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Coast Live Oak Thinning Study in the Central Coast of California[1]

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Abstract: A long-term thinning study was established in ten stands of coast live oak (*Quercus agrifolia* Nee) in the Central Coast of California. Information about diameter, basal area, and volume growth and yield is being obtained from unthinned control plots and from plots thinned to 50 and 100 square feet of basal area per acre. Descriptive information was also collected about the overstory, understory, and the site. Remeasurement at 5-year intervals will provide valuable data about the effects of thinning in coast live oak stands.

During the past decade there has been increasing interest in the potential of wood for supplying energy. California's oak woodland is one source receiving increasing pressure for harvesting. These woodlands are mostly an unmanaged and underutilized resource that could provide a continuous source of wood fiber for energy and wood products, given proper management.

Coast live oak (*Quercus agrifolia* Nee) was selected for this study because of its extensive range in California, from San Diego to Mendocino County covering about 750,000 acres (Bolsinger, personal communication). The species has been utilized for fuelwood and charcoal production. To our knowledge it has not been conscientiously managed for fiber or wood production. Coast live oak's relatively rapid growth rate, especially when compared to blue oak (*Quercus douglasii* Hook and Arn.) or other deciduous oaks found on non-conifer soils, will allow for a more rapid return on an investment for stand improvement. Coast live oak commonly grows in dense, relatively even-age stands and appears to be amenable to thinning.

Based on four studies (Pillsbury 1978,1985; Pillsbury and De Lasaux 1985; and De Lasaux 1980) involving inventory of coast live oak stands (Figure 1) they are typically dense, ranging from 100 to over 700 trees per acre (averages for these studies varies from 300-350) and basal area ranges from about 75 to 250 square feet per acre (averages for these studies is 150-160). Tree spacing ranged from about 7 to 20 feet (average of 12-13) while average tree diameter for the stands varied from about 5 to 17 inches (averages of 10-11). Coast live oak stands are largely between 40 and 110 years of age although stands have been measured as young as 28 years and as old as 131 years. Typically they average 60-80 years in age. Site index values varied from a low of 32 feet to a high of 84 feet at 50 years.

We are aware of no coast live oak studies that show the effects of thinning on the growth of the residual stand. Thinnings are normally conducted to stimulate the growth of the trees that remain

