

OBSERVATIONS OF A THIRTY-ONE-YEAR-OLD RADIATA PINE
(PINUS RADIATA D. DON) PLANTATION IN NORTHERN CALIFORNIA

(FRAZIER PLANTATION - JACKSON DEMONSTRATION STATE FOREST)

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ABSTRACT

Growth of a radiata pine (Pinus radiata D. Don) (also known as Monterey pine) plantation was examined 31 years after establishment in the coast redwood region of northern California.

Individual trees exhibited extraordinary growth of diameter and height. However, overall survival was poor (<5%) and most surviving trees showed poor form.

Diseases (red band needle blight and western gall rust) have also been a persistent problem. More research on the genetics, pathology, and silviculture of this promising species is needed before further commercial plantations are attempted in the central north coast area.

KEY WORDS

Dothistroma pini, Endocronartium barknessii, Jackson Demonstration State Forest, redwood region

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Figure 1. Increment cores were collected to assess growth of 24 trees. Note diameter size of radiata pine in 31-year-old plantation.

INTRODUCTION

In order to meet future demands for wood products, foresters are pursuing many avenues of investigation. Plantations of exotic forest species have been successful in many parts of the world and indeed some countries depend on introduced conifers for their commercial forest industry. In particular, the accomplishments of New Zealand and Australian foresters with radiata pine (Pinus radiata D. Don) are well known (Sutton 1978). Radiata pine has also been developed as a valuable species in Africa (Van Larr 1979, Fry 1962) and South America (Fenton 1979).

Radiata pine has been considered for many uses. It was first planted for windbreaks in New Zealand and Australia during the 1880's much like Eucalyptus was introduced and used in California. New Zealand currently has over 1.5 million acres (600,000 ha) of radiata pine and is adding some 80,000 acres (32,000 ha) a year to this total (Harris 1979). Fenton (1979) reported that 90% of the plantations in Chile consist of radiata pine. Foresters in these countries look to plantation-grown pines to compete well in world markets, especially as pruned, clear saw logs and clear plywood (Sutton 1978).

Much interest was shown in growing radiata pine commercially in the coast redwood region of northern California in the 1950's and 1960's and several experimental plantings were established. Sindel (1963) and Krugman (1963) published data from young plantations but little is known of mature plantations in California.

The present investigation concerns the oldest plantation of radiata pine on Jackson Demonstration State Forest. It was established in 1951 and has been maintained and monitored by the California Department of Forestry.

STUDY SITE

The plantation (Figures 1 and 2) is located on Jackson Demonstration State Forest in Mendocino County, California. The site has an average elevation of 500 feet (152 m) and is 15 miles (24 km) inland from the Pacific Ocean. The stand has a southern aspect with an average slope of perhaps 30%. Mean annual temperature extremes at the site range from 25° F. to 80° F. (-4° to 27° C.). Precipitation averages 50 inches (1.3 m) a year, falling almost exclusively as rain during the winter period, November to April. Many summer days also provide some coastal fog that improves the available moisture situation.

Soils are in the Hugo series (Gardner, et al. 1963) overlying a sandstone/shale parent material. The soil is a moderately acid, well-drained loam, and usually greater than 4 feet (1.2 m) deep. The area is classified as Site II for Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] and coast redwood [Sequoia sempervirens (D. Don) Endl.] on the California Soil-Veg Map and is very productive timberland.

Historically the area was dominated by old growth coast redwood with some Douglas-fir. In September 1951, during the logging of this old growth forest, a wildfire broke out. The fire cleared all understory, leaving only a few living trees and snags. After removal of the downed timber, the site was virtually clear of vegetative cover.

During the winter and spring of 1951-52, 13,350 nursery-grown 1-0 seedlings of radiata pine were planted. No further site preparation was performed as the young trees were planted soon after the fire. A spacing of 8 x 8 feet (2.4 x 2.4 m) was apparently used and the original plantation covered about 16 acres (6.5 ha).



Figure 2. Height measurements were taken on 45 trees. Note downed material on forest floor.

The seed source for the radiata pine is obscure. Nursery records from the early 1950's indicate the seed was probably from the Año Nuevo stand of radiata pine which is located 15 miles (25 km) north of Monterey Bay, California.

Survival was greater than 50% in 1952, one year after planting. In 1954, after 3 years, 44% were still alive. By 1965, only 4% of the trees remained alive and our survey indicated that some additional mortality occurred since that time. Most living trees are now in a long band near the top of an 800-foot (244 m) elevation, south-facing 15% slope.

