STATE BOARD OF FORESTRY.

CIRCULAR No. 2.

G. B. LULL, State Forester.

IN CO-OPERATION WITH THE FOREST SERVICE, U. S. DEPT. AGRICULTURE.

A HANDBOOK FOR

EUCALYPTUS PLANTERS

(SECOND EDITION.)

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STATE BOARD OF FORESTRY.

JAMES N. GILLETT ..... Governor.

CHAS. F. CURRY ..... Secretary of State.

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PROVISION FOR CO-OPERATIVE WORK.

SECTION 4. The State Forester shall, upon request and whenever he deems it essential to the best interests of the people and the State, co-operate with counties, towns, corporations and individuals in preparing plans for the protection, management and replacement of trees, woodlots and timber tracts, on consideration and under an agreement that the parties obtaining such assistance pay at least the field expenses of the men employed in preparing said plans.—Stat. 1905:235.

CONTENTS.

A HANDBOOK FOR EUCALYPTUS PLANTERS.

INTRODUCTION.

The growing interest in forest planting in California makes it desirable that prospective planters be supplied with concise information regarding the demands and qualities of the genus Eucalyptus, which, owing to its rapid growth and wide adaptation to economic uses, is destined to be planted more extensively than any other tree. Reliable information on this genus is now obtainable in Bulletin No. 35 of the Forest Service, but the information contained is more general in nature than the typical, quick-action planter is willing to digest. More recently a detailed, though as yet unpublished, report on the planting of the commercial eucalypts has been made by S. J. Flintham of the Forest Service after a study conducted in coöperation with the State of California. The essentials for planters have been culled from this report and other sources and embodied in this circular to meet the great demand for specific information on the economies of Eucalyptus planting.

HISTORY OF EUCALYPTUS IN CALIFORNIA.

The eucalypts are exotics in California, having been introduced from Australia in the early fifties by travelers who were impressed with the splendid proportions and rapid development of the genus in its native habitat. They were first planted in the vicinity of San Francisco for ornamental purposes. Later, in the sixties, they were planted near Los Angeles. The rapid growth and complete adaptability of the exotic to its new environments instantly claimed the attention of nurserymen, who recognized its suitability for commercial planting. Between 1870 and 1875 considerable planting was done for fuel, windbreaks and shade along avenues. One of these early groves was established near Irvington in the Santa Clara Valley in 1870, and later, 1872 and 1873, the first plantation in Southern California was made by Hon. Ellwood Cooper on his ranch near Santa Barbara. The well-known Widney and Nadeau groves, set out in 1874 and 1875, were the first extensive plantations made near Los Angeles.

THE TIMBER EUCALYPTS.

Eucalyptus has deservedly claimed more attention than any other exotic genus, and probably more than most of those indigenous to the United States. Great energy and persistence in experimenting with

the genus have been manifested by nurserymen and pioneer planters ever since its introduction. More than 150 species have been identified by botanists who have studied the Australian forests. Fully 100 of these, including practically all the species considered valuable for timber, have been introduced and planted in California.

For general purposes, however, the blue gum has been used more extensively than all other species combined, and even to-day the knowledge of most laymen of the eucalypts is confined to their acquaintance with this species. Several other species, however, possess special qualities which warrant their selection for particular uses and for certain localities. Among these are the sugar, manna, gray, red and lemon gums, which, with the blue gum, owing to their rapid growth and splendid development, rank as the timber eucalypts.

SYLVICAL CHARACTERISTICS.

Age and Size. In Australia the eucalypts reach ages of from 400 to 500 years, and dimensions second only to the California Sequoias. Indeed, in height development, though not in diameter, they surpass them. Many species are said to reach heights from 300 to over 400 feet, and diameters exceeding 12 to 15 feet. These dimensions result from long periods of growth in the virgin forests, however, and no such sizes have yet been attained by eucalypts planted in California.

No eucalypt has grown to greater age than 40 years in this State. At this age the period of rapid development has not been passed, and no disposition to become short-lived is shown, as is frequently the case with species grown outside their habitat. Blue gum trees 175 feet in height and 5 or 6 feet in diameter have been produced here in from twenty-four to thirty years. The single quality, rapidity of growth, entitles the eucalypts to serious consideration, for no other species can attain like dimensions in five times this period.

Form. Naturally the timber eucalypts maintain an erect form, with strong main axes and slender limbs. Young trees shoot up rapidly into slender poles with scantily branched crowns and feathery, drooping foliage. The bole gradually clears of limbs, particularly where the density of the stand causes lateral shading. Open-grown timber has more numerous and larger limbs.

Tolerance. The timber eucalypts are species of moderate shade endurance. During their early growth they will bear more shade than later in life. The seedlings are even shade-demanding, and succeed best under partial shade. When growth has commenced, however, full light should be afforded them.

The intolerance of saplings and poles is well indicated by their rapid height growth, upon which they depend in competition to escape sup-

PLATE 1. Blue gum timber 24 years old, showing characteristic clear, straight growth of this species. Trees over 36 inches in diameter, 175 feet tall, and 100 to 120 feet clear.

pression. It is not uncommon to see saplings too spindling to stand erect, caused by their efforts to overtop a competitor for light.

Root Development. The eucalypts use a great amount of water, hence they prefer a deep soil, through which the roots may penetrate to lower strata in search of greater supplies of moisture. In shallow soils overlying rock or hardpan the roots are forced to spread laterally, and on such situations the growth is generally stunted and slow.

In early years root development is exceedingly rapid, that of young seedlings greatly exceeding the growth of the plant above the surface. During early growth most eucalypts send down a taproot as well as numerous spreading laterals. The taproot of the blue gum, at least, rarely penetrates to a depth greater than 6 feet, further development being concentrated in the strong laterals.

The roots exhibit a strong impulse to seek water, and to reach it sometimes extend over 100 feet, crossing under ditches, pavements and roads. If they gain access to pipes or ditches through cracks or breaks in the masonry, they send out large masses of small feeding roots. Cisterns and water-pipes have been completely clogged in this manner.

Windfirmness. The production of an extensive lateral root system renders the eucalypts very windfirm. Their strong anchorage in the soil, combined with the flexibility of the growing stem, renders them particularly valuable for windbreak purposes, since a break which will yield before the force of the wind tends to deflect the air currents upward, and protects areas far to leeward, whereas an unyielding barrier breaks the wind only on areas in close proximity to it.

Reproduction. The complete adaptability of the eucalypts to California is especially shown by their strong reproduction here by both seed and sprouts.

Sprout Reproduction. All the eucalypts planted in California sprout vigorously from the stump or roots after cutting or in response to any injury to the tree. The small trees in young plantations generally sprout up thriftily after they have been cut back by animals or after saplings have been killed to the ground by frost or fire. After fire injury also, in an attempt at refoliation, the stems generally clothe themselves thickly from the ground to the top with short sprout branches like fire-injured redwoods.

Whenever it is desirable to reproduce a species which possesses coppicing qualities advantage is generally taken of them. With most species, however, the sprouts produced after the third or fourth cutting are less thrifty than those after the first or second. This tendency to weaken seems absent in the eucalypts, or if present, coppicing has not been practiced long enough in California to reveal it. Fuelwood

groves have sprouted up vigorously after the fourth and fifth cutting, and seedling trees over thirty years old sprout after cutting as thriftily as young trees. Indeed, it is almost impossible to kill the stumps of old trees or to prevent the sprouting of old roots left in the ground after the stumps have been grubbed out.

Seed Reproduction. Since natural regeneration is not practiced, the natural seeding of eucalypts is of little commercial importance. Seed is produced abundantly by all the eucalypts introduced into California. The fruit generally remains on the trees, unopened, until the fall of the seed cases to the ground. Wind dissemination plays no part in the extension of Eucalyptus, and as the seeds are not eaten by birds, the seedlings always occur beneath or very near the parent tree.

GENERAL REQUIREMENTS.

Every species makes definite ecological demands upon its habitat. The optimum development of a species is contingent upon the fulfillment of its requirements. It generally happens, however, that the demands of a species are not inflexible, and the species will survive if its requirements are but partially met. For example, a species will survive and grow indifferently, if it receives less food or light than it requires for best development. In the case of temperature much depends upon the age and condition of the tree species at the time its normal temperature range is crossed. If it is thriving and the temperature change comes gradually it will frequently withstand the shock without injury. Under less favorable conditions it will not recover. Except upon temperature the demands of eucalypts are fairly flexible. Their thermal demands, however, must be met. Whenever Eucalyptus planting is undertaken outside the thermal range of the species used some loss must be expected. Where only small plantations are made a risk is generally warranted. But where extensive commercial plantations, involving heavy expense, are made, they should lie within the thermal range of the species used. Since this circular deals with the commercial production of eucalypts, the planting of any species will not be recommended outside its thermal range. It is probable that most of the species treated will grow, indifferently at least, considerably outside of the range where their planting will be advised.

Soil. Practically, all the eucalypts grow best on a deep, fertile, well-drained, loam soil. But, as more valuable crops likewise develop most successfully there, the necessity arises of finding similar or poorer classes of land, which, on account of inaccessibility, or roughness,

is not of first value for agricultural purposes. These abound in the valleys and on the slopes of the lower hills throughout California. The chemical composition of the soil is of little importance, so long as an excess of injurious chemicals does not occur. The physical properties of the soil, such as permeability, retentiveness, etc., are vastly more important.

Temperature. No one factor has so much influence in governing the extension of Eucalyptus as temperature. The fact that its planting range is practically restricted to California is wholly attributable to the frost-tenderness of the genus. During the seedling years the danger from frost is greatest. The susceptibility of the sugar gum seedlings to frost injury is particularly marked.

Thermometer readings of temperature are not always true indices of the influence of frost on a tender plant. Much depends upon the condition of the plant at that particular time. If a period of warm weather is followed by a sudden drop in temperature, the plant suffers more than it would if an equally low temperature had come gradually. The exposure of the plantation is likewise important. If the plantation has an eastern exposure where it is reached by the first rays of the sun, the damage will be greater than if it remains in partial shade while the temperature ascends slowly.

The following order indicates the frost-hardiness of the timber eucalypts very closely: Red, gray, manna, blue, sugar, and lemon gum.

Moisture. A rapid growing plant, like anything else which grows rapidly, requires lots of food. This is taken up by the roots in the form of mineral salts in solution and elaborated in the leaves. Hence, the tree can not get its food unless its roots can obtain water. Therefore, other conditions being equal, the rate of growth depends directly on the amount of water the plant secures. While eucalypts will grow where the soil moisture is deficient, the rate of growth will be much slower than where the tree gets all it needs. For commercial purposes it is unwise to attempt to produce Eucalyptus where the soil moisture is markedly deficient. A fairly retentive, deep soil which receives an annual rainfall of from 25 to 30 inches will produce good trees.

Deficient soil moisture is supplemented by atmospheric moisture in the fog belt, where the fog is condensed by contact with the foliage. During a heavy fog the foliage of gum trees drips as if from a shower, and the ground under the trees becomes soaked overnight. The occurrence of fog accounts largely for the excellent growth of Eucalyptus on sandy soil at the Presidio, on the Piedmont Hills, and elsewhere in situations, otherwise inhospitable, throughout the Bay counties. Fogs, likewise, make the Los Angeles plain one of the favorable regions in

the State for Eucalyptus culture, although less so than the Bay counties, owing to lesser precipitation.

PLATE 2. Gray gum tree about 20 years old in an experimental plantation. Tree grown in an unfavorable situation to a height of over 100 feet and a diameter of 14 inches.

Among the timber eucalypts some are able to thrive on less moisture than others. The following order indicates their relative drought-hardiness: Sugar, red, gray, manna, lemon, and blue gum.

PLANTING REGIONS.

The area within which the timber eucalypts may be successfully propagated has been broadly defined as that bounded by the frost line. The manna and gray gums may be safely planted when the temperature does not drop below 22° F. This area is shown, approximately, by the accompanying isothermal map. Commercial planting outside the 22° F. isotherms is not recommended for any species, nor outside the 26° F. and 28° F. isotherms for blue and sugar gums, respectively.

For successful growth the requirements of eucalypts for soil and moisture are but little more elastic than for temperature. It is unwise to set high-priced seedlings on shallow soil or where the water table is far below the surface. Planters should not forget that the rapid growth and proper development of eucalypts is contingent on their food supply rather than on any inherent quality. Where the water table is accessible at not more than 25 feet below the surface, good growth may be expected.

CHOICE OF SPECIES.

Generally speaking, the blue and sugar gums should be chosen for planting within their thermal ranges. Outside these the red, gray and manna gums must be considered as the leading species.