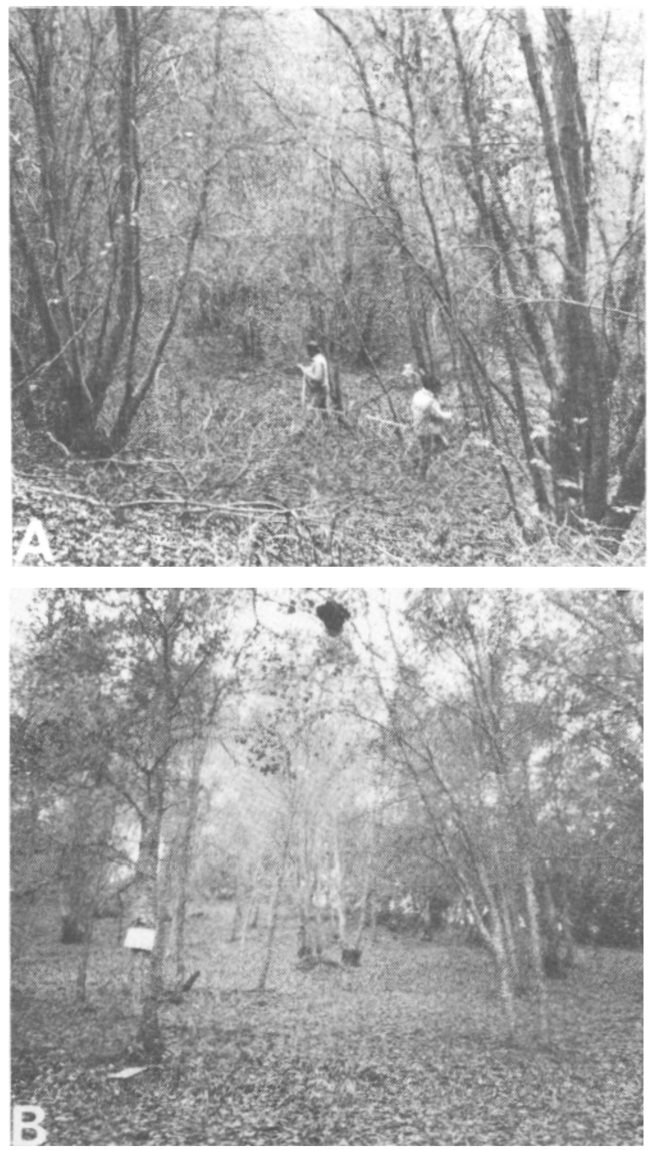

Figure 1. Unthinned (A) and thinned (B), 42 year old Coast live oak stand.

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and to increase the total yield of useful fiber from the stand. The basic objectives of thinning are: a) to redistribute the growth potential of the stand into fewer but larger trees, and b) to utilize all the merchantable material produced by the stand prior to harvest (Smith 1962). A long-term thinning project might consist of a series of cuttings to temporarily reduce the stand density (usually measured in basal area or volume). Artificial changes in stand density do not affect total volume production unless the stand becomes exceedingly dense or open (Smith 1962). The faster diameter growth induced by thinning, however, increases the proportion of stem wood that is large enough for profitable use. Thus, thinning can be used to increase the economic yield of a stand in spite of evidence that, in the biological sense, gross production of wood or of total dry matter is not subject to much alteration.

Normally a thinning or series of thinnings should be done early in the life of the stand, and after the first harvest it is recommended that a more frequent thinning prescription be followed for the next generation of trees. However, given the current stand densities and ages of coast live oak stands found in the central coast region, it is possible that a moderate to heavy thinning would still accelerate diameter increment to the benefit of the landowner.

The age that the final harvest would occur (rotation) for coast live oak was examined in a preliminary site, growth and yield study on the Central Coast (Pillsbury and De Lasaux 1985). Based on the growth rate and stand condition, a biological rotation of a stand could be as early as 50 years, although a harvest at age 75 or 80 would be feasible especially for stands on lower sites.

Currently, little is known about site productivity, regeneration, tree growth and the potential effects of harvesting on oak woodlands. Little information is available on different management practices and their effects. Growth and yield information is mostly unavailable for western hardwoods. By developing a number of permanent plots, growth can be documented over time. This data will prove valuable to foresters and landowners who wish to maximize fiber production in existing stands or want to compare the potential for different management strategies.

The primary long-term objective of this study is:

1. Establish a series of permanent plots to develop long-term diameter, basal area and volume growth and yield information for thinned and unthinned stands of coast live oak in Monterey, San Luis Obispo, and Santa Clara counties.

Other objectives of this study include:

1. Evaluate the changes in understory vegetation following thinning.
2. Evaluate the regeneration of coast live oak (stump sprouts and seedlings) following thinning.
3. Evaluate disturbance of soils during the thinning process and the effects of such disturbance.

Many of the stands measured in previous studies are near rotation age, whether they could benefit from thinning is important to know. This study may help to determine if a thinning of older stands will yield increased fiber while allowing for immediate income from the removed trees.

METHODS

Plot Selection

Ten sites were selected for this study and were distributed as follows: Monterey County - 4 sites, San Luis Obispo County - 5 sites, and Santa Clara County - 1 site. Three plots were established at each site consisting of one control plot and two plots that were thinned to 50 and 100 square feet per acre respectively. Plots were established in stands approximately 40 to 85 years old.

Several factors were considered to determine which plot should be thinned to either 50 or 100 square feet per acre. If the three plots were approximately equal in basal area normally the center plot was selected as the control or unthinned plot because it would most likely represent the average field condition. For other sites, normally the plot having the lowest basal area stocking level was selected for thinning to 50 square feet per acre, the plot having the highest level of basal area stocking was selected for thinning to 100 square feet per acre, and the plot having the middle stocking level became the control.