As is common for disturbed sites in this area, a dense cover of blue blossom (*Ceanothus thyrsiflorus* Esch.) occupied the site within a year following the

fire. This shrub cover shaded many of the pines and probably contributed to their mortality. In 1962 only a few trees were still shaded by the 12-15 foot (3.7-4.6 m) tall brush (Sindel 1963); most of the survivors had broken through and were showing rapid growth.

In 1956, several 50-foot-wide (15.3 m) strips were opened through the plantation to aid access in case of fire. It was observed that blacktail deer (*Odocoileus hemionus columbianus*) used these strips for access into the plantation, the male deer killing many pine by rubbing their antlers against them. No further work to open fire strips or control brush on the site was performed after this.

Western gall rust (Endocronartium harknessii) was noted on the lower limbs of many pine in 1962. In 1965, 38 trees with severe bole infections were removed and 109 other trees were limb-pruned to a height of 8 feet as a control of rust. Few trees showed signs of gall rust in our 1982 survey so the pruning and removal treatment was apparently successful. Red band needle blight (Dothistroma pini) infected the trees severely in the mid 1960's. Growth was slowed due to the decrease in crown biomass, but no mortality occurred as a result of the disease (Sindel 1982, per. comm.). The crowns of living trees in 1982 varied considerably in volume but no evidence of the blight was discovered. Radiata pine is reported to become resistant to this disease after about 20 years of age (Bega 1979).

METHODS

The plantation was sampled in September 1982. The pine stand was located on air photos and three one-acre plots encompassing an estimated one-third of the living trees in the plantation were selected to be sampled.

Every living pine tree in the plots was measured for diameter at breast height (DBH). Western gall rust was said to be present on a tree if obvious galls were seen to exist on the bole or branches. A subjective estimate was made as to the health of each tree according to the tree's crown appearance and stature [trees were rated 1) excellent, 2) good, 3) fair, 4) inferior and 5) poor]. Every tree was also assigned to a conformation class depending on whether the tree was upright, forked, bent or straight, and as to the severity of any maladjustment. Five classes similar to the health categories were used. Many live trees greater than 40 feet (12.2 m) in height and 4 inches (10.2 cm) DBH were found bent, either leaning on neighboring trees or bent to the ground. This could be a result of rapid growth and the

inability of the trunk to support the extending leaders. Competition in the dense stand could also have resulted in spindly growth.

Ocular estimates of the percent of tree height containing some live crown were made to the nearest 5 per cent. Such estimates were made on all 126 trees.

Height measurements were recorded with a topographic clinometer for 45 trees, 15 from each plot. These heights are from trees that represent a cross section of diameters for the stand.

Increment cores were removed at DBH from 24 dominant or codominant trees to assess growth performance during the past 15 years. Natural regeneration of the pines and evidence of animal damage to trees was also noted on each plot.

RESULTS AND DISCUSSION

It was observed that about 10 acres (4.1 ha) of the original 16 acres (6.5 ha) planted still have some pine on them. Living Ceanothus brush is almost nonexistent. Redwood sprouts and surviving trees from the 1951 fire now offer the most significant competition for the pine.

The trees in the plantation show considerable variation (Table 1). Of the 126 living pines measured on the 3 plots, the smallest was 2 inches (5.1 cm) DBH and the largest was 34.6 inches (87.9 cm) DBH and 119 feet tall (36.3 m). The tallest tree was 153 feet (46.7 m) [21.5 inches (54.6 cm) DBH] while others were less than 10 feet (3.1 m) tall.

Trees greater than 10.5 inches (26.7 cm) DBH are shown separately in Table 1 as these are presumed to be potential crop trees.

The heights of these trees are comparable to those from plantations in other parts of the world (Burkhart and

Tennent 1977, Fry 1962, Fenton 1979; Figure 3). Forked tops were observed in 13 trees and 8 trees had broken tops.

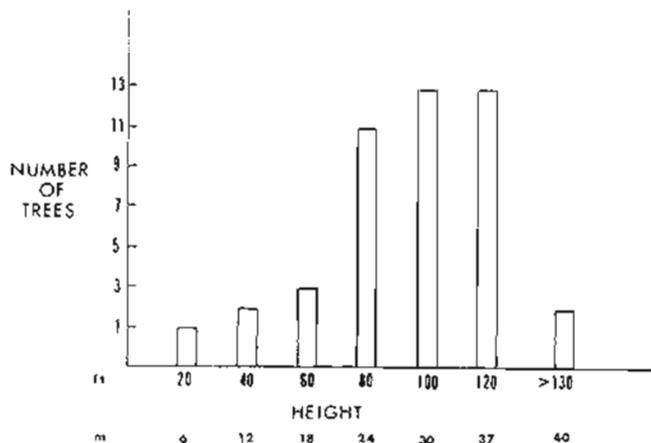


Figure 3. Histogrammatic representation of heights of 45 radiata pines grown for 31 years in a plantation in northern California. Height values shown are midpoints of twenty-foot (6.1 m) intervals.