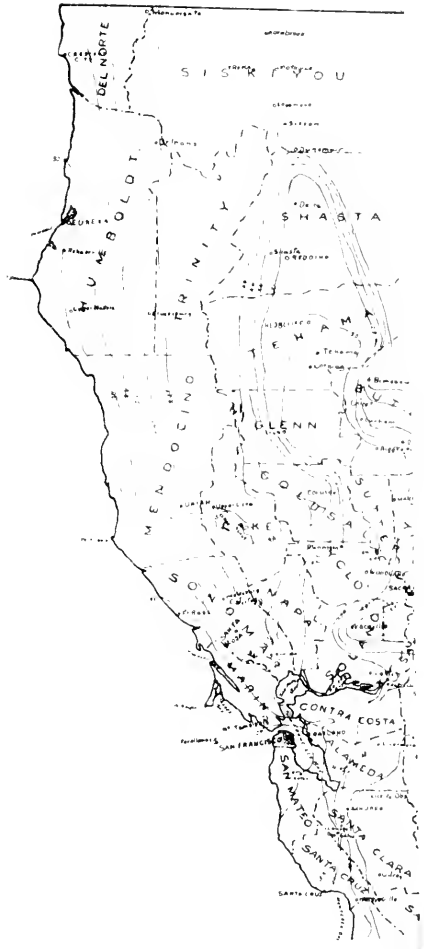
Whenever the selection of species lies between blue and sugar gum, the kind of product desired and the amount of soil moisture present must determine the choice. If firewood, piles, or dimension stuff is desired, the blue gum should be selected, especially if there is no marked deficiency of soil moisture. If poles, ties or a wood of unusual durability and strength is desired the sugar gum should be chosen, particularly if the situation is rather arid. The sugar gum is the more drought-resisting, but the blue gum is the more rapid-growing.

Outside the planting range of the blue and sugar gums the red gum commends itself, owing to its frost-hardiness and the durability of its timber. In frosty or swampy locations it should receive first preference. The uses of its product are limited, however, by the fact that it is inclined to a crooked, branchy form. It is of rapid growth and furnishes a product which is very durable in contact with the soil.

The gray gum is equally rapid in growth, but is somewhat less frost-hardy than the red. It grows in good form, especially in plantations, and furnishes a very durable timber.

Manna gum grows very rapidly, but it is hardly worthy of consideration, since it is but slightly more frost-hardy than the sugar and blue gums, while its timber is inferior to that of either species.

Lemon gum is probably more valuable for ornamental than for economic planting. Its rate of growth is about equal to that of red


DEL NORTE
SISKIYOU
HUMBOLDT
TRINITY
SHASTA
TEHAMA
MENDOCINO
GLENN
COLUSA
LAKE
SONOMA
NAPA
SOLANO
YOLO
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ

MAP OF

CALIFORNIA

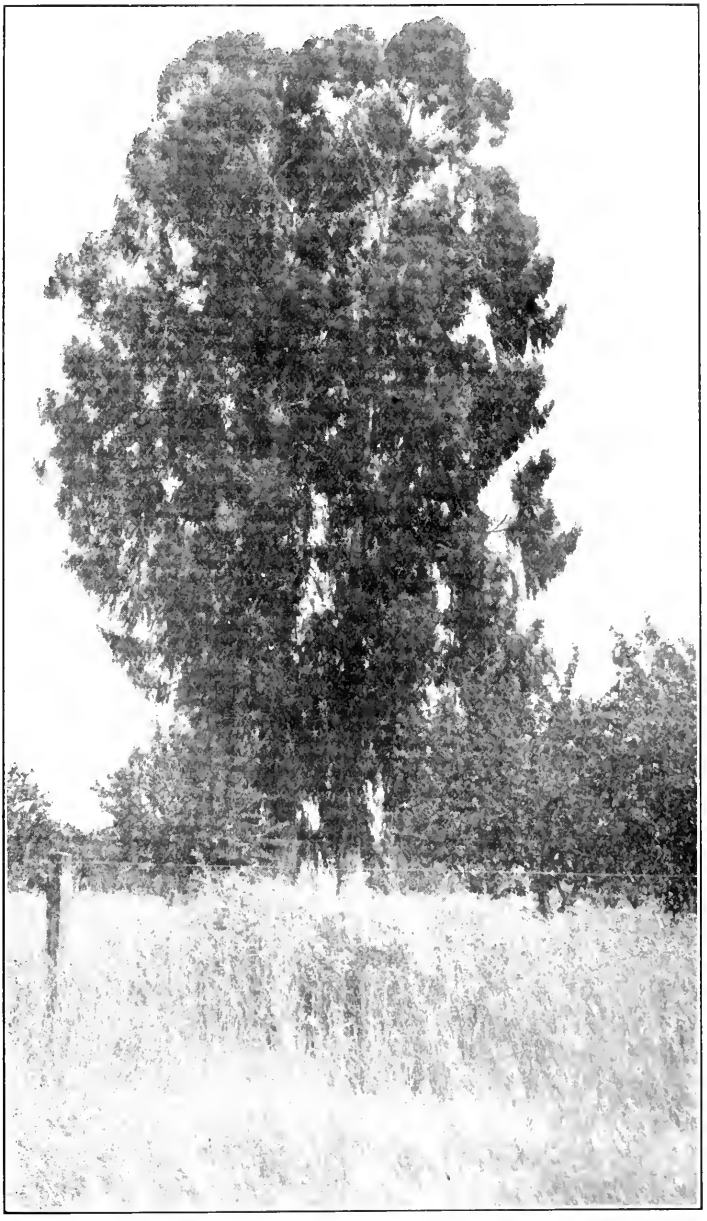


PLATE 3. Exceptional development of manna gum in the San Joaquin Valley. Trees clear, straight, and of very massive proportions. The two trees are 20 to 25 years old, 4 to 5 feet in diameter, 150 to 160 feet tall, and 50 to 60 feet clear.

gum, but it is less frost-hardy and produces a less durable though better formed timber.

HOME-GROWN *VS.* NURSERY SEEDLINGS.

The following list contains the names and addresses of the California firms that are known to deal in Eucalyptus seeds and seedlings. Some of these deal in Eucalyptus stock exclusively.

Dealers in Eucalyptus Seed.

Cox Seed Co.	San Francisco.
Germain Seed and Plant Co.	Los Angeles.
Stengel Exotic Nursery Co.	Los Angeles.
Theo. Payne	Los Angeles.
Johnson & Mussar	Los Angeles.
Fancher Creek Nursery Co.	Fresno.

Nurserymen Propagating Eucalyptus Seedlings.

Cox Seed Co.	San Francisco.
Pacific Nursery Co.	San Francisco.
Western Nurseries	San Francisco.
Seaman	Oakland.
Germain Seed and Plant Co.	Los Angeles.
Stengel Exotic Nursery Co.	Los Angeles.
Theo. Payne	Los Angeles.
Sessions	San Diego.
Warner	Santa Ana.
Young	Santa Ana.
O. Roessner	Pomona.
Griffin	Pomona.
Fancher Creek Nursery Co.	Fresno.
Wilson	Fresno.
Wilson	Dinuba.
Wilson	Visalia.
California Nursery Co.	Niles.
Ritchman	Fullerton.
Timothy Carroll	Anaheim.
J. W. Armstrong	Ontario.
N. Eaton	Ontario.
Stratton	Petaluma.
Leonard Coates Nursery Co.	Morgan Hill.

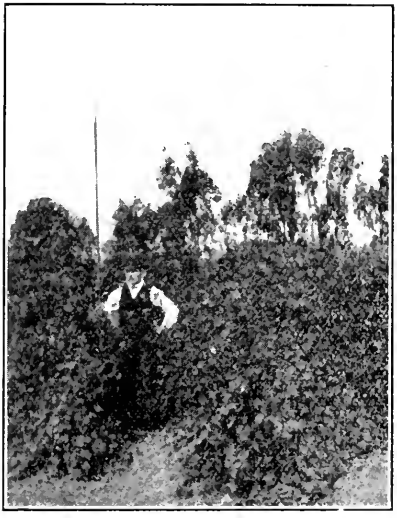
Whenever planters desire only small quantities of stock it will be advisable to secure it from a dealer. The price demanded for seedlings will be considerably higher than the actual cost of raising the seedlings, but not sufficiently great to warrant small planters attempting to propagate their own seedlings. Generally, the regular price will be reduced by a nurseryman even to a small planter who contracts in advance for a stated number of seedlings.

If large quantities of seedlings are to be used annually for several consecutive years, the saving in the cost of seedlings will warrant the planter in establishing a small nursery and propagating his own stock. The practicability of doing this depends largely on the local prices demanded for seedlings, however, and on the facilities at hand for raising them.

The prices for seedlings exacted by nurserymen in different parts of the State vary from $8 to $30 per thousand, depending largely on the local demand. Hence, if a planter lives in a locality where $30 per thousand is asked, it is expedient, at least, to use home-grown seedlings.

On the other hand, if but $8 per thousand is demanded, generally, it will be more advisable to purchase them outright than to assume the initial expense of preparation and the subsequent work of propagating the plants, although they can be raised for $2.50 to $3.50 per thousand.

Cheapness is not the only quality which commends home-grown seedlings. The certainty of having them when they are wanted is assured, and generally higher-grade stock can be raised than nurserymen supply. The risk entailed in transporting seedlings from the nursery to the planting site is also avoided.



Sugar gum plantation, 1 year old, in Los Angeles Valley. Trees now 7 feet tall.

Blue gum plantation, 1 year old, in Los Angeles Valley. Trees now 14 feet tall.

PLATE 4.

NURSERY PRACTICE.

Lath House. As stated under the heading "Tolerance," Eucalyptus seedlings are naturally shade-demanding and succeed best under partial cover. This condition is created artificially by the construction of a lath house, within which the seedlings are raised to planting size. The amount of light admitted is determined by the width of the spaces between the laths. In practice it has been found that half light and half shade, secured by spacing the laths a distance equal to their width, is about right.

It sometimes happens that the seedlings are attacked by a fungous disease called "damping off," which really amounts to the rotting of the stems just at the surface of the soil. This disease is particularly liable to appear if the seedlings are watered too much, or in the late

afternoon when the soil remains wet overnight, or when they are over-shaded. To check it, it is necessary to admit more light or to sprinkle the surface of the seed boxes with dry sand. In any case the admission of light and the freer circulation of air are desirable, hence the laths should be put on in panels so they can be removed if desired.

Another point to be observed in constructing a lath house, particularly in windy locations, is to lay the lath on the sides of the house diagonally instead of vertically or horizontally. This will give the house greater strength.

The size of the house must be determined by the number of seedlings required per year. As a general guide it is safe to count on forty seedlings for every square foot of floor space enclosed.

Seed Boxes. It is desirable to sow Eucalyptus seeds in boxes instead of in the open soil, in order to facilitate the handling of seedlings and to control the development of their roots. The boxes should be about 18 to 20 inches in surface dimension by 3 or 4 inches deep, and filled almost to the top with fine, mineral soil, free from weed seed. This should be smoothed uniformly, care being taken not to leave any hollows or holes, and not more than 1,000 seeds should be sown in each box. After sowing, the seed should be covered a little deeper than the diameter of the seed with a layer of fine sand.

After the seed is sown, a very light layer of leaf-mold, or sawdust, should be sprinkled on the surface of the soil. This will help to retain the mosisture and thus hasten germination. During warm weather germination may be expected in from four to ten days. When the seedlings appear above the surface the sawdust may be removed. Some contend that redwood sawdust prevents damping off, but the reason for this is not clear.

Watering Seedlings. The regulation of the water supply for Eucalyptus seedlings requires careful attention. Too much and too little water injures them equally. Nearly every difficulty experienced in raising Eucalyptus seedlings can be overcome by gauging the water supply so that the soil is kept moderately moist at all times during the sunny part of the day and somewhat drier at night. If the seedlings begin to wilt, they should be examined immediately and carefully to ascertain whether the wilting is due to drought or "damping off," for in the former case water is needed, while in the latter a drying process, already described, should be instituted. The symptoms are very similar and should not be confused.

As a general rule it is safer to err on the side of too little water rather than on that of too much. It should be given during the day when there is a considerable period of sunlight ahead. During the last two

or three weeks before planting, the seedlings can be hardened and made more woody by curtailing their water supply, though it should not be withdrawn enough to stunt them.

Transplanting. If the 1,000 seeds planted in each box germinate and grow well they will begin to crowd each other when the seedlings are about two inches tall. When this condition obtains it should be relieved by pulling out all but 100, which should be left evenly distributed in each box. Those removed should be transplanted in other boxes.

In removing them from one box to another the roots of the seedlings should not be exposed to the air too long. Eucalyptus seedlings are not so tender as those of conifers, however, and will revive after considerable hardship.

Immediately after being transplanted the seedlings are likely to wilt slightly. If watered freely and shaded well for a few days, however, they will revive, unless the roots have been killed by exposure during the operation. To avoid this it is advisable to transplant on a cloudy or foggy day.