This approach alters the stand structure in a similar manner for both of the thinned plots. The percent basal area cut method was not used to determine where the treatments should be applied. Reducing the basal area level by some percentage would not allow for differences in initial stocking levels, stand table distribution, or the complexity of crown classes and tree vigor levels that are commonly found throughout the sites.

Each plot is one-fifth acre in size and is surrounded by a two-fifths acre buffer zone for a total area of three-fifths acre. Plots were established by compass and tape; metal rebar was used to monument plot corners.

Data Collection

Trees were divided into two categories: "cut trees" and "tag trees". For purposes of this study, "cut trees" are those trees that were small (normally less than 6 inches dbh), defective, and should automatically be removed. Only dbh and total height were recorded for "cut trees". All other trees were defined as "tag trees" and were marked with an aluminum tree tag. The information recorded from "tag trees" was used in the analysis to determine which trees were to be left (make up the residual stand) and which were to be removed (thinned as part of the treatment). The following information was obtained for each tree: tree number, species, dbh, total height, merchantability indicator code, vigor code, azimuth from plot center, horizontal distance from plot center, crown class, and a code that indicated if the tree should be removed and if the tree forked below breast height. The same data was collected for trees in the control plot.

The DBH measurement location was marked by a nail. Occasionally the reference nail for the DBH measurement had to be located 1 to 2 feet above or below DBH level (4.5 feet) due to abnormalities such as tree forking, and swelling. Determination of tree heights was difficult especially when the tree had excessive lean, up to 70 degrees from vertical in a few cases. Tree lengths were used as tree heights for all leaning trees.

DATA ANALYSIS

Development of Stand. Basal Area and Stock Tables

Basic mensurational data were compiled for each plot before and after thinning and extrapolated to a per acre stand basis. A stand table consisting of the number of trees of a given species per diameter class per acre was developed. Trees were put into 2-inch diameter classes (e.g., the 8-inch class includes trees 7.00 through 8.99 inches). Basal area tables were also developed by species and diameter class on a per acre basis. Stock tables, the cubic foot volume of trees of a given species per diameter class per acre, were developed.

Tree volumes for hardwoods were computed according to three utilization standards, total volume, wood volume, and sawlog volume based on equations by Pillsbury and Kirkley (1984). Total volume is the total outside bark volume including the stump. Wood volume is inside bark volume from stump height (1 foot) to a 4 inch top (inside bark) for all stems. Sawlog volume is the inside bark volume found in trees having an 11-inch or greater DBH and have straight, sound segments 8 feet or greater in length, from stump height to a 9 inch top diameter inside bark. Only total volumes were computed for non-hardwood species. Tree volume equations used in the study the following form:

$$\text{Volume (cu. ft.)} = b_0(\text{DBH})^{b}1\ (\text{Ht})^{b}2\ (\text{Sawlog Ind.})^{b}3$$

where: DBH is diameter at breast-height in inches,
Height is total height in feet,
Volume is in cubic feet based on one of the three utilization standards discussed above,
Sawlog Ind. is a code of "1" or "10". A value of "10" means the tree meets the sawlog criteria discussed above, and a value of "1" means that it does not meet sawlog standards. If the tree is not of sawlog quality and size, the last term can be dropped from the equation, and
b_0-b_1-b_2-b_3 are regression coefficients.

The total tree volume was calculated from a local volume equation developed from data by Pillsbury and Stephens (1978) and Pillsbury and Kirkley (1984). This was done to obtain a more precise estimate of volume growth following successive inventories because height, a less precise variable to measure, is not used in the equation. To determine the effect of eliminating height from the calculation of total volume, volumes for the three plots at site number 1 were compared using both local and standard volume equations to determine the actual difference. The difference, 1.3%, is not considered significant. All wood and sawlog volumes are from standard volume equations developed by Pillsbury and Kirkley (1984). A comparison of the proportion of volume measured as total, wood and sawlog volume is shown in Figure 2.

