight. PSW 97860 (E. P. Meinecke) March 1920, from the Presidio, San Francisco, California. UC 209261 (D. R. Miller) November 1962, Deer Flat County Park, Monterey County, California, on senescent needles of living trees.

Hedgcock (1932) reported this fungus on Monterey pine in Washington, D. C., probably the same occurrence as noted by Scott (1960) for U.S.A. Grove (1937) says that this species can be a true parasite and cause disease and that *Pestalotia funerea* forma *conigena* (Lév.) has been found on cones of Monterey pine planted in Cornwall. Noted by Birch (1937) for New Zealand, and by J. B. Martinez[17] for Spain.

***Pezicula livida* (Berk. & Br.) Rehm (XX)**
(Ascomycetes, Helotiales)

Canker. Collected (D. R. Miller) at Deer Flat County Park, Monterey, Monterey County, California, March 1962, from dead or damaged twigs of pines generally of poor vigor. Twigs show many small, round or elongated swellings that often open into a slit in the bark. Lee Bonar commented on the difficulties in identifying this fungus: He said (personal communication) that swellings are acervulus in nature, forming cushion-shaped to conical stroma with a layer of conidiospores and conidia on the outer surface, and that this fungus is probably the conidial stage of the Pezicula named.

Spaulding (1961) states that *Pezicula livida* occurs in North America and Europe on pine, fir, and spruce weakened by drought or frost.

***Phytophthora cinnamomi* Rands (XXX)**
(Phycomycetes, Peronosporales)

Root rot. Zentmyer and Munnecke (1952) report Monterey pine killed by this fungus in a southern California nursery where it acted as a typical root parasite.

This highly destructive pathogen is world wide in distribution Spaulding (1961). It has not yet been found, however, in native stands of Monterey pine. Listed by Scott (1960) for exotic plantations in Argentina, and by Newhook (1957, 1960) and Hepting & Newhook (1962) in New Zealand and of major importance in littleleaf of *Pinus echinata* in the United States (Campbell & Copeland 1954).

***Pithya cupressi* (Fr.) Rehm (X)**
(Ascomycetes, Pezizales)

Needle spot. UC 553899 from planted trees, Oakland Hills, Alameda County, California, January 1936. The preferred name of this fungus is *Pithya cupressina* (Fr.) Fckl.

***Pleurotus ostreatus* (Fr.) Kummer (X)**
(Basidiomycetes Agaricales)

Trunk rot. UC 532355 (Lee Bonar) March 1935, at Redwood Peak, Oakland, Alameda County, California on dead bark of Monterey pine stump. Described by Boyce (1961) and Spaulding (1961) on hardwoods where it is usually saprophytic but occasionally a wound parasite.

***Polyporus abietinus* Fr. (X)**
(Basidiomycetes Agaricales)

Trunk rot. PSW 85397 (E. P. Meinecke) April 1911, near Monterey, Monterey County, California. Recent collections (D. R. Miller) from native stands were made at Monterey, Cambria, and Swanton, November 1962. Other specimens are available from Sutro Forest and Fort Scott, San Francisco, California (PSW 85388, 85389, 85391, 85395, and 85411), all on dead trees or branches and on down logs. Abundant on trees killed by fire. All early collections in PSW Herbarium were named *Polystictus abietinus.* Found on conifers in all parts of the United States and Canada. Noted by Martinez[18] from Spain as *Polystictus abietinus* Sacc. & Cub.

***Polyporus anceps* Pk. (XX)**
(Basidiomycetes Agaricales)

White pocket rot. PSW 98041 (D. R. Miller) November 1962, Del Monte Properties, Monterey County, California; on basal trunk of dead standing tree. Not previously reported on Monterey pine.

***Polyporus caesius* Fr. (X)**
(Basidiomycetes Agaricales)

PSW 98037 (D. R. Miller) November 1962, Deer Flat County Park, Monterey, Monterey County, California, from debris on ground under mixed age stand of pine. Listed by Scott (1960) for New Zealand as a saprophyte on dead trees.