Protection of Nursery. The damage to nursery stock caused by birds and small rodents can be controlled by preventing them from effecting an entrance to the lath house. Ants, however, are likely to invade the lath house and cause considerable trouble if left unmolested. They can be kept from the seedlings by painting the edges of the boxes with corrosive sublimate, which the ants will not cross. An established colony can be killed by pouring carbon bisulphid into the passage holes, which should then be plugged with dirt to confine the gas.

FIELD PLANTING.

In the portions of California suitable for Eucalyptus culture the season is divided between periods of drought and abundant rainfall. In some sections the summer drought is broken by rains in October; in others it may continue till late in November or December, or even later. If late in January or in February sufficient rain has fallen to moisten the soil to a depth of one foot or more, planting should be begun in order that the plantation may become established during the continuance of the rainy season.

No fixed rules to govern planting need be given. Every planter can best decide for himself what arrangement of his men gives best results. On wild, uncultivable land it has frequently been found advantageous to divide the men into three squads. The first, consisting of men equipped with mattocks, precedes the other and prepares holes for the seedlings by removing the sod and digging up the mineral soil. The

second follows, each man having a box of plants and an ordinary trowel, which he uses to scoop out the loosened soil, making a hole to receive the plant, about the roots of which he packs soil closely. The third, consisting of less than half the number of either of the others, keeps the second squad supplied with plants. On tilled land the first squad may be dispensed with.

SPACING.

The proper spacing of seedlings in a plantation is a matter of first importance. Upon it depends the number of seedlings required per acre, the length of time cultivation is necessary, the rate of growth of the trees, and the character of the product. California planters, observing the small spindling trees in the interior of dense plantations and the larger trees along the edges, have inclined to very wide spacing. For different plantations the spacing has varied from 4 by 4 feet to 16 by 16 feet, and the opinion is prevalent that spacing 8 by 8 feet is too close. The very rapid growth of eucalypts soon closes up an open plantation and seems to warrant wider spacing than is advisable with most slower-growing trees. For best results, however, Eucalyptus plantations should not be spaced closer than 6 by 6 feet, nor wider than 10 by 10 feet for any purpose.

The wider spacing is allowable if firewood is the only product sought. For ties, piles, poles, dimension stuff, or any material in which good form is an indispensable quality, the plantations should be spaced not wider than 8 by 8 feet. Sugar and lemon gums, which naturally grow tall and spindling with scanty foliage, should be spaced 6 by 6 feet preferably, and never more than 8 by 8 feet. A similar spacing is recommended to correct the crooked-growing tendency of red gum.

Uniformity of spacing should always be attempted. Sometimes the topography of the planting area will render its attainment impossible, or at least impracticable, in which case it should be approached.

Level, tilled land can be marked to insure uniformity of spacing. On untilled land uniformity may be approximated by keeping the men in the mattock squad in line. Where extensive planting operations are carried on one man may be detailed to set flags at stepped distances apart, to guide the mattock men on the ends of the line. Those between them will soon learn to keep an equal distance apart.

CULTIVATION.

Wherever the condition of the planting area lends itself readily to cultivation, this treatment should be accorded the plantation at least two or three times during each of the first two dry seasons after planting. Once a month is better. Plantations on untilled land will respond sufficiently to hoeing to warrant its practice once, at least.

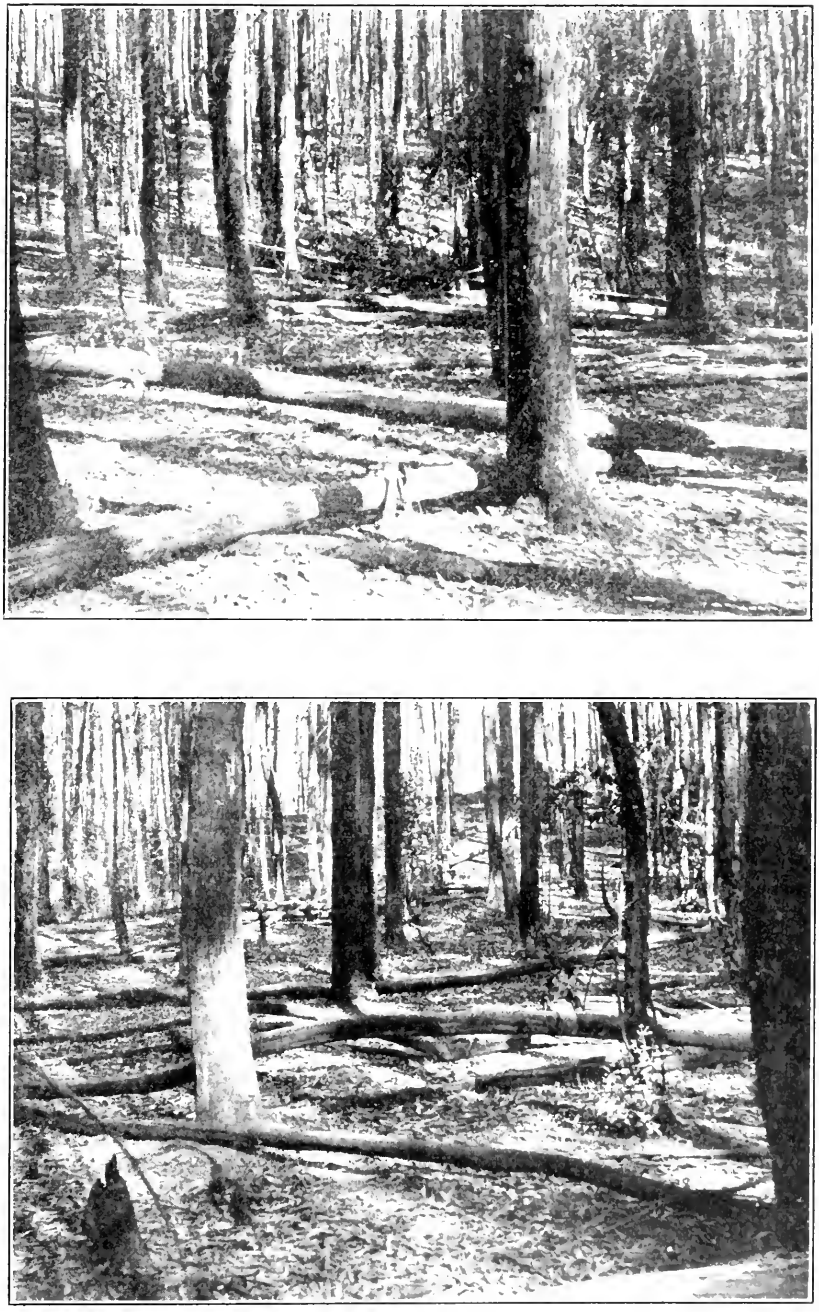


PLATE 5. Result of a severe ground fire in an old Eucalyptus stand. Trunks charred, many trees killed and fallen, the ground burned clear of litter, and now sprinkled with leaves from fire-injured trees.

Too great stress can not be laid on the benefits derivable from cultivation. Not only is the weed growth, detrimental to plantations, destroyed, but the surface soil is loosened and evaporation is checked. The planter who attends carefully to the cultivation of his grove will be rewarded by the greater number of trees which withstand the drought and by the more rapid growth of his plantation.

COST OF PLANTATIONS.

The total cost of establishing and caring for plantations during the first two years has varied from $15 to over $50 per acre. An expense of $25 per acre is generally considered a fair figure. However, this cost is the result of setting out small groves, for which seedlings have generally been purchased from nurserymen. When stock is grown in a home nursery the cost of planting large areas should not exceed $15 or $20 per acre. Small groves for which plant material is purchased will generally entail a higher expense.

PROTECTION.

Once the plantation is well established its protection from fire and roving stock is the chief feature of management to demand attention. Eucalypts are particularly inflammable, because of the oil contained in their foliage and bark, hence even a slow fire causes serious injury.

Plantations established in open country should have a strip fully a rod wide plowed around them every spring, particularly if they are situated near a railroad or in a locality frequented by hunters. In addition, the owner or caretaker of the plantation should secure an appointment as fire warden from the State Forester, and obtain a supply of fire-warning notices to post conspicuously in the vicinity of the plantation. Although the danger from fire is great in many portions of the State, planters should not be deterred by it, for they have full redress for damages through a civil action, whenever sufficient evidence of the careless or malicious origin of the fire can be collected.

Roving stock of all kinds should be strictly excluded from the plantations. The need for this is particularly great while the trees are small enough to be trampled upon.

Gophers, squirrels, rabbits and other rodents which infest and damage young plantations should be destroyed by firearms or poison.

CUTTING, THINNING AND PRUNING.

All operations which curtail the foliage of the tree should be performed during the late fall or winter, when its functioning processes are suspended or least active. If this is done the surface cut will heal

during the time the tree is dormant and loss of vitality by "bleeding" will be avoided.

In cutting, care should be exercised to slope the stump like the roof of a house, so that the rain falling on it will be conducted off instead of sinking in and permitting fungous growth to start. It is also advisable to cut the stumps very low the first time, for succeeding cuttings will have to be higher to avoid the thickened growth caused by the production of numerous coppice shoots.

The advisability of thinning depends on the age which the grove will be allowed to attain and the use to which the product is to be put. If the grove is to be cut for firewood when six or seven years old, thinning will not be advisable. But if the plantation is expected to produce telephone or telegraph poles, piles or dimension material, which will require longer to mature, a moderate thinning will be advisable during the winter of the fifth or sixth year after the trees have been forced into height by crowding. As soon as the competition for light is relieved by thinning, the rate of height growth will decrease and that of diameter will increase.

The degree of thinning must always be determined by the condition of the plantation and the character of the product desired. Groves should never be opened enough to permit the growth of weeds or to allow the slender trees to be thrown by the winds. Definite rules can not be given in advance. Unless the planter has had experience enough to guide his judgment, it will be advisable to secure an examination of the plantation by a forester, which may be done under the conditions of Section 4 of the State Forest Law.

Pruning will be inadvisable generally. If the plantations are spaced properly the formation of objectionable branches will be prevented by lack of light.

GROWTH.

The measurements upon which the accompanying tables of growth and yield are based were taken in different groves upon sample plots aggregating approximately 10 per cent of the total area of Eucalyptus plantations in California. Since blue gum has been planted commercially to the exclusion of other eucalypts, the collection of data was necessarily restricted to plantations of this species. Although the growth of blue gum is the most rapid of the eucalypts planted in California, the tables may be used to estimate the growth of other commercial species.

The portions of the State for which the tables may be regarded as authoritative are: the Bay counties, the coast region near Santa Barbara, the Los Angeles and Santa Ana valleys, and the coastal valleys near

San Diego. The localities in which the groves measured are situated are mentioned in tables 4 to 10. No plantations are growing in other sections of the State from which data upon growth and yield can be obtained, but the tables will undoubtedly indicate closely the growth of blue gum throughout its planting range.

The majority of the groves measured were situated in Southern California, and the data were collected after the succession of exceptionally dry years in that section from 1898 to 1903. The growth of plantations was considerably retarded during that period of very low rainfall, the sites, occupied by the groves giving the lowest yield, being generally those most unfavorably affected by the drought. The majority of the groves when measured were less than eight years old, hence their growth does not represent the maximum productive capacity of their sites. It is believed the tables are very conservative for the growth of blue gum in California.

Tables 1 to 3 show the volumes of blue gum trees in cubic feet, cords and board feet. For these tables measurements of seedlings and sprout trees were combined, since they differ but little in form and habit of growth. The cubic foot and cordwood tables are based on the computation of the contents of entire trees. The volume and the clear length only, scaled by the Scribner rule, was used for the board foot table. Owing to the scarcity of plantations of older and larger trees, volumes can not be given for trees over 160 feet in height, 24 inches in diameter, and 30 years of age.

In both the volume and yield tables for cordwood, the New England cord of 128 cubic feet is used. The results were obtained by dividing the figures given in the cubic foot tables by 90 cubic feet, which represents very closely the average solid contents of a cord of Eucalyptus wood. However, the New England cord is little used in California, a cord of 96 cubic feet, or about 65 cubic feet solid contents being in general favor. To change from New England to California cords, the amounts should be increased one-fourth.

Tables from 4 to 10 record the growth and yield of individual blue gum plantations. Separate tables have been constructed for seedling and sprout plantations upon different types of soils. Portions of many sprout groves have been cut at different periods, and represent the growth at different ages. Therefore, different portions of the same groves are often separated in the tables to permit arrangement of the sample plots by successive ages, and to show the progress of growth and yield.