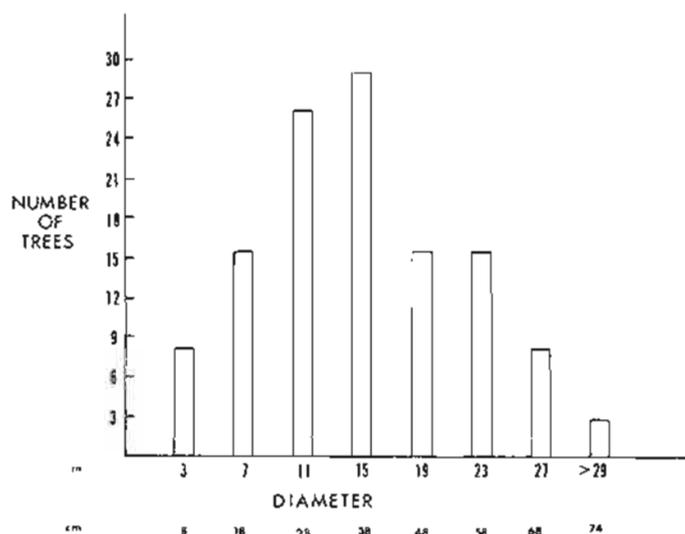


Figure 4. Distribution of diameters of 126 radiata pine at 31 years of age grown in a plantation near Fort Bragg, California. Diameter values shown are midpoints of four-inch (10.2 cm) intervals.

Stem form was variable, as is typical in other plantations (Bannister 1979, James 1979). Only 30 trees (about 24% of the survivors) rated excellent or good on our subjective form scale. Many of the trees leaned and probably have developed compression wood and may not remain standing for long. Sindel (1963) suggested that poor form resulted from excessive growth rate; if so, this could possibly be corrected by changing the initial stocking rate. Selection for straightness (James 1979) might also offer a solution.

Average diameters of the greater than 10.5 inch (26.7 cm) DBH trees also compare favorably with those of New Zealand, African and South American stands (Fenton 1979, Fry 1962, Van Larr 1979; Figure 4). This is a high potential site, but under more intensive management, diameter, height and form could be substantially improved (Will and Hodgkiss 1977). Diameter appeared significantly correlated with form for all trees, indicating that the larger DBH trees have the best forms.

The majority of trees appeared healthy with the larger trees generally having a good live crown (average = 55% of height). Radial growth increments for these larger trees were declining in a negative exponential fashion (Figure 5) over the past 10 years but this growth was still reasonable yielding 5.5 rings to the inch (2.54 cm).

The 1965 pruning and tree removal to control western gall rust appears to have been successful. Limb galls were evident on only 18 trees and only 3 of these were in the greater than 10.5-inch (26.7 cm) DBH group.

Our notes indicated that natural regeneration of pine had occurred: 32 pines 0-3 feet (0-0.91 m) tall, 4 pines 3-6 feet (0.91-1.8 m) tall, and 8 pines greater than 6 feet (1.8 m) tall were encountered indicating establishment has been occurring for some years.

Radiata pine is very susceptible to cold damage, but the Año Nuevo source from which these trees are probably derived is the most cold-tolerant (Hood 1975). The regeneration that is present could be the first that has occurred in the stand (the tallest trees had about 8 branch whorls) or only that since a severe cold spell in 1972 (Hood 1975). However, we found no direct evidence that the 1972 cold spell killed earlier regeneration.

The phenomenal growth shown by radiata pine has prompted suggestions of 16-year rotations for pulp use (Grant 1978). Harris (1979) also encouraged an 18-year rotation for use as an energy crop. Energy cropping of pine (especially conversion to methanol) is thought to be a practical answer to some nations' energy problems. Small and large landowners could benefit from plantation projects with such short

rotation periods. The pine is also used for pulp and chips but this is not thought to hold much potential in California until the problems of how to deal with insect and disease pests are better understood (Sweeley 1982).

While individual trees showed exceptional growth the plantation as a whole has not been a commercial success. Less than 3 per cent of the total planting have developed into potentially merchantable trees and most of these have some defect. Subtracting the cost of proper disease control, pre-commercial thinnings, and other plantation management procedures against current market prices for this species make a plantation operation less than marginal.