***Polyporus carbonarius* Murr. (X)**
(Basidiomycetes Agaricales)

Sapwood rot. Rhoads (1921) reported on a stump and a fallen log in a plantation at San Francisco, California. Listed by Scott (1960) for U.S.A.

***Polyporus dichrous* Fr. (X)**
(Basidiomycetes Agaricales)

Trunk rot. PSW 85447 (E. P. Meinecke and A. S. Rhoads) April 1912, near Pebble Beach, Monterey County, California, from down tree decaying on one side. Reported by Rhoads (1921). Close to the sporophore the rot produced by this fungus is of the brown carbonizing type with associated decay having a white appearance. Listed by Scott (1960) for U.S.A.

[17] See footnote 12.

[18] See footnote 12.

***Polyporus fragilis* Fr. (X)**
(Basidiomycetes Agaricales)

Brown carbonizing rot. UC 521276 (Wm. Lucke) March 1934, Oakland Hills, Alameda County, California, on rotting bark of a stump of planted tree. Conks small to medium-size, occur in large numbers often overlapping. The pore surface of fresh conks changes color readily when touched

***Polyporus gilvus* (Schw.) Fr. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. UC 539465 (Lee Bonar) November 1935, on dead planted pine, San Rafael, Marin County, California. Decay mostly confined to sapwood. The annual sporophore is small and often occurs in large numbers. Occurs chiefly on deciduous trees.

***Polyporus mollis* Fr. (XX)**
(Basidiomycetes, Agaricales)

Brown carbonizing rot. UC 525451 (H. E. Parks) 1922 in Berkeley Hills, Alameda County, California, on planted trees. Resembles *Polyporus fragilis.*

***Polyporus perennis* Fr. (X)**
(Basidiomycetes, Agaricales)

Slash rot. PSW 85505 (A. S. Rhoads) April 1919, at Fort Scott, San Francisco, California on debris under planted trees.

***Polyporus schweinitzii* Fr. (XXX)**
(Basidiomycetes, Agaricales)

Root and butt rot. PSW 85550 and 85555 (E. P. Meinecke) April 1911, at Del Monte, Monterey County, California, on living and dead trees. Noted during surveys of November 1962, in Cambria, Monterey, and Swanton areas. Listed by Scott (1960) for U.S.A. as *Coltricia schweinitzii* (Fr.) G. H. Cunn.

In Monterey pine the fungus causes the typical, brown carbonizing, cubical butt rot and root decay. Incipient decay shows as light-yellow to red-brown discoloration as wood becomes soft. Cubes of decayed wood crumble into a fine powder. Annual conks appear during wet season; sporophores as described for other conifers by Boyce (1961).

***Polyporus smallei* (Murr.) Sacc. & Trott. (X)**
(Basidiomycetes, Agaricales)

Slash and sapwood rot. PSW 85563 (E. P. Meinecke) February 1926, from Del Monte Forest, Monterey County, California. On dead limb of pine 7 inches diameter lying on ground.

***Polyporus tomentosus* Fr. var. *circinatus* (Fr.) Sartory & Maire (XXX)**
(Basidiomycetes, Agaricales)

Root and butt rot. PSW 85449 and PSW 85453 (E. P. Meinecke) April 1911, at Del Monte, Monterey County, California and (E. P. Meinecke and F. Gravatt) March 1916, in same area. Both collections from a living tree near base of the trunk. This fungus causes white pocket rot of stumps, basal trunk, or roots. Decay looks much like that caused by *Fomes pini.*

***Polyporus versicolor* Fr. (X)**
(Basidiomycetes, Agaricales)

White trunk rot. PSW 85403 and 85605 (A. S. Rhoads) April 1919, Sutro Forest and Fort Scott, San Francisco, California, on planted trees killed by fire. Common and world-wide on deciduous trees and only occasional on conifers. Rhoads (1921) reported this collection as *Polystictus versicolor* (L.) Fries. Listed by Scott (1960) as *Coriolus versicolor* (L. ex Fr.) Quél in New Zealand, and by Martinez[19] for Spain.