In the sprout yield tables the number of trees in the column showing the present stand per acre is often several times as great as would result from the spacing mentioned. This is due to the number of

sprouts allowed to grow up from a stump after cutting the seedling tree. In the seedling table the number of trees in the present stand is frequently lower than the spacing would indicate. This results from the thinning or burning of the stand or the natural reduction in the number of trees. If a stand has been thinned or burned, the fact is noted in the column headed "Remarks."

TABLE 1.—Volume of Blue Gum Seedlings and Sprouts.

Diameter breast-high.	Total height—Feet.													
	30	40	50	60	70	80	90	100	110	120	130	140	150	160
Inches.	*Volume—Cubic Feet.*													
2	0.4	0.7	1.9	1.3										
3	.6	.9	1.3	1.7										
4	1.0	1.4	1.9	2.3	2.8	3.3								
5	1.6	2.1	2.6	3.2	3.9	4.8	5.8							
6		3.0	3.6	4.3	5.2	6.4	7.6	9.0						
7			4.8	5.7	6.8	8.1	9.6	11.0						
8				7.3	8.6	10.1	11.8	13.5	15.4					
9				9.0	10.7	12.4	14.4	16.4	18.6	20.5				
10						15.0	17.2	19.6	22.1	24.7	27.3			
11						17.6	20.4	23.0	26.0	29.1	32.0			
12						20.4	23.7	26.6	30.9	33.5	36.8			
13						23.7	27.2	30.7	34.4	38.0	41.5	45.7		
14									39.2	42.3	46.3	51.3		
15										46.6	51.2	56.8		
16										50.9	56.0	62.5	71.6	84.2
17										55.0	60.8	68.4	78.3	91.0
18											65.8	74.2	84.9	98.0
19											70.7	80.0	91.5	105.0
20												86.0	98.6	112.5
21													105.8	120.0
22													112.8	127.5
23													120.0	135.0

TABLE 2.—Volume of Blue Gum Seedlings and Sprouts.

Diameter breasthigh.	Total height—Feet.													
	30	40	50	60	70	80	90	100	110	120	130	140	150	160
Inches.	*Volume—Cords.*													
2		0.01	0.01	0.01										
3	0.01	.01	.01	.02										
4	.01	.02	.02	.03	0.03	0.04								
5	.02	.02	.03	.04	.04	.05	0.06							
6		.03	.04	.05	.06	.07	.08	0.10						
7			.05	.06	.08	.09	.11	.12						
8				.08	.10	.11	.13	.15	0.17					
9				.10	.12	.14	.16	.18	.21	0.23				
10						.17	.19	.22	.25	.27	0.30			
11						.20	.23	.26	.29	.32	.36			
12						.23	.26	.30	.34	.37	.41			
13						.26	.30	.34	.38	.42	.46	0.51		
14									.44	.47	.51	.57		
15										.52	.57	.63		
16										.57	.62	.69	0.80	0.94
17										.61	.68	.76	.87	1.01
18											.73	.82	.94	1.09
19											.79	.89	1.02	1.17
20												.96	1.10	1.25
21													1.18	1.33
22													1.25	1.42
23													1.33	1.50

TABLE 3.—Volume of Blue Gum Seedlings and Sprouts.

Diameter breasthigh.	Total height—Feet.											
	50	60	70	80	90	100	110	120	130	140	150	160
Inches.	*Volume—Board feet.*											
7	5	5	10	10	15	15	20					
8	10	10	15	20	25	30	35					
9	15	20	25	30	35	45	50	60				
10		30	35	45	50	60	70	80	90			
11			50	60	70	80	90	100	110			
12				75	90	100	110	120	135			
13					110	120	130	145	160			
14							150	165	190	220		
15								190	220	255		
16								220	255	290	330	370
17								250	290	330	370	420
18								280	325	370	415	465
19										415	460	515
20										460	505	565
21											555	620
22											600	675
23											650	725
24												775

TABLE 4.—Growth and Yield of Blue Gum Plantations.

Seedling growth—Loam and sandy-loam soils.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Shaw	Long Beach	Los Angeles	3	1.0	8 x 9	554	3.6	5	39	47	602.0	6.7		2.2	
do	do	do	4	1.0	9 x10	463	4.9	10	50	67	1,167.8	13.0	560	3.3	
Nelson	Florence	do	5	.5	8 x 8	382	3.1	5	30	38	263.6	2.9		.6	
do	do	do	7	1.0	8 x 8	565	4.7	8	47	67	1,255 2	13.9	110	2.0	
do	do	do	7	.5	8 x 8	546	5.0	7	50	67	1,362.2	15.1	100	2.2	
do	do	do	7	1.0	8 x 8	488	4.6	8	46	67	1,031.9	11.5	150	1.6	
do	do	do	7	1.0	8 x 8	486	4.9	8	49	67	1.164.8	12.9	140	1.8	
do	do	do	7	1.0	8 x 8	464	5.0	9	50	67	1,220.6	13.6	355	1.9	
Long Beach	Long Beach	do	8	1.0	6 x 6	1,058	4.6	9	63	97	3,498.2	38.9	730	4.9	
do	do	do	8	1.0	6 x 6	1,022	4.4	8	60	97	3,118.9	34.7	380	4.3	
do	do	do	8	1.0	6 x 6	987	4.9	9	69	97	3,707.3	41.2	1,450	5.2	
do	do	do	8	1.0	8 x 8	560	5.4	10	65	87	2,346.0	26.1	1,495	3.3	
do	do	do	8	1.0	8 x 8	525	6.0	10	70	87	2,769.4	30.8	3,040	3.9	
Cuthbert	do	do	9	.3	8 x 8	640	6.6	12	71	77	3,899.3	43.3	1,785	4.8	
Cooper	Ellwood	Santa Barbara	14	1.0	6 x 7	932	4.5	8	52	66	2,143.7	23.8	290	1.7	
do	do	do	14	1.0	6 x 7	928	4.9	9	58	79	2,954.1	32.8	1,080	2.3	
do	do	do	14	1.0	6 x 7	907	4.7	8	53	66	2,230.6	24.8	185	1.8	
do	do	do	14	1.0	6 x 7	903	4.6	8	52	66	2,134.2	23.7	130	1.7	
do	do	do	14	1.0	6 x 8	838	5.1	8	59	79	2,822.0	31.4	840	2.2	
do	do	do	14	1.0	6 x 8	788	4.6	8	52	66	1,885.7	21.0	135	1.5	
do	do	do	14	1.0	6 x 8	639	4.9	8	50	65	1,943.2	21.6	160	1.5	
do	do	do	14	1.0	6 x 8	626	4.9	8	50	65	1,886.8	21.0	205	1.5	
Johnson (1)	Norwalk	do	14	1.0	8 x 8	452	7 7	16	100	145	6,089.0	67.7	16,310	4.8	
do (2)	do	do	14	1.0	8 x 8	438	7.2	15	95	140	5,080.0	56.4	11,950	4.0	
Merritt	Spring Valley	San Diego	15	1.0	9 x 8	79	5.9	34	108	135	3,990.5	44.3	18,585	3.0	Thinned.
Cooper	Ellwood	Santa Barbara	23	1.0	9 x 9	437	9.4	17	98	124	7,159.5	79.6	20,765	3.5	
McDonald	El Cajon	San Diego	27	.6	12 x12	280	9.7	19	80	132	4,094.6	45.5	13,092	1.7	
Nadeau	Florence	Los Angeles	27	.5	8 x 8	268	13.3	23	130	169	10,369.0	115.2	44,190	4.3	Thinned.
Cooper	Ellwood	Santa Barbara	28	1.0	5 x 5	295	7.7	13	85	118	3,166.9	35.2	6,070	1.3	Thinned.
do	do	do	28	.4	5 x 5	275	8.4	14	88	101	3,605.0	40.1	7,950	1.4	Thinned.
do	do	do	28	.6	5 x 6	255	7.7	14	85	118	2,720.3	30.2	5,567	1.1	Thinned.
do	do	do	29	1.0	6 x 8	691	8.1	14	85	102	7,602.7	84.5	17,160	2.9	
do	do	do	29	1.0	6 x 8	595	7.8	13	83	102	6,126.9	68.1	12,800	2.3	
do	do	do	29	.3	8 x 8	467	8.2	15	84	119	5,445.7	60.5	12,700	2.1	
do	do	do	29	1.0	6 x 6	395	7.8	17	80	119	4,502.6	50.0	9,710	1.7	Thinned.
Marsh	Berkeley	do	29	.5	8 x 8	258	10.1	16	90	103	4,625.2	51.4	14,750	1.8	Thinned.

TABLE 5.—Growth and Yield of Blue Gum Plantations.

Seedling growth—Clay-loam soil.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Presidio	San Francisco	San Francisco	13	0.4	5 x 4	1,828	4.9	8	43	58	7,194.5	79.9	6,513	6.1	High yield due to dense planting.
do	do	do	13	.5	Irregular	758	6.6	11	50	60	3,573.4	39.7	3,760	3.1	
do	do	do	13	1.0	do	715	6.1	11	50	60	2,692.8	29.9	1,780	2.3	
Buvy	Burlingame	San Mateo	18	1.0	6½x 6½	162	9.6	17	69	90	2,111.4	23.5	5,690	1.3	Thinned.
Brown	Berkeley	Alameda	25	1.0	8 x 8	426	9.7	20	90	141	7,612.6	84.6	25,125	3.4	
Smith(lower)	do	do	27	.8	8 x 8	369	8.9	15	97	114	5,389.9	59.9	15,788	2.2	Burned.
do do	do	do	27	1.0	8 x 8	326	8.5	14	95	114	4,245.5	47.2	11,695	1.7	Burned.
Reservoir	do	do	29	1.0	8 x 8	354	8.7	13	81	118	4,295.3	47.7	10,870	1.6	Burned.
do	do	do	29	1.0	8 x 8	307	9.9	14	84	118	4,999.2	55.5	15,140	1.9	Burned.
do	do	do	29	1.0	8 x 8	299	9.2	15	82	118	4,159.2	46.2	11,780	1.6	Burned.
Smith(upper)	do	do	29	.5	8 x 8	290	10.2	22	93	121	5,560.8	61.8	17,870	2.1	Burned.
Reservoir	do	do	29	.5	8 x 8	280	8.8	18	76	96	3,494.2	38.8	10,360	1.3	Burned.
Institute	do	do	29	1.0	14 x14	269	12.4	23	105	150	8,172.2	90.8	33,590	3.1	
Reservoir	do	do	29	.5	8 x 8	260	10.1	15	85	118	4,504.6	50.1	14,440	1.7	Burned.
do	do	do	29	1.0	8 x 8	258	10.2	16	85	118	4,529.7	50.3	14,450	1.7	Burned.
do	do	do	29	1.0	8 x 8	256	10.2	16	85	118	4,449.9	49.4	14,040	1.7	Burned.
Garber	do	do	29	1.0	8 x 8	241	11.3	21	94	123	5,539.9	61.6	19,835	2.1	Burned.
Reservoir	do	do	29	.5	8 x 8	230	10.1	18	85	118	4,104.2	45.6	13,760	1.6	Burned.
do	do	do	29	1.0	8 x 8	200	10.4	20	86	118	3,765.9	41.8	12,560	1.4	Burned.
do	do	do	29	1.0	8 x 8	186	12.1	21	99	122	5,215.0	57.9	19,105	2.0	Burned.
Smith(upper)	do	do	29	.4	8 x 8	173	11.1	15	96	121	3,913.8	43.5	13,475	1.5	Burned.

TABLE 6.—Growth and Yield of Blue Gum Plantations.

Seedling growth—Adobe soil.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres*	*Feet.*	*Trees*	*Inches*	*Inches.*	*Feet*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Powder	Los Angeles	Los Angeles	7	0.5	10 x 10	382	6.8	12	65	90	2,469.0	27.4	4,430	3.9	
do	do	do	7	.5	10 x 10	338	6.6	11	63	90	2,024.4	22.5	3,430	3.2	
Alamitos	Long Beach	do	16	1.0	10 x 10	384	6.8	12	64	85	2,382.9	26.5	3,965	1.7	
Fair	Irvington	Alameda	29	1.0	6 x 6	491	11.0	12	111	170	13,979.6	155.3	51,480	5.4	Thinned.
do	do	do	29	.5	6 x 12	172	15.2	22	128	159	9,012.4	100.1	41,360	3.5	Thinned.
Winery	do	do	33	.8	8 x 8	455	10.6	19	125	164	12,241.0	136.0	44,675	1.1	

TABLE 7.—Growth and Yield of Blue Gum Plantations.

Seedling growth—Sand soil.