Thinning Prescription

The strategy used for cutting was a combination improvement cut and low thinning. Two plots at each site were thinned to 50 and 100 square feet basal area respectively, while the third, control plot, was not thinned. Trees designated as "cut trees" during initial field measurements were

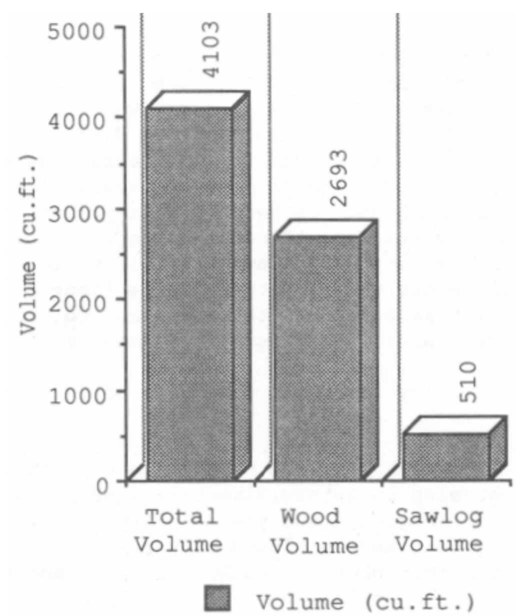

Figure 2. Proportion of total volume, wood volume, and sawlog volume in the coast live oak thinning study stands in Monterey, San Luis Obispo, and Santa Clara counties.

Table 1. Summary of coast live oak stand characteristics for central coast counties prior to thinning.

Site No.	Average Age (years)	Site Index (feet)	Crown Cover (%)	Average Spacing (feet)	Average Diameter (inches)	Number Trees (#/ac)	Basal Area (sf/ac)	Volume Total[1]	Wood[2]	Sawlog[3]
								cubic feet per acre		
1	52	52	97	9.6	7.7	478	153	3558	2059	135
2	57	36	96	10.8	10.4	372	219	5391	3022	0
3	28	84	84	7.8	5.7	723	125	2470	1611	101
4	63	60	93	13.7	12.4	255	202	5867	4572	2259
5	77	48	87	19.4	16.1	133	163	5060	3690	649
6	41	47	92	9.9	7.4	447	135	3013	1727	35
7	81	33	77	12.7	8.7	272	111	2594	1379	23
8	73	53	90	13.0	10.5	262	157	4052	3026	1216
9	85	39	87	19.8	16.7	115	170	5111	3391	539
10	61	42	90	11.7	9.8	335	157	3947	2478	145
Average	62	50	89	12.8	10.5	339	159	4106	2696	510

[1]Total volume includes all stem and branch wood pl8us stump and bark; excludes roots and foliage
[2]Wood volume is computed from stump height (1 foot) to a 4 inch top outside bark; excludes roots, bark and foliage.
[3]Saw-log volume is computed for trees 11 inch d.b.h. and larger; from stump height to 9 inch top outside bark for straight sections 8 feet long; excludes roots, bark, and foliage.

automatically removed from the stand. These were mostly small diameter trees (less than 6 inches) of poor vigor and were either in the suppressed or intermediate crown class. The decision to cut a "tagged" tree was based on the following criterion. Trees were removed if they:

a) were not coast live oak,
b) were damaged or defective,
c) were less than 6 inches dbh,
d) were one stem of a forked tree,
e) were of suppressed or intermediate crown class, or
f) were of poor vigor.

In most cases further basal area reduction was needed to obtain either 50 or 100 sq. ft. basal area for the plot. Additional trees were removed if they:

g) were obviously from a previous stand,
h) were not sawlog quality or size, or
i) were too closely spaced to an adjacent tree.

Also, some changes in tree selection were made during the tree removal process. Trees that had excessive lean and whose crown adversely crowded adjacent crowns were removed. If the felling of a large tree would likely break or damage other trees, then either the large tree was not cut or the trees that would be damaged were also included on the removal list. The actual changes in the composition and structure of the stand resulting from thinning are illustrated in Figure 3-8. The bar graphs show the average change calculated from data for the 10 sites in Monterey, San Luis Obispo, and Santa Clara counties.

RESULTS

Stand, basal area and stock tables were developed for each plot and will be used to compare the changes due to stand growth every five years.