***Polyporus volvatus* Pk. (X)**
(Basidiomycetes, Agaricales)

White trunk rot. PSW 85627 (E. P. Meinecke) Monterey, California April 1915. Common on dead trees recently killed by fire or insects in Monterey, Swanton, and Cambria native stands. Scott (1960) lists *P. volvatus* for U.S.A.

***Poria cinerascens* Bres. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. PSW 98040 (D. R. Miller) November 1962, Miller Ranch Road, Swanton, Santa Cruz County, California, on down log.

***Poria mollusca* (Fr.) Bres. (X) (Basidiomycetes, Agaricales)**

Trunk or slash rot. PSW 85672 (A. S. Rhoads) January 1919, and PSW 85671 (E. P. Meinecke) May 1924, from Sutro Forest and Fort Scott, San Francisco, California, on fallen branches.

***Poria sericeomollis* (Rom.) Baxter (X)**
(Basidiomycetes, Agaricales)

Brown cubical rot. UC 605295 (Lee Bonar) November 1938, Oakland Hills, Alameda County, California, on decayed planted pine. Listed by Scott (1960) for New Zealand.

***Poria spissa* (Schw.) Cke. (X)**
(Basidiomycetes, Agaricales)

Brown rot. UC 477470 (N. L. Gardner) March 1916, near Ingleside, San Mateo County, California. Common on angiosperms in eastern North

[19]See footnote 12.

America. This collection is probably the basis for the listing of Seymour (1929) and Scott (1960) for U.S.A.

***Poria vulgaris* (Fr.) Cke. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. UC 554992 (H. E. Parks) February 1924, on burned Monterey pine long along Tunnel Road, Berkeley, Alameda County, California.

***Poria xantha* (Fr.) Cke. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. PSW 98038 (D. R. Miller) November 1962, Del Monte Properties, Monterey County, California, on dead standing snag.

***Rhizina undulata* Fr. (XX)**
(Ascomycetes, Pezizales)

Root rot. UC 292000 (Lee Bonar) July 1923, Berkeley Hills, Alameda County, California, under planted pines in wet soil. Annual fructifications developing on ground are irregular in shape and have an undulating brown upper surface. Spaulding (1961) says the pathogen is associated with root rot of conifers shortly after fire. Forms effused brown-black fungus bodies with root-like tendrils reaching into soil and starting from coniferous roots damaged by fire. Often cited in literature as *Rhizina inflata* (Schaeff.) Sacc. Weir (1915) cites evidence of parasitism on conifers.

***Schizophyllum commune* Fr. (X)**
(Basidiomycetes, Agaricales)

Sapwood rot. PC 239462 (E. B. Copeland #3745) October 1903, Palo Alto, California, on planted tree. Rare on conifers and not previously listed for Monterey pine in North America. Listed by Scott (1960) for New Zealand.

***Scoleconectria scolecospora* (Bref.)**
Seaver (XX)
(Ascomycetes, Hypocreales)

Canker. PC 236523 (C. F. Baker #68) October 1901, Palo Alto, San Mateo County, California, on dead twigs. This fungus is generally called *Ophionectria scolecospora* Bref.

Overholts (1924) reports finding this fungus in Pennsylvania on *Pinus ponderosa, P. strobus* L., and *P. sylvestris* L.; found also on a dead sapling of *Abies balsamea* (L.) Mill. Often occurs in association with white pine blister rust. Seaver (1909) describes the *Scoleconectria.*

***Sparassis radicata* Weir (XX)**
(Basidiomycetes, Agaricales)

Root rot. UC 372395 (E. E. Morse) February 1927, Berkeley Hills, Alameda County, California, from roots of a live tree, which died the following year. Fruiting body similar to that described by Weir (1917) for his collections from the roots of living conifers in North Idaho.