Presidio	San Francisco	San Francisco	10	0.2	4 x 4	2,315	3.9	7	24	31	2,309.9	25.7		2.6	
do	do	do	10	.4	Irregular.	540	5.0	8	46	57	1,319.0	14.7	300	1.5	
do	do	do	13	.5	5 x 5	1,166	5.2	11	47	59	3,103.8	34.5	1,710	2.7	
do	do	do	13	.5	8 x 4	888	5.4	12	52	64	2,658.0	29.5	1,100	2.3	
do	do	do	13	.5	Irregular.	818	4.9	8	37	45	1,665.2	18.5	270	1.4	
do	do	do	13	1.0	do	791	5.4	10	49	68	2,337.9	26.0	1,170	2.0	
do	do	do	13	1.0	do	755	5.4	10	49	68	2,239.5	24.9	1,210	1.9	
do	do	do	13	1.0	do	652	5.8	10	51	68	2,291.7	25.5	2,005	2.0	
do	do	do	13	.5	7 x 8	638	5.7	10	56	86	2,657.6	29.5	2,510	2.3	
do	do	do	13	1.0	Irregular	634	5.9	11	45	51	2,166.7	24.1	1,325	1.9	
do	do	do	13	.6	do	602	5.5	10	50	65	1,877.3	20.9	792	1.6	
do	do	do	13	1.0	do	568	6.0	12	56	68	2,418.3	26.9	2,030	2.1	
do	do	do	13	1.0	do	565	5.6	11	54	68	2,092.6	23.3	1,565	1.8	
do	do	do	13	.6	8 x 8	565	6.1	10	51	67	2,296.8	25.5	2,363	2.0	
do	do	do	13	1.0	Irregular.	552	5.5	9	50	59	1,737.3	19.3	1,145	1.5	
do	do	do	13	1.0	do	550	5.9	12	56	68	2,231.3	24.8	1,720	1.9	
do	do	do	13	.4	8 x 8	505	5.5	11	44	72	1,592.0	17.7	1,563	1.4	
do	do	do	13	1.0	Irregular.	488	6.1	12	56	68	2,295.1	25.5	1,795	2.0	
do	do	do	13	1.0	do	421	6.5	13	64	78	2,440.6	27.1	4,535	2.1	
do	do	do	13	1.0	do	312	6.7	15	53	71	1,659.6	18.4	2,785	1.4	

TABLE 8.—Growth and Yield of Blue Gum Plantations.

Sprout growth—Loam and sandy-loam soil.

Name of Grove	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Kellogg	Loara	Orange	$\frac{3}{12}$	0.4	8 x 8	2,335	1.3	3	24	30	186.0	2.1		3.2	
do	do	do	$1\frac{3}{12}$	.5	8 x 8	1,122	2.3	4	31	39	502.0	5.6		3.7	
Thaxter	Florence	Los Angeles	2	1.0	8 x 8	1,029	2.1	3	27	33	419.8	4.7		2.4	
Nadeau	do	do	2	1.0	8 x 8	948	2.4	5	28	37	449.5	5.0		2.5	
Hoff	do	do	2	1.0	9 x 9	869	2.9	5	40	55	776.4	8.6		4.3	
Becket	Orange	Orange	$2\frac{1}{2}$	1.0	10 x10	526	3.1	6	33	45	490.4	5.4		2.2	
Thaxter	Florence	Los Angeles	3	1.0	8 x 8	1,486	2.7	5	36	46	1,017.7	11.3		3.8	
Cuthbert	Long Beach	do	3	.5	8 x 8	1,400	2.7	5	35	46	1,000.2	11.1		3.7	
Hoff	Florence	do	3	1.0	9 x 9	1,196	3.3	7	44	90	1,523.6	16.9		5.6	
Thaxter	do	do	3	1.0	8 x 8	1,190	2.8	8	37	46	899.8	10.0		3.3	
Dominion	Compton	do	3	1.0	9 x 9	983	2.8	6	34	49	721.5	8.0		2.7	
do	do	do	3	1.0	9 x 9	907	2.6	6	33	49	615.4	6.8		2.3	
do	do	do	3	1.0	9 x 9	802	2.5	5	33	49	504.4	5.6		1.9	
Becket	Orange	Orange	3	1.0	10 x10	794	2.9	6	39	61	734.6	8.2		2.7	
Hoff	Florence	Los Angeles	3	1.0	9 x 9	788	3.2	6	43	90	877.1	9.7		3.2	
Becket	Orange	Orange	3	1.0	10 x10	751	3.9	8	47	71	1,240.8	13.8		4.6	
Nadeau	Florence	Los Angeles	4	1.0	10 x10	1,399	3.2	7	39	58	1,525.9	17.0	5	4.3	
do	do	do	4	1.0	8 x 8	1,350	3.1	7	38	58	1,360.5	15.1	15	3.8	
do	do	do	4	1.0	8 x 8	1,172	3.5	7	46	65	1,514.1	16.8	20	4.2	
Dominion	Compton	do	4	.5	9 x 9	1,158	3.0	6	36	49	1,144.0	12.7		3.2	
Nadeau	Florence	do	4	1.0	8 x 8	1,139	3.2	7	44	65	1,279.8	14.2	15	3.6	
do	do	do	4	1.0	8 x 8	1,131	3.0	7	43	65	1,108.8	12.3	5	3.1	
do	do	do	4	1.0	8 x 8	1,006	3.2	7	44	65	1,132.1	12.6	5	3.2	
Hoff	do	do	4	1.0	9 x 9	888	4.2	10	52	90	2,019.3	22.4	455	5.6	
Nadeau	do	do	4	1.0	8 x 8	830	3.7	6	42	58	1,243.0	13.8		3.5	
Hoff	do	do	4	1.0	9 x 9	824	4.1	11	51	90	1,748.2	19.4	700	4.9	
Cuthbert	Long Beach	do	$4\frac{1}{2}$	1.0	8 x 8	1,113	3.4	8	44	64	1,491.8	16.6	40	3.7	
Thaxter	Florence	do	5	1.0	8 x 8	1,441	3.6	9	55	91	2,606.0	29.0	555	5.8	
do	do	do	5	1.0	8 x 8	1,378	4.2	11	58	91	3,542.7	39.4	2,380	7.9	
Nadeau	do	do	5	1.0	8 x 8	1,141	3.9	10	49	77	2,158.4	21.0	780	4.8	

do	do	do	5	1.0	8 x 8	1,126	3.1	7	42	77	1,254.1	13.9	30	2.8	
Hoff	do	do	5	1.0	9 x 9	1,017	4.5	9	55	90	2,703.5	30.0	1,225	6.0	
Becket	Orange	Orange	5	1.0	10 x10	838	4.6	9	57	90	2,401.7	26.7	1,075	5.3	
Sexton	Compton	Los Angeles	6	1.0	8 x 8	1,227	5.0	12	70	121	5,343.5	59.4	6,650	9.9	
Thaxter	Florence	do	6	1.0	10 x10	923	4.0	9	49	73	1,810.8	20.1	270	3.4	
do	do	do	6	1.0	8 x 8	889	5.1	12	68	95	3,625.6	40.3	4,560	6.7	
Becket	Orange	Orange	6	1.0	10 x10	830	4.7	10	59	98	2,538.8	28.2	1,985	4.7	
McDonald	Wilmington	Los Angeles	6	1.0	Irregular.	631	3.0	7	32	46	456.1	5.1	10	.9	
Thaxter	Florence	do	6	1.0	10 x10	479	4.6	11	53	73	1,247.7	13.9	495	2.3	
Carson	Wilmington	do	7	1.0	8 x 8	1,655	3.9	9	55	89	3,745.5	41.6	785	5.9	
Nadeau	Florence	do	7	1.0	8 x 8	1,491	4.1	10	54	84	3,258.5	36.2	1,835	5.2	
Carson	Wilmington	do	7	1.0	8 x 8	1,476	4.2	9	60	87	3,765.8	41.8	1,590	6.0	
Thaxter	Florence	do	7	1.0	8 x 8	1,334	4.0	8	62	110	3,529.2	39.2	675	5.6	
Nadeau	do	do	7	1.0	8 x 8	1,233	3.7	9	48	84	1,977.6	22.0	345	3.1	
Thaxter	do	do	7	1.0	8 x 8	1,183	4.5	11	66	110	4.076.2	45.3	2,890	6.5	
do	do	do	7	1.0	8 x 8	990	4.8	11	68	110	3,898.4	43.3	3,935	6.2	
Dorr	Santa Fe Spgs.	do	8	1.0	8 x 8	1,473	4.5	11	65	121	5,110.7	56.8	5,475	7.1	
Holden	Garden Grove	Orange	8	1.0	Irregular.	1,036	4.6	12	60	100	3,389.6	37.7	2,655	4.7	
Adams	Orange	do	8	.3	8 x 8	907	2.9	5	36	50	740.3	8.2		1.0	
do	do	do	8	3	8 x 8	780	3.2	6	40	56	871.3	9.7		1.2	
do	do	do	8	.3	8 x 8	683	3.6	7	43	56	932.3	10.4	17	1.3	
Thaxter	Florence	Los Angeles	9	1.0	10 x10	1,087	4.8	13	62	117	3,924.2	43.6	3,295	4.8	
do	do	do	9	1.0	10 x10	1,076	4.4	11	58	117	3,204.3	35.6	2,585	4.0	
do	do	do	9	1.0	10 x10	713	5.6	12	70	117	3,713.8	41.3	5,745	4.6	
Woodhead	Santa Fe Spgs.	do	16	.3	8 x 8	573	8.5	16	95	162	9,466.7	105 2	29,533	6.6	Thinned.

TABLE 9.—Growth and Yield of Blue Gum Plantations.

Sprout growth—Clay-loam soil.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Corcoran	Garden Grove	Orange	$\frac{2}{3}$	0.5	10 x 10	1,218	1.8	3	26	34	359.2	4.0		6.0	
Nichol	Santa Fe Spgs.	Los Angeles	2	.5	8 x 8	1,764	1.8	3	20	36	145.8	1.6		.8	
Baker	do	do	2	.2	6 x 10	1,595	2.1	3	27	36	703.0	7.8		3.9	
Nichol	do	do	2	1.0	8 x 8	824	2.2	3	30	38	352.2	3.9		2.0	
Baker	do	do	3	.3	10 x 6	1,333	2.7	5	42	60	1,424.7	15.8		5.3	
Alamitos	Long Beach	do	3	1.0	9 x 9	1,128	2.9	6	39	56	1,140.0	12.7		4.1	
do	do	do	4	1.0	8 x 8	1,742	2.8	6	43	73	2,019.0	22.4		5.6	
Baker	Santa Fe Spgs.	do	4	.3	6 x 10	1,437	3.5	7	47	76	2,182.3	24.2	267	6.1	
Alamitos	Long Beach	do	4	1.0	9 x 9	1,268	3.7	7	46	65	1,681.9	20.7	95	5.2	
Dominion	Compton	do	4	1.0	9 x 9	1,145	3.3	7	40	56	1,404.5	15.6	5	3.9	
do	do	do	4	1.0	9 x 9	1,025	3.5	7	44	56	1,357.1	15.1	5	3.8	
Cuthbert	Long Beach	do	$4\frac{1}{4}$	.5	8 x 8	1,150	3.3	7	33	64	1,394.0	15.5	10	3.4	
Bank	Los Angeles	do	5	1.5	6 x 10	1,823	2.1	5	30	102	960.8	10.7	217	2.1	
Stewart	Compton	do	5	.5	8 x 8	1,288	4.3	8	59	92	4,062.0	45.1	3,480	9.0	
Woodhead	Santa Fe Spgs.	do	5	.5	8 x 8	1,238	4.4	8	63	94	1,199.6	46.7	3,909	9.3	
Nichol	do	do	5	1.0	8 x 8	1,151	2.8	6	42	72	1,070.6	11.9		2.4	
Baker	do	do	5	.2	10 x 6	1,060	4.2	8	64	85	3,022.5	33.6	1,450	6.7	
Nichol	do	do	5	1.0	8 x 8	1,019	2.7	7	41	72	852.3	9.5	10	1.9	
Corcoran	Garden Grove	Orange	5	.3	10 x 10	857	3.9	8	47	61	1,456.3	16.2	67	3.2	
Gunn	Santa Fe Spgs.	Los Angeles	$5\frac{1}{2}$	1.0	12 x 6	1,341	3.6	8	51	84	2,169.3	24.2	230	4.4	
do	do	do	$5\frac{1}{2}$	1.0	12 x 6	1,321	3.7	8	52	84	2,273.1	25.3	200	4.6	
Holden	Garden Grove	Orange	6	.5	8 x 8	784	3.9	8	47	74	1,401.4	15.6	140	2.6	
Doty	Compton	Los Angeles	$7\frac{1}{2}$	1.0	5 x 10	1,509	3.8	10	57	100	3,638.1	40.4	2,025	5.4	
do	do	do	$7\frac{1}{2}$	1.0	5 x 10	1,398	3.9	10	57	100	3,458.9	37.3	1,530	5.1	
Dorr	Santa Fe Spgs.	do	8	1.0	8 x 8	1,389	4.3	12	64	121	4,404.0	48.9	4,010	6.1	
Gunn	do	do	8	1.0	12 x 6	1,284	4.1	10	60	97	3,435.2	38.2	1,465	4.8	
Walton	Compton	do	$8\frac{3}{4}$	1.0	8 x 8	895	4.4	8	55	82	2,233.2	24.8	315	3.0	
McDonald	El Cajon	San Diego	9	1.0	10 x 12	534	6.9	24	78	148	4,793.5	53.3	10,565	5.9	

TABLE 10.—Growth and Yield of Blue Gum Plantations.