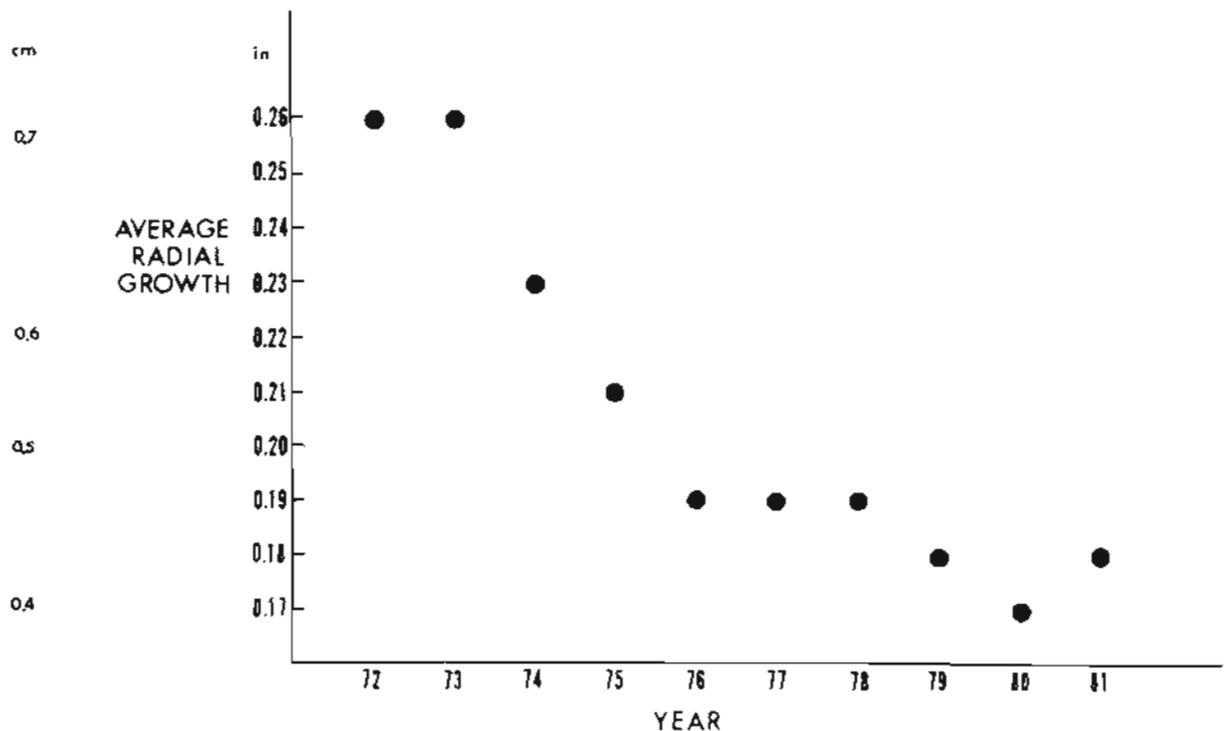


Figure 5. Average growth per year for the last 10 years (1972-81) of 15 radiata pine greater than 10.5 inches (26.7 cm) diameter breast height.

Table 1. Average tree characteristics of a 31-year-old radiata pine plantation near Fort Bragg, California. Data shown are means (plus or minus one standard deviation) of N trees >10.5" (26.7 cm) DBH or of n trees of all sizes. Growth [average inches (or cm) of radial increase per year] is for the last ten years.

Trait	Trees >10.5" (26.7 cm) DBH	All Trees	No. Trees >10.5" DBH	No. Trees All Sizes
DBH (inches)	18.6 (5.5)	15.2 (7.1)	89	126
(cm)	47.2 (14.0)	38.6 (18.0)		
Height (feet)	104.1 (18.8)	95.6 (27.6)	37	45
(m)	31.7 (5.7)	29.2 (8.4)		
Live Crown (%)	51.5 (20.6)	45.5 (24.7)	89	126
Form*	2.8 (0.8)	3.3 (1.1)	89	126
Health*	2.7 (0.7)	3.0 (0.9)	89	126
Growth (inches)	0.2 (0.1)	0.18 (0.9)	15	24
(cm)	0.5 (0.3)	0.5 (2.3)		

*Subjective ratings from 1 = excellent to 5 = poor; see text for detail.

There is some disagreement about the value of establishing radiata pine plantations in the redwood region. Proponents cite the species' more rapid growth to merchantable size and superior wood qualities when compared to other native whitewoods. On the other hand, others say the native redwood and whitewoods exhibit significant growth without such a high risk of disease and insect problems. Also, the indigenous whitewoods, and especially redwood, have a substantial commercial value with an established industry to harvest and mill them.

At present the market for radiata pine in California is essentially untried. Additional research with radiata pine, particularly with select trees, is needed if this species is to become commercially important in northern California.

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