Boyce (1961) describes the Sparassis root rot as causing a yellow brown carbonizing decay of old conifers in the West, confined to roots. The annual large, white fleshy fruiting bodies with thin flat branches arise from perennial stalks that are connected with underlying diseased roots.

***Stereum hirsutum* Fr. (X)**
(Basidiomycetes, Agaricales)

White rot. Collected (A. S. Rhoads) on fallen branches of planted pine, San Francisco, California. PSW 85803 (W. W. Wagener) July 1931 (Stereum) probably same species, on lower dead limbs of planted trees in Hillsborough, San Mateo County, California. Rhoads (1921) reported that a conifer is an unusual host. Listed by Scott (1960) .for U.S.A. and by Seymour (1929).

***Stereum purpureum* (Fr.) Fr. (X)**
(Basidiomycetes, Agaricales)

White mottled rot. UC 294732 (H. E. Parks) February 1924, Tunnel Road, Berkeley, Alameda County, California, from burned pine trees.

According to H. E. Parks, trees were killed by fire in September 1923, and badly infected the following spring. Conks were covering large areas of the burned trees and were mostly resupinate, but some showed a bracket form. Fruiting surface brownish and folded, upper surface light gray or dirty white and. densely tomentose, obscurely zonate.

***Stereum sanguinolentum* Fr. (X)**
(Basidiomycetes, Agaricales)

Trunk rot. PSW 85761 (E. P. Meinecke) April 1911, Del Monte Properties, Monterey County, California, on bark of dead branch. UC 568923, February 1937, Sequoia Park, Oakland, Alameda County, California, on stump of dead tree.

Boyce (1961) states that *S. sanguinolentum* causes mottled bark disease and has been associated with the death of planted conifers in Idaho. Widespread as saprophyte on coniferous slash and causes heart rot of living trees of eastern white pine, balsam fir, and spruce. World wide in distribution according to Spaulding (1961), but not previously listed for Monterey pine in North America. Listed by Scott (1960) in Australia and New Zealand.

***Tremella pinicola* Britz. (X)**
(Basidiomycetes, Tremellales)

UC 585779 (T. T. McCabe) March 1938, in Oakland Hills, Alameda County, California.

***Tubercularia insignis* Cke. & Harkn. (X)**
(Fungi Imperfecti, Moniliales)

Twig blight. CAS 1720 (H. W. Harkness #2170) type specimen, February 1881, San Francisco, California, (Cooke & Harkness 1884c) on bark of twigs. Listed by Seymour (1929), and by Scott (1960) in California.

***Venturia barbula* (Berk. & Br.) Cke. var. *foliicola* Ell. (XX)**
(Ascomycetes, Sphaeriales)

Needle scab. UC 209259 (D. R. Miller) November 1962, Deer Flat County Park, Monterey County, California, on faded, grayish needles, mostly on older needles.

***Zygodesmus fuscus* Cda. (XX)**
(Fungi Imperfecti, Moniliales)

Collected (Harkness #2489) May 1884, at Mt. Diablo, California, on planted tree. Reported by Harkness (1885) and listed in Seymour (1929). Corda's type specimen of *Z. fuscus* was checked by Rogers (1948) and said to be *Tomentella biennis* (Fr.) A. M. Rogers. Specimen from Monterey pine not available for study.

***Zygodesmus marginatus* Cke. & Harkn. (XX)**
(Fungi Imperfecti, Moniliales)

CAS 1899 (H. W. Harkness #2360) type specimen, April 1881, in San Francisco, California, on decaying bark of planted pine. Threads thicker than diameter of spores, or of equal thickness (Cooke and Harkness 1884a).