Sprout growth—Adobe soil.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cords.*	*Board ft.*	*Cords.*	
Hazard	Los Angeles	Los Angeles	1	1.0	8 x 8	775	2.3	5	26	37	356.0	4.0		2.4	
do	do	do	1	1.0	10 x 10	729	2.1	3	22	32	297.0	3.3		2.0	
do	do	do	1	1.0	10 x 10	550	2.1	3	24	32	225.4	2.5		1.4	
do	do	do	1	1.0	10 x 10	488	2.1	3	22	32	202.6	2.3		1.4	
do	do	do	1	1.0	10 x 10	247	2.2	4	25	32	104.8	1.2		.7	Burned.
do	do	do	2	1.0	10 x 10	209	2.0	3	21	28	81.6	.9		.5	Burned.
do	do	do	2½	1.0	8 x 8	805	2.4	5	28	39	385.0	1.3		1.9	
do	do	do	2½	1.0	8 x 8	544	2.4	4	28	39	266.2	3.0		1.3	
do	do	do	2½	1.0	8 x 8	761	2.3	4	28	42	345.6	3.8		1.5	
Murphy	Compton	do	3	.8	8 x 8	1,539	2.8	5	36	47	1,135.4	12.6		4.2	
Hazard	Los Angeles	do	3	1.0	10 x 10	1,481	1.6	3	22	34	275.4	3.1		1.0	
Alamitos	Long Beach	do	3	1.0	8 x 10	1,480	2.8	6	38	52	1,242.5	13.8		4.6	
do	do	do	3	1.0	8 x 10	1,180	2.8	6	38	52	978.6	10.9		3.6	
Hazard	Los Angeles	do	3	1.0	10 x 10	889	2.0	3	25	37	359.6	4.0		1.3	
do	do	do	3	1.0	10 x 10	859	2.2	4	26	39	416.1	4.6		1.5	
do	do	do	3	1.0	10 x 10	711	2.1	5	29	43	344.4	3.8		1.3	
do	do	do	3	1.0	10 x 10	696	2.3	5	27	39	351.1	3.9		1.3	
do	do	do	3	1.0	10 x 10	677	2.3	4	28	41	306.8	3.4		1.1	
do	do	do	3	1.0	10 x 10	672	2.2	3	26	31	204.6	3.3		1.1	
do	do	do	3	1.0	10 x 10	559	2.3	4	28	41	249.0	2.8		.9	
do	do	do	3	1.0	10 x 10	518	2.2	4	27	42	228.8	2.5		.8	
do	do	do	3	1.0	10 x 10	404	2.7	5	31	40	233.9	2.6		.9	
Alamitos	Long Beach	do	4	1.0	8 x 10	1,413	3.4	7	49	71	2,226.1	24.7	30	6.2	
Steele	Compton	do	4	1.0	8 x 8	1,409	1.1	8	54	85	3,364.9	37.4	2,150	9.3	
Hazard	Los Angeles	do	4	1.0	10 x 10	557	2.5	5	31	44	286.0	3.2		.8	Burned.
do	do	do	4	1.0	10 x 10	551	2.5	6	31	41	299.2	3.3		.8	Burned.
do	do	do	4	1.0	10 x 10	521	2.6	5	29	46	296.4	3.3		.8	Burned.
do	do	do	4	1.0	10 x 10	494	2.3	4	29	41	232.0	2.6		.7	Burned.
Alamitos	Long Beach	do	4	1.0	10 x 10	368	3.7	5	33	40	247.6	2.8		.7	Burned.
do	do	do	4	1.0	9 x 9	326	4.0	7	36	56	426.1	4.7	10	1.2	Burned.
do	do	do	4	1.0	10 x 10	321	3.6	7	32	46	313.3	3.5	25	.9	Burned.
do	do	do	4	1.0	9 x 9	288	4.3	8	37	56	473.4	5.3	110	1.3	Burned.

TABLE 10.—Growth and Yield of Blue Gum Plantations—*Continued.*

Sprout growth—Adobe soil.

Name of Grove.	Location.		Age.	Area measured.	Original spacing.	Present stand per acre.	Diameter.		Height.		Yield per Acre.				Remarks.
	Town.	County.					Average.	Maximum.	Average.	Maximum.	Total.	Total.	Total.	Av. annual.	
			Years.	*Acres.*	*Feet.*	*Trees.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Cu. Ft.*	*Cords.*	*Board ft.*	*Cords.*	
Hazard	Los Angeles	Los Angeles	4½	1.0	8 x 8	742	2.4	6	30	57	428.1	4.8	———	1.1	
do	do	do	4½	.5	8 x 8	694	2.7	6	27	45	414.4	4.6	———	1.0	
Alamitos	Long Beach	do	5	1.0	8 x 8	1,659	3.4	8	50	95	2,632.9	29.3	340	5.9	
do	do	do	5	1.0	8 x 8	1,644	3.5	8	50	95	2,848.8	31.7	370	6.3	
Sexton	Compton	do	5	1.0	8 x 8	1,331	4.2	10	60	106	3,668.7	40.8	1,815	8.2	
Hazard	Los Angeles	do	5	1.0	8 x 10	1,288	2.2	7	23	43	436.5	4.9	5	1.0	
Alamitos	Long Beach	do	5	1.0	8 x 8	1,028	4.0	9	50	80	1,895.1	21.1	295	4.2	
do	do	do	5	1.0	8 x 8	978	3.9	8	50	80	1,697.2	18.9	180	3.8	
Hazard	Los Angeles	do	5	1.0	8 x 10	789	2.5	6	28	50	390.2	4.3	———	.9	
Sampson	do	do	5	.1	10 x 10	710	4.2	8	45	79	1,416.0	15.6	400	3.1	
Hazard	do	do	5	1.0	8 x 10	658	2.7	5	29	50	362.5	4.0	———	.8	
do	do	do	5	1.0	8 x 10	583	2.7	6	28	45	356.1	4.0	———	.8	
do	do	do	5	1.0	8 x 10	538	2.6	6	27	45	294.3	3.3	———	.7	
do	do	do	5	1.0	8 x 10	519	2.6	5	27	45	278.6	3.1	———	.6	
Dupuy	do	do	5½	.5	8 x 10	1,018	2.9	5	40	67	937.4	10.4	———	1.9	
do	do	do	5½	1.0	10 x 12	623	3.1	6	41	67	682.1	7.6	———	1.4	
do	do	do	5½	1.0	10 x 12	485	3.4	7	44	67	663.4	7.4	5	1.3	
Montague	Compton	do	6	1.0	8 x 8	1,602	3.3	8	45	81	1,226.1	24.7	65	4.1	
Sampson	Los Angeles	do	6	.2	8 x 8	1,290	4.0	8	52	90	2,745.0	30.5	900	5.1	
Glass	Compton	do	7	.5	8 x 8	2,942	3.8	8	51	85	5,593.2	62.1	870	8.9	
Montague	do	do	7	1.0	8 x 8	1,513	3.6	9	51	100	3,157.6	35.1	660	5.0	
Rosecrans	Gardena	do	7	1.0	10 x 10	1,313	3.8	8	53	80	2,551.0	28.3	220	4.0	
Hazard	Los Angeles	do	7	1.0	10 x 10	562	4.3	10	45	68	1,224.1	13.6	335	1.9	
Doty	Compton	do	7½	1.0	10 x 5	1,624	4.1	11	60	109	4,330.4	48.1	2,075	6.4	
do	do	do	7½	1.0	10 x 5	1,601	4.4	11	62	109	5,161.2	57.3	3,490	7.6	
do	do	do	7½	1.0	10 x 5	1,384	4.4	10	62	109	4,240.6	47.1	1,955	6.3	
do	do	do	7½	1.0	10 x 5	1,367	4.5	11	63	109	4,513.0	50.1	3,180	6.7	
Montague	Compton	do	8	1.0	8 x 8	1,528	4.0	10	57	100	3,889.0	43.2	945	5.4	
Rosecrans	Gardena	do	8	1.0	10 x 10	988	3.5	7	50	80	1,751.2	19.5	20	2.4	
do	do	do	11	1.0	10 x 10	1,022	3.1	9	37	65	1,049.6	11.7	45	1.1	
Montague	Compton	do	12	1.0	5 x 5	736	6.1	13	85	156	5,452.9	60.6	10,650	5.1	Thinned.
Gill	Berkeley	Alameda	13	.3	4 x 4	1,287	4.4	8	53	71	3,104.3	34.5	233	2.7	

The blue gum has gained the reputation of possessing a phenomenal rate of growth, and by an inspection of the figures of average and maximum growth this may be appreciated. Under favorable conditions trees in seedling plantations have reached a maximum development of 5 inches in diameter and 67 feet in height in four years. This represents an average of 17 feet height growth per year, though a growth of 10 to 15 feet in height yearly is the general average. In the height of the first growing season seedlings have frequently been observed to make an average height growth of 6 inches a day. The most rapid seedling growth noted was made by a tree which in nine years reached a height of 125 feet and a diameter of 36 inches. As is usual among vigorously sprouting trees, sprouts upon old root systems surpass seedlings in rate of growth. Ages are occasionally recorded in the sprout tables in fractions of a year, representing the number of months' growth. In eight months a maximum diameter of 3 inches and 34 feet height has been reached while in three years a maximum diameter of 7 inches and 70 feet in height has been attained.

In different groves and even upon different sample plots in the same grove a considerable variation in yield is shown, often ranging from maximum to minimum upon the same soil. This variation is determined to some extent by the character of the planting site, the permeability of the soil and the moisture available, and partly by the density of planting. It is governed mainly, however, by the density of the present stand of trees in consequence of the treatment accorded after planting. The deterioration of a grove because of lack of cultivation or protection, or from neglect after cutting, is sufficient to reduce the yield to a minimum on sites capable of maximum production. Unfortunately, the variation of this factor prevents its use in the construction of tables.

Sufficient data are not available from the measurements of young plantations to construct a complete table, giving the yield of poles and piles at different ages. A tree with a butt diameter of 9 inches is required to produce a pole of the smallest merchantable size, namely, 20 feet long with a top diameter of 7 inches. Sprout stands are usually cut before eight years of age, and in this time the yield of poles is low, since few trees in dense sprout stands attain the butt diameter required. The acre yield of poles having a top diameter of 7 inches from two representative seedling plantations of maximum growth has been estimated as follows:

TABLE 11.—Yield of Poles per Acre.

No.	Age.	20 Feet.	30 Feet.	40 Feet.	50 Feet.	60 Feet	Total.
1	16	37	35	21	17	13	123
2	16	30	27	16	9	8	90

Each of these acres yielded, in addition, 30 cords of fuelwood.

ECONOMIC PLANTING.

Windbreaks. The protection afforded by windbreaks must be reckoned an important factor in the horticultural development of California. The necessity of windbreak protection in many sections of the State is so great that without it certain crops can not be raised. Many trees are suitable for windbreak planting, yet California farmers are united in the opinion that Monterey cypress is the only competitor of blue gum and other eucalypts for this purpose.

The eucalypts excel other species in their towering height and rapid growth, thus affording a protection most quickly. The trees are slender and open-crowned, but double rows of trees or close planting provide a strong check against the wind. The blue gum surpasses all others for this purpose, and should be used throughout its thermal range. Its tall, limber shafts yield before the wind and act as a cushion to deflect the air currents upward over an orchard, while ordinary windbreak trees form a solid wall on the leeward side of which the wind draws down and forms eddies.

In the open valleys of Southern California Eucalyptus windbreaks have become a prominent feature of the landscape and their presence is recognized as indispensable to successful orcharding. To their protection may be attributed in large measure the fine quality of the California citrus crop, and in this way these trees return vast sums annually to the State. In citrus sections, such as the Santa Paula, San Fernando, San Bernardino, San Gabriel and Santa Ana valleys, windbreaks alone render the production of citrus fruits profitable. In unprotected orchards, nearly the entire crop is frequently blown from the trees, or so scarred and bruised that the grade and market value are much reduced. Orchard trees are even broken or partially defoliated during severe storms. To avert this danger and improve the grade of fruits, windbreak planting is being greatly extended even in old citrus sections.