Initial stand characteristics for the ten stands measured in this study are shown in Table 1. Values shown for each stand are averaged from three one-fifth acre plots prior to thinning.

Figures 3 through 7 illustrate the change in the number of stems per acre, basal area per acre, total volume per acre, wood volume per acre and sawlog volume per acre as an average for the 10 sites for each treatment.

FUTURE ANALYSIS AND NEEDS

It is anticipated that the thinning study sites will be remeasured in successive five-year periods. Trees remaining on the treatment plots and all trees on the control plot will be inventoried for species, dbh, total height, sawlog indicator, tree vigor, and crown class. Also each plot should be measured for percent crown cover. New stand, basal area, and stock tables will be developed to show the relative change in distribution. Differences in basal area and volume will be converted to annual growth and analyzed to determine the level of increase obtained by thinnings.

More information is needed about the regeneration of coast live oak stands. We know that coast live oak is usually a vigorous stump sprouter after harvesting, but little specific information is known about how sprouting of this species is affected by stump size, age, site conditions, and the degree of exposure resulting from thinning. Although some of this information will be obtained from this study, the study was not designed to get the detailed information needed to accurately evaluate the effect of thinning levels on the spouting potential of coast live oak. More intense work is needed to obtain the information needed to develop effective management practices for the species.

Advanced reproduction (seedlings and small trees) are frequently present in coast live oak stands. How it will respond to thinning and how thinning will affect the establishment of new seedlings must also be determined. Guaranteeing satisfactory stocking is a basic requirement of stand improvement.

Finally, this study is only a beginning of the work needed to determine the overall role of thinning in the management of coast live oak in terms of total wood fiber production, increase growth of the residual trees, site effects, and economic consequences.

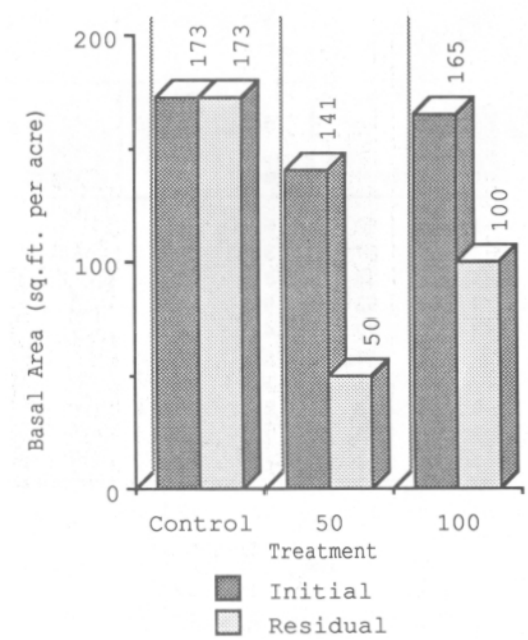

Figure 4. Comparative stand information for basal area per acre by treatment for the 10 coast live oak study sites in Monterey, San Luis Obispo, and Santa Clara counties.

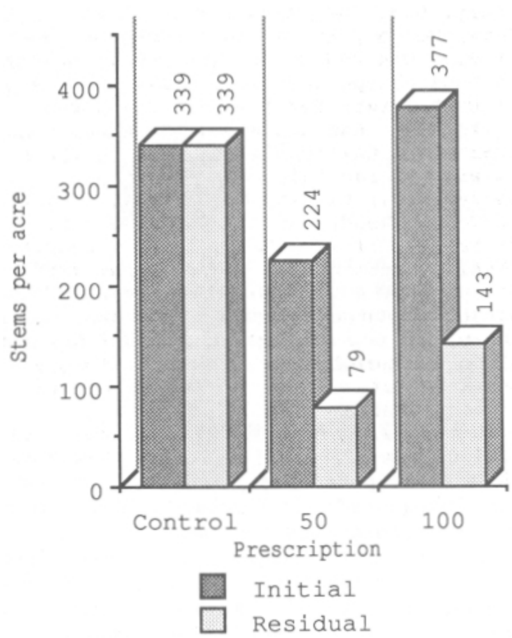

Figure 3. Comparative stand information for number of stems per acre by treatment for the 10 coast live oak study sites in Monterey, San Luis Obispo, and Santa Clara counties.