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APPENDIX

Fungi Associated with Pinus Radiata Outside of Western North America

This list of fungi is based on publications avail able to the author through 1963. A report in press (1964) entitled "The Pathology of Forest Trees and Shrubs in New Zealand," by J. W. Gilmour, New Zealand Forest Service, lists three fungi not listed here that are associated with Monterey pine in New Zealand: *Cylindrocladium scoparium* Morg., *Dematophora necatrixi* Hartig, and *Phytophthora megasperma* Drechs. These fungi cause root disease.

Anthostomella piedmontana Ferr. & Sacc.
Pathogenicity not reported. Scott (1960). Australia.

Ceratostomella coerulea Münch (X)
(=*Ceratocystis pilifera* (Fr.) C. Moreau)
Blue stain. Cummins (1933), Scott (1960). Australia.

Ceratostomella pilif era (Fr.) Wint. (XX)
(=*Ceratocystis pilifera* (Fr.) C. Moreau). Blue stain. Cummins (1933), Laughton (1937), Scott (1960). Australia, South Africa.

Coriolus sanguineus (Fr.) G. H. Cunn. (X)
(=*Polyporus sanguineus* Fr.)
Brown rot. Cunningham (1948b), Birch (1937), Scott (1960). New Zealand.

Coriolus zonatus (Fr.) Quél. (X)
(=*Polyporus zonatus Fr.).* White rot. Scott (1960). New Zealand.

Corticium punculatum Cke. (XX)
On bark and fallen branches. Cunningham (1953), Scott (1960). New Zealand.

Corticium utriculicum G. H. Cunn. (XX)
On bark and decaying branches. Cunningham (1953), Scott (1960). New Zealand.

Daedalea trabea (Pers.) Fr. (X)
(=*Lenzites trabea* (Fr.) Fr.) Brown rot. Cunningham (1948c), Scott (1960). New Zealand.

Dacryomyces palmatus Bres. (X)
Trunk and branch decay. Martinez (1942), Scott (1960). Spain.

Dasyscypha calyciformis ((Fr.) Rehm (XX)
Canker. De Gryse (1955), Spaulding (1961). New Zealand.

Diplodia acicola Sacc. (XX)
Needle disease. Martinez (1942), Scott (1960). Spain.

Diplodia natalensis P. Evans (XX)
(=*Diplodia theobromae* (Pat.) Nowell). Needle blight. Young (1936). Australia.

Dothistroma pini Hulb. (XX)
Needle blight and die-back. Gibson (1963) Kenya, So. Rhodesia, Tanganyika, Uganda. Previously reported as *Actinothyrium marginatum* Kunze by Gibson (1962).

Forces applanatus (S. F. Gray) Gill. (X)
White rot. Scott (1960). New Zealand.

Pontes mastoporus (Lév.) Cke. (X)
White rot. Scott (1960). New Zealand.

Fomes scruposus (Fr.) G. H. Cunn. (X)
White rot. Scott (1960). New Zealand.

Fusarium lateritium Nées var. *pini* Hepting (XX)
Pitch canker. Hepting (1961). Eastern U.S.A.

Fusarium oxysporum Schlecht. (XXX)
Damping-off. Frezzi (1947), Spaulding (1961). Argentina. Martinez (See footnote 12). Spain.

Hydnum coralloides Fr. (X)
Rot in dead trees. Scott (1960). New Zealand.

Hypoderma brachysporum Rostr. (XX)
Needle cast. Green (1957). Great Britain. Martinez (See footnote 12). Spain.

Hypoderma desmazieri Duby (XX)
Needle cast. Peace (1962). Great Britain. Darker (1932) includes *H. brachysporum* and *H. strobicola* Tub. under this single species name.

Hymenochaete mougeotii (Fr.) Cke. (X)
Trunk rot, fire-killed trees. Scott (1960). New Zealand.

Hypodermium sulcigenum Fr.
(=*Hypodermella sulcigena* (Lk. ex Fr.) Tub.) Pathognicity not reported. Scott (1960). Australia.

Inonoius tabacinus (Mont.) Karst.
(=*Polyporus tabacinus* Mont.). Pathogenicity not reported. Scott (1960). New Zealand.