More extensive shelter-planting is advisable in many sections of the State, notably in the Sacramento and San Joaquin valleys. Hitherto windbreaks have been used chiefly to shelter citrus orchards, but now they are coming into favor to shelter vineyards, deciduous orchards, olives and walnuts. Much more extensive development may be attained by their use in sections where strong or cold winds are felt. Along the coast, shelter from sea winds is found to increase the yield of grain crops.

Eucalyptus windbreaks in some sections have changed the aspect of the country and by moderating the winds have greatly improved the climate. Waste, sandy, stretches have been turned to productive agricultural use. In the region of Oxnard the towering windbreak lines hold the loose sand from drifting before the steady sea winds, and

the region has thus become, largely through their agency, an important center of sugar-beet production.

PLATE 6. Avenue planted with blue gum trees in San Bernardino Valley. Trees serve as windbreaks for citrus orchards. They are 12 to 20 inches in diameter and 125 feet high at 12 to 15 years of age.

Along the coast the planting of shelter belts for the protection of towns has been practiced to some extent, to the greater comfort of the

resident population. This branch of shelter planting should be extended particularly on the windward side of seaport towns, where windbreaks in proper places will protect anchored vessels and facilitate shipping. Windbreak planting should also be practiced in many coast localities to hold the sand from drifting inland and covering up valuable agricultural land, crops and dwellings.

Fully grown Eucalyptus windbreaks running at right angles to the direction of the prevailing winds every quarter mile across level country afford effective protection. Near the foothills the lines should be closer together, since the winds blowing down from the mountains gain greater velocity. Through orchards they are generally located every 100 or 200 feet. Though a heavy wind may be swaying the tops of the trees in a windbreak, usually there is hardly any stir in the air near the ground within a well-protected citrus orchard. The wind is never sufficiently strong to whip the foliage or injure the fruit.

All crops protected in this way suffer less from winds than open-grown crops. They remain uninjured when unprotected crops are blighted, unless the arrangement of the windbreaks results in defective wind-drainage and the formation of a frost hole. After a cold night, during frosty winter months, the shade cast by a windbreak on the eastern side of an orchard will often prevent injury from too rapid thawing.

Citrus trees are unfavorably affected by shade, hence the yield of fruit of rows adjoining a windbreak is often lessened. Windbreaks on the north and east sides of an orchard are less harmful than on the west or south side. Under ordinary conditions the south side of an orchard should be left open for wind-drainage.

The best spacing of gum trees for windbreaks is 4 feet apart each way in double rows. The trees of the second row should be planted opposite the open spaces in the first row. Double, or even triple, rows should be planted where the winds are severe. Triple rows will always be adequate for crop protection, though shelter belts from 10 to 20 rows wide may be advisable to protect from strong sea winds.

Monterey cypress is frequently planted alternately or in double rows with eucalypts to maintain a dense shelter near the ground, since the gum trees clear the lower stem with later growth, giving access to the winds. This combination is an excellent one, since great density is united with towering height. The cypress is well adapted to this use by its tolerance of shade. Cypress and eucalypts should be planted in separate rows and not alternated in the same row, the cypress being located on the windward side of the line, excepting on the north side of a field, where it should be planted on the south side of the line to receive more light.

On irrigated land trees are not compelled to root deeply for moisture, hence they maintain a very shallow root system. If a Eucalyptus windbreak surrounding irrigated land is not irrigated, its roots will extend to adjoining orchards and appropriate moisture from them to supply its own needs. The area drawn upon depends upon the size of the windbreak, but usually it is not greater than 50 feet each way.

To prevent this, wide root extension must be limited and the sheltering trees forced to root into deeper soil layers. This can be accomplished without injury to the shelter belts, by running a parallel trench 6 to 10 feet from them. The trench should be dug 3 or 4 feet deep, cutting off the surface roots of the gum trees, then refilled to prevent the roots from dipping beneath it to seek the orchard. The roots will then spread out in the loosened soil of the trench, which should be reopened about every second year to restrain their extension beyond it. The result is to compel deep rooting, which is attested in numerous orchards by the heavy production of citrus trees in rows adjacent to the windbreak.

Commercial Plantations. With the exception of a few small, scattered groves of black locust, planting for timber production in California has been confined to the eucalypts and chiefly to the blue gum. This species has been grown extensively in Southern California for fuel, and except for small amounts of oak, juniper, mesquite and pine has supplied the section for the past thirty years.

The returns on investments in Eucalyptus plantations have been generous, in many cases exceeding those received from equal areas under cultivation in orchards or agricultural crops. Groves set out in the fertile Los Angeles valley have yielded from 50 to 80 cords per acre at every cutting. Yields of 75 cords per acre every seven or eight years have been frequent.

At the present time there are several thousand acres in California planted to Eucalyptus. The following is a partial list of the larger fuelwood groves:

Owner.	*Location.*	*Acreage.*
Cooper	Ellwood	200
Bennett	Del Mar	200
Nadeau	Florence	115
Meecham	Petaluma	100
Varrick	Orange	90
Hazard	Los Angeles	90
Thaxter	Florence	80
Nichol	Santa Fe Springs	80
Smith	Berkeley	80
Bixby	Long Beach	80
Rosenerans	Gardena	80
Gunn	Santa Fe Springs	50
Hough	Huntington Park	40
Sexton	Compton	40
Kellam	Compton	40

PLATE 7. Stand of sugar gum 14 years old planted on a chaparral slope in the Sierra Madre foothills. Trees 6 to 12 inches in diameter and some over 100 feet tall.

PLATE X. Interior of a 14-year-old grove of sugar gum planted in the foothills of the Sierra Madre Mountains at an elevation of over 2,000 feet. Good forest conditions established.

In recent years several plantations of large size have been established in anticipation of a market for gum wood of merchantable size or for poles, piles, and railroad ties.

The plantation of Mr. Dwight Whiting at El Toro, Orange County, now covering 1,000 acres, is the most extensive commercial plantation in the State. Its oldest portions are now three years old. Planting will be continued annually until a forest of 4,000 acres is established. The plantation consists almost entirely of gray, red, and sugar gums.

The Bixby Company of Long Beach has begun the planting of an area of about 3,000 acres near Orange, Orange County. Blue, gray, lemon and sugar gums, in varying proportions, will be used.

The Santa Fe Railroad Company has recently acquired a tract of 8,600 acres in San Diego County, which will be devoted to Eucalyptus production to supply the company with poles, piles, ties, and other timber. The gray, lemon, sugar and blue gums will be planted.

The Union Lumber Company, located at Fort Bragg, Mendocino County, is the first lumber organization to become interested in the commercial planting of Eucalyptus. This company has cut over an area of 10,000 to 15,000 acres of redwood during the course of its operations. The logged redwood lands do not naturally restock with merchantable timber, because space between stumps afford too much entrance to lateral light, causing the production of limbs and hence knotty timber. Eucalyptus will be planted between the clumps of coppice shoots to cut off the lateral light and force the redwood second-growth into height development.

The Central Counties Land Company, which has recently acquired extensive holdings on and near Clear Lake, Lake County, has begun the propagation of blue and sugar gum seedlings for planting on its lands both for ornamental and commercial purposes.

The Pacific Electric Company and the Ontario Power Company have recently acquired smaller tracts in Riverside and San Bernardino counties, upon which they have begun planting with several species of Eucalyptus to raise tie timbers and poles for electric wiring. Extensive commercial planting is also being undertaken by many other companies and individual landowners in several different sections of the State. It is apparent that much greater attention to Eucalyptus planting may be expected in the near future.

TIMBER UTILIZATION.

Fuelwood. In Southern California the use of gum fuelwood has been most general. Gum cordwood is a staple fuel and may be found on sale in woodyards in most of the valley sections of the State. In the northern valleys it is much less common than in Southern California, owing to

its greater scarcity and the competition of valley oaks, which have been slaughtered regardless of their value for ornament and shade. Fuel oils have supplanted fuelwood to some extent, yet in Southern California, where fuel oils are available, fuelwoods have never been disposed of at a sacrifice.

Eucalyptus wood has high fuel value. It makes a quick, hot fire, hence it is very suitable for cooking purposes and for use in open fireplaces. It burns with a bright blaze and emits a pleasant, aromatic odor. In heating qualities it is hardly inferior to California oak wood. Most consumers are prejudiced in favor of oak wood, however, hence gum wood commands a lower price in the market than oak or mesquite. In different localities the price of gum fuelwood varies from $5 to $14

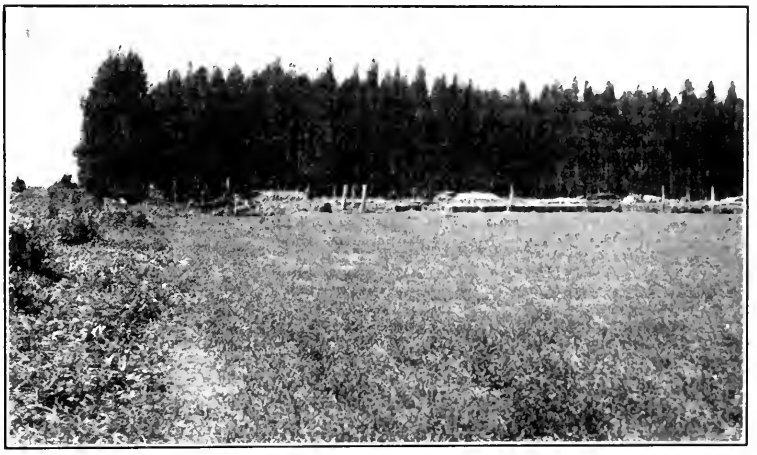


PLATE 9. Cutting a 6-year-old stand of blue gum for fuel. Portable sawing and splitting machine and piled cordwood in foreground. Stand averages 80 feet in height. Five acres cut yielded 350 California cords.

per cord, with tendencies toward the latter. Wood of the slower-growing encalypts and that of old trees possesses higher value than young wood from quick-growing species. Green gum wood makes poor fuel.

Gum wood is sold by the short cord of 96 instead of 128 cubic feet, two tiers of wood, 10 to 18 inches long, piled 8 feet long and 4 feet high, constituting a cord. Ten-inch wood is generally sold at the same price as 18-inch wood, without protest by the consumer. The wood cut from the rapid-grown gum sprouts is mainly sapwood, which shrinks greatly in drying. A cord will lose 15 per cent or more of its volume in seasoning.

Cordwood for the market is usually cut from tall, slender, sprout-grown trees rarely over 8 inches in diameter. The trees are sawed into fuel lengths without peeling the bark. If left in the round the sticks

do not burn as well as if split. Splitting must not be delayed after cutting, as the wood becomes very hard upon drying. Wood of sugar and red gum is quite straight-grained and splits without difficulty. Blue gum wood, particularly the sap-wood of old, open-grown trees, is very tough and cross-grained. The interlocked fibres must be chopped through in splitting and seasoned blocks defy all attempts to split them with an ax.

A small industry has grown up in Southern California through the cutting of blue gum groves for fuel. Traveling cutting concerns undertake the cutting of groves by contract, employing gangs of choppers and operating portable sawing and splitting machines in working up the product. The cost of cutting varies with the cost of labor from $2 to $3 per cord, and a margin of from $3 to $8 profit is left the owner, according to the advantage with which the wood is sold and its nearness to market.

Green wood should be piled for seasoning away from contact with the ground. The wood decays rapidly in contact with the soil and soon loses its fuel value.

A superior grade of charcoal can be made from gum wood. Where old groves are rooted up after repeated cuttings, the massive stumps are frequently burned for charcoal, and cordwood has likewise been used to some extent for this purpose.

Posts. A supply of strong, durable fence posts is one of the greatest needs of the California rancher. At present, dependence is placed in redwood and to a limited extent in local plantations of black locust. The hardness and strength of Eucalyptus wood would justify its use for posts if it were more durable in contact with the soil. Certain species, notably sugar and red gum, are of average durability.

Round blue gum posts from sapling groves have been used to some extent, but without satisfactory results. Split or sawn posts of more mature timber would doubtless last much longer, but these have not been widely used owing to the difficulty of splitting the wood. It is apparent that Eucalyptus has fallen into disrepute for post purposes without receiving a thorough trial.

Experiments in seasoning and treating Eucalyptus to determine its durability under better treatment have been undertaken recently by the Forest Service in coöperation with the State of California. Thousands of posts, of the size ordinarily used, were cut from young sprout plantations. Some were set green and unpeeled, others peeled and seasoned. Still other posts, green, seasoned, peeled, and unpealed were impregnated with hot creosote for different lengths of time in small portable tanks. They were then given distinguishing marks and set in fence lines in soils of different kinds.

Examinations of the posts will be made from time to time to determine their durability under different methods of treatment. The experiment, when concluded, will demonstrate whether blue gum may be used to advantage for post material.