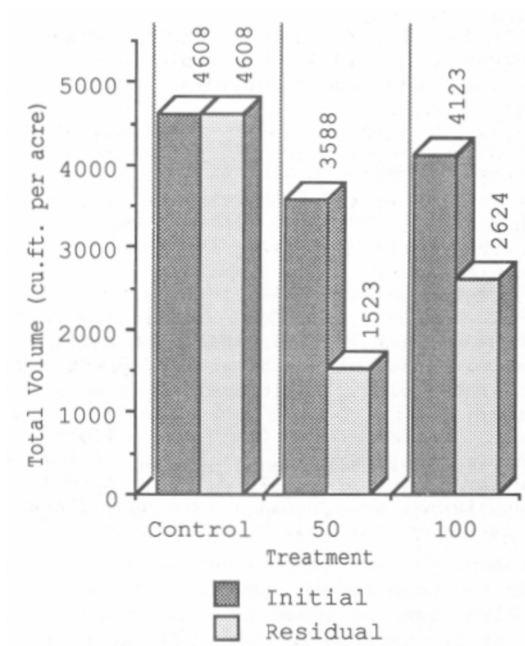

Figure 5. Comparative stand information for total volume per acre by treatment for the 10 coast live oak study sites in Monterey, San Luis Obispo, and Santa Clara counties.

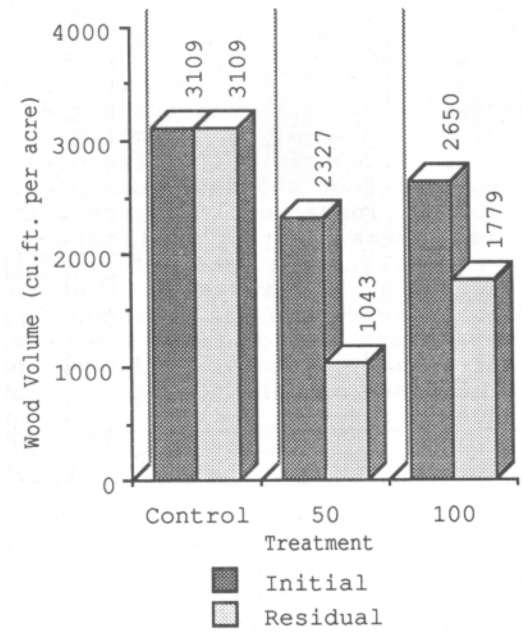

Figure 6. Comparative stand information for wood volume per acre by treatment for the 10 coast live oak study sites in Monterey, San Luis Obispo, and Santa Clara counties.

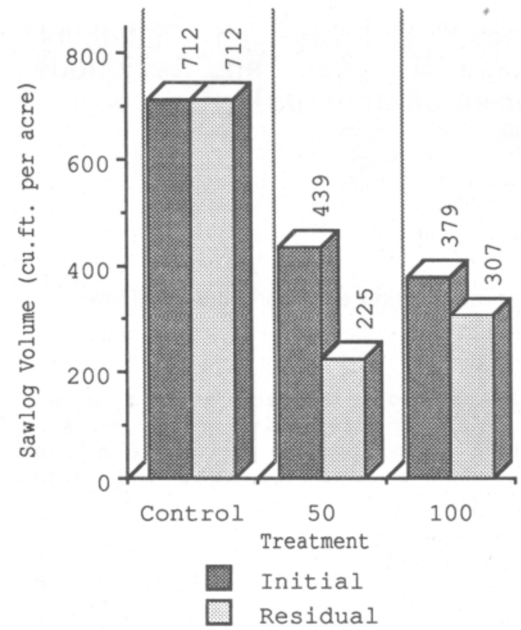

Figure 7. Comparative stand information for sawlog volume per acre by treatment for the 10 coast live oak study sites in Monterey, San Luis Obispo, and Santa Clara counties.

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