Irpex brevis Berk. (X)
White rot. Cunningham (1949), Scott (1960). New Zealand.

Irpex fuscoviolaceus Fr. (X)
Yellow rot with white pockets. Martinez (1942), Scott (1960) . Spain.

Lecanosticta acicola Wolf & Barbour (XX)
Needle blight. Martinez (See footnote 12). Spain.

Lenzites beckleri Berk. (X)
Stump rot. Scott (1960). New Zealand.

Lenzites palisoti Fr. (X)
(=*Daedalea elegans* Fr.) Stump rot. Doidge (1950), Scott (1960). South Africa.

Leptoporus trabeus (Rostk. (XX)
(=*Lenzites trabea* (Fr.) Fr.). Trunk rot. Martinez (See footnote 12). Spain.

Lopharia cinerascens (Schw.) G. H. Cunn.
Pathogenicity not reported. Scott (1960). New Zealand.

Lopharia vinosa (Berk.) G. H. Cunn.
Pathogenicity not reported. Scott (1960). New Zealand.

Macrophomina phaseoli (Maubl.) Ashby (X)
Root rot. Spaulding (1956). South Africa.

Merulius himantioides Bourd. & Galz. (X)
Wood decay. Martinez (See footnote 12). Spain.

Merulius lacrymans (Wulf.) Fr. (X)
Lumber decay. Scott (1960). New Zealand.

Nectria pinea Dingley (X)
Trunk rot. Dingley (1951), Scott (1960). New Zealand.

Odontia bicolor (Fr.) Bres. (X)
Stringy white rot. Scott (1960). New Zealand.

Pellicularia filamentosa (Pat.) Rogers (XXX)
Damping off. Thulin et al. (1958). New Zealand.

Pellicularia vaga (Berk. & Curt.) Rogers (X)
Trunk rot. Cunningham (1953), Scott 1960). New Zealand.

Peniophora cremea (Bres.) Sacc. & Syd.
Pathogenicity not reported. Cunningham (1955), Scott (1960). New Zealand.

Peniophora sacrata G. H. Cunn. (XX)
Root and stem canker. Gilmour (1959). New Zealand.

Pestalotia hartigii Tub. (X)
Stem canker. Spaulding (1956). South Africa.

Pestalotia macrochaeta (Speg.) Guba
Pathogenicity not reported. Doidge (1950), Scott (1960). South Africa.

Phacidiopycnis pseudotsugae (M. Wits.) Hahn (XX)
Canker. Spaulding (1961). New Zealand.

Phoma acicola (Lév.) Sacc. (XX)
Needle blight. Martinez (See footnote 12), Scott (1960). Australia.

Phoma pinastrella Sacc.
Pathogenicity not reported. Doidge (1950), Scott (1960). South Africa.

Phoma strobiligena Desm. var. *microspora* Sacc.
Pathogenicity not reported. Scott (1960). Australia.

Phomopsis pseudotsugae Wilson (XX)
Canker. Great Britain Forestry Commission (1961). Great Britain.

Phomopsis strobi Syd. (XX)
Twig canker. Birch (1935), Scott (1960), Stoate and Bednall (1953). Australia, New Zealand.

Phytophthora cactorum (Leb. & Cohn) Schroet. (XXX)
Seedling blight. Newhook (1959). New Zealand.

Phytophthora citricola Saw.
Pathogenicity not shown. Newhook (1959). New Zealand.

Phytophthora cryptogea Pethyb. & Laff.
Pathogenicity not shown. Newhook (1959). New Zealand.

Phytophthora citrophthora (R. E. & E. H. Sm.) Leonian (X)
Root rot. Spaulding (1956). Argentina.

Phytophthora parasitica Dast. (XXX)
Canker and blight. Scott (1960). Australia.

Phytophthora syringae Kleb. (XXX)
Dieback. Newhook (1959). New Zealand.

Polyporus albidus Fr. (X)
Brown cubical rot. Scott (1960). New Zealand.

Polyporus amorphus Fr. (X)
Trunk rot. Cunningham (1948a), Scott (1960). New Zealand.

Polyporus lacteus Fr. (X)
(=*Polyporus tulipiferae* (Schw.) Overh.). Trunk rot. Cunningham (1948a), Scott (1960). New Zealand.

Polyporus rosulatus G. H .Cunn. (X)
Brown cubical rot. Cunningham (1948a), Scott (1960). New Zealand.

Polyporus setiger Cke. (X)
Trunk rot. Scott (1960). New Zealand.

Polyporus tephroleucus Fr. (X)
Trunk rot. Cunningham (1948a), Scott (1960). New Zealand.

Polyporus thelephoroides Fr. (X)
Trunk rot. Cunningham (1948a), Scott (1960). New Zealand.

Polyporus vernicifluus Berk. (X)
Trunk rot. Scott (1960). New Zealand.

Poria ferruginosa (Fr.) Karst. (XX)
White spongy rot. Spaulding (1961). Australia.

Poria lenis (Karst.) Sacc.
Pathogenicity not reported. Scott (1960). New Zealand.

Poria mucida (Fr.) Cke.
Pathogenicity not reported. Scott (1960). New Zealand.

Poria vaillantii (Fr.) Cke. (X)
Tumber decay. Birch (1937). New Zealand.

Poria versipora (Pers.) Rom. (X)
White rot. Scott (1960). New Zealand.

Pullularia pullulans (deBy.) Berk. (XX)
Needle blight. Cummins (1933), Scott (1960). Australia, New Zealand. Called *Hormonema dematoides* Lob. & Melin by Cummins (1933).

Pythium ultimum Trow (XX)
Root rot. Doidge (1950), Thulin et al. (1958), Scott (1960). South Africa, New Zealand.

Rhizoctonia lamellifera Small (XXX)
Root rot. Laughton (1937), Spaulding (1961). South Africa.

Rhizoctonia silvestris Melin (XXX)
Root disease. Levisohn (1954), Scott (1960). Great Britain:

Rhizoctonia solani Kuehn (XXX)
Damping-off. Thulin et al. (1958), Scott (1960). New Zealand.

Scirrhia acicola (Dearn.) Siggers (XX)
Leaf spot. Spaulding (1961). Spain. Siggers (1939) shows that this fungus is the perfect stage of *Septoria acicola* Sacc.

Scleroderris abietina (Lager.) Gremmen (XX)
Pine dieback. Spaulding (1961). Spain.

Septoria acicola Sacc. (XX)
Needle cast. Martinez (1942), Scott (1960). Spain.

Solenia candida Fr. (X)
Wood rot. Scott (1960). New Zealand.

Stereum schomburgkii Berk. (X)
Trunk rot. Scott (1960). New Zealand.

Thelephora fimbriata Schw. (X)
Smothering fungus. Doidge (1950), Scott (1960). Australia, Chile, New Zealand, S. Africa.

Thelephora terrestris Fr. (X)
Smothering fungus. Birch (1937). New Zealand.

Trametes protea (Berk.) G. H. Cunn. (X)
Brown rot. Cunningham (1948c), Scott (1960). New Zealand.

Trametes trogii Berk. (XX)
Trunk rot. Spaulding (1956). Argentina.

Trichoscyphella calycina (Fr.) Nannf. (X)
Canker. Scott (1960). New Zealand.

Vermicularia tiliae Lk.
Listed by Seymour (1929) for U.S.A. (California) but not confirmed for *P. radiata* by any records available.

Xylogramma hysterinum (Fr.) Rehm
Pathogenicity not reported. Scott (1960). Australia.

Xanthochrous abietis Bourd. & Galz. (XX)
(=*Trametes abietis* Karst.) Butt rot. Martinez (See footnote 12). Spain.