Red, blue, sugar and red iron bark gums were used. It was found that all yielded to treatment remarkably well. The average cost per post was 6 or 7 cents for preservative alone. To this must be added the minor cost items, labor and wear of apparatus. The greater durability of treated gum posts is still unknown, but judging from the increased life of other inferior woods after treatment, and the known value of creosote as a preservative, it is safe to predict an increased durability all out of proportion to the cost of treatment.

Poles. A large amount of timber is used annually for poles for electric wiring. The increase in value has almost prohibited the use of the much preferred Oregon pine (*Pseudotsuga taxifolia*), and pole timbers of lower grade have come into use. Oregon cedar from which from six to fifteen years' service is obtained, depending on the character of the soil in which the poles are set, is the chief substitute. Experiments are also being conducted looking toward the substitution of yellow pine and yellow cedar. Eucalyptus poles have been tried to a limited extent, and may be expected under treatment to outlast the pole timbers in present use.

Railroad Ties. The development of transcontinental, interurban and urban railways has created a strong demand for timber suitable for ties. Eucalyptus timber has not yet come into general use for ties, although the indications are that it will be used more extensively in the future. The value of the wood for tie use has been tested by the Southern Pacific Company. Some hundreds of ties of California-grown blue gum were laid green and untreated in sandy soil in the roadbed through central Nevada. They exhibited good wearing qualities and the requisite strength, but, through lack of proper seasoning, checked badly, so that in some cases they failed to hold the spikes. At the end of four years the ties showed no signs of decay; after seven years' service some were worthless from decay, but some were sound at the end of eleven years.

The result of the experiment officially reported to the company credited the gum ties with being equal to the best second grade Southern pine, but the experiment was not followed by more extensive use. Gum timber can not compete with the best tie timber in durability, but if the life of gum wood is extended by preservative treatment its wearing qualities will make it a superior tie timber.

With increase in cost of redwood and pine timber, lower grade ties of the more durable eucalypts should find a place in the market. Sea-

soned gray, red and sugar gum timbers are moderately durable and should give longer service than blue gum. Sugar gum is probably the best eucalypt for tie production.

Mine Timbers. Blue and sugar gum have been used with success in timbering mines near Escondido. The gum timber has been found superior to any other obtainable there. Few of the timbers have decayed, although the mines are flooded during a part of each year. Difference in value of the two species has not yet become apparent, but it is probable the sugar gum will prove superior, as it excels blue gum in both strength and durability.

Wharf Piling. The problem of maintaining wharves has become an important one on the Pacific coast. Not only are the best pile timbers very expensive, but they will not resist the attacks of the teredo and limnoria and have to be replaced continually.

Both the teredo and limnoria are troublesome all along the Pacific coast, being carried from port to port by the shipping. The teredo attacks the piling at the ground line, under water, and burrows chambers through the wood. When the piling is unprotected, this source of injury is generally negligible, for the timbers are more speedily eaten off at the water line by the limnoria. The limnoria have no natural enemies in American waters to decimate their numbers, hence they are constantly increasing and becoming more troublesome. Their attacks are particularly severe in the warm waters of the southern ports and in sheltered harbors.

In an attempt to maintain durable wharves, experiments have been made with costly iron and cement piles, but the lower cost and greater ease of setting keeps the wooden pile in favor. Various expensive treating and sheathing experiments have been tried, but preservative processes have failed so far to check the borers. Limnoria will not attack wood which is coated with sand. This fact has been taken advantage of to defeat them by applying a rough cement wash to the exposed surface of the piles. This coating not being elastic, however, fails to prevent the limnoria from entering at season checks and continuing their work under the cement covering. Pile timbers are generally creosoted or oiled, and often wrapped and battened, to increase their period of service, but limnorias attack even creosoted wood. When untreated, piles are generally set unpeeled, as the borers do not work while the bark remains.

Aside from its use for fuel, gum timber has been most extensively used for piling. After extended trial the blue gum pile has been determined the best in use on the Pacific coast. Whenever it can be obtained, contractors and wharf managers discriminate in its favor.

It is attacked and ultimately destroyed by borers, notwithstanding contrary statements. Its superiority seems to lie in its extreme hardness, for when gum and softwood piles are used together in a wharf, the borers concentrate their attack on the softer piles. Experienced

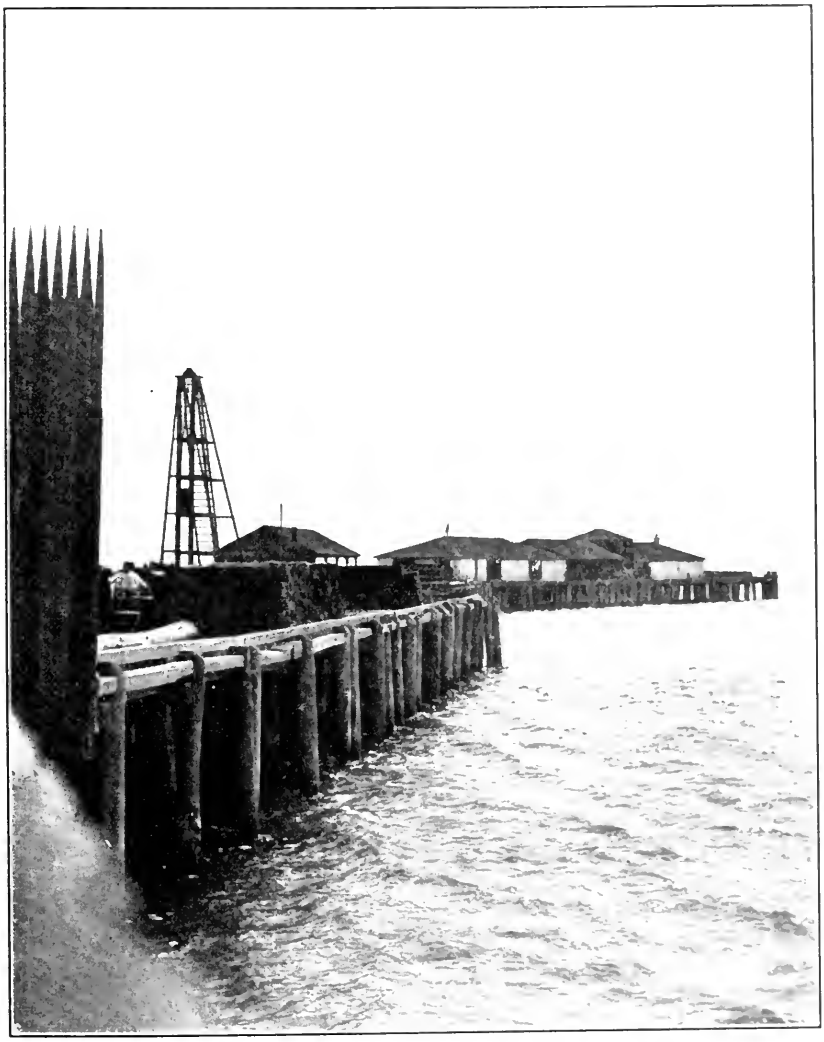


PLATE 10. Blue gum piling in the wharf at Santa Barbara.

users discriminate in favor of piles from old, slow-grown trees cut during the winter and seasoned thoroughly.

Eucalyptus piles in general use are from 30 to 35 feet long and from 12 to 24 inches in diameter. Such piles bring from $5 to $15 apiece on the stump.

Gum piling was first used in the wharf at Santa Barbara. Its use in some other wharves was accidental, but since its successful trial it has been used in the wharves at Crescent City, Oakland, Port Harford, Gaviota, Santa Barbara, Serena, Summerland, Avalon, Oceanside and San Diego. On account of its superior service it is used in the wharf at Crescent City despite the local supply of redwood timber.

Dimension Material. No valuable hardwood timber is native to California or the Pacific coast. Demands for it have been supplied by importation from Eastern centers of production at high prices and high freight rates. Eucalyptus has been widely used for saw-timber in Australia, but in California its commonness has prejudiced users against it. Added to this is the fact that very little dimension material has been produced, practically all the plantations having been cut for fuel. At present it can hardly be found in the market.

Pioneer manufacturers, operating planing mills in San Francisco, Los Angeles and San Jose, have persevered for twenty years in utilizing it as ordinary hardwood stock. Difficulty has been encountered in the introduction of a new material, however, so their business has remained small. They have overcome local prejudice to some extent by guaranteeing their product. Severe and extended trial has proven that it possesses superior qualities of strength, hardness and flexibility. Seasoned blue gum timber has been substituted in San Francisco for orders of maple, hickory, and "ironwood" without the knowledge but to the entire satisfaction of the purchaser.

No fixed stumpage price for Eucalyptus timber prevails. It is bought either by the single tree or at the market price of cordwood. Large trees which contain 4 to 6 cords, or will cut 1,500 to 3,000 feet B. M., are bought for from $12 to $25 per tree. The total cost of stumpage, logging, manufacturing and seasoning is about $20, hence it is apparent that manufacturers can readily undersell Eastern hardwoods. Gum timber has been sold at from $100 to $125 per M, and retails for 12½ cents per foot for finished and 10 cents for rough timber.

QUALITIES OF EUCALYPTUS WOOD.

The timber eucalypts furnish a hardwood possessing qualities similar to those of Eastern hickory and ash. The wood of different species differs in strength and durability, but in general the timber is very strong, heavy and hard, with a close-grain and homogeneous structure.

The specific gravity of the wood of most species is greater than that of water, the dry wood of blue gum averaging over 60 pounds per cubic foot, varying from 50 to 70 pounds, according to the age of the timber. The wood of other species is still heavier. It is very tough, resisting indentation, tension or torsion. This is of advantage, for it

will not crack nor break out under strain at joints or bolt holes. The wood is stiffer and less elastic than Eastern hickory.

The wood of different species ranges in color from white to dark brown. The heart and sapwood of many species is indistinguishable. The heart of blue gum is a little darker than the sapwood, while that of red gum is red or dark brown in color. The grain of blue gum closely resembles that of hickory and ash.

SEASONING.

The difficulties experienced in seasoning Eucalyptus timber have been a great obstacle to its more extensive utilization. It has received an undeserved reputation for warping and checking from many who have used it green or improperly seasoned. It is no more difficult to season than oak, hard maple and many other hardwoods, which are annually cut and seasoned by the million feet in the Eastern States. The success attained by several experienced manufacturers proves that it yields readily to thorough methods.

To insure successful seasoning the trees should be felled between November and March. Sawlogs should be manufactured as soon as possible after cutting, for they check quickly with exposure to sun and winds. When not to be sawn immediately, they should be piled in the shade without peeling. The ends of the logs should be painted to prevent checking.

Ordinarily, sawn lumber should be loose-piled under cover with abundant space for air circulation. The ends of the timbers should be weighted. By this treatment 6 by 8 inch or larger timbers are thoroughly and evenly seasoned without warping or checking, though the wood may shrink considerably during the seasoning process. Inch boards are apt to warp in seasoning, so the lumber is usually sawn into planks. The heartwood is more apt to check than the sapwood.

Air seasoning produces better results than kiln seasoning. Air-dried lumber may be used in a year, but two years' seasoning gives better results and is generally practiced.

USES OF LUMBER.

Vehicle Parts. Blue gum has been extensively used as a substitute for other hardwoods in the manufacture of vehicles. Its strength and elasticity recommend it very highly as a substitute for hickory and ash, which are rapidly becoming scarce. Gum timber is just as durable and nearly as strong as hickory. If kept from contact with the soil, it will not decay under exposure to the weather, and will retain its shape if properly seasoned.

Its usefulness for vehicle parts has been recognized locally for a long time. The ranchers of the Los Angeles and Santa Clara valleys

have used it for poles, shafts, reaches, axles, doubletrees, racks, bolsters, spokes, hubs and felloes and for the wooden parts of plows, harrows and other agricultural implements. Like its first use for piling, Eucalyptus was first employed for vehicle parts by accident.

Recently gum wood was experimentally used for wooden ties on heavy auto trucks. The motors of these vehicles are damaged and bolts are soon cut off by the jar of running on steel rims on city pavements, and expensive sets of rubber tires last but a few months. A wooden tire was devised by bolting seasoned blocks of gum wood, set with the grain vertical, into a patent rim attached to the wheels. The tires have been used successfully for six months without attention or repair, and show few signs [illegible] to take up vibrati[illegible]

Insulat[illegible] [illegible] locust wood for [illegible] part of the manuf[illegible] fornia-grown gum [illegible] s have been filled in Canada and the Eastern States. Gum pins are in use in most of the telephone and power transmission lines in this State, and are used exclusively by leading contractors. Sound pins are still in use after fifteen years' service.

Furniture. Seasoned blue and red gum wood has been used to a limited extent for cabinet work and for the manufacture of furniture. Handsome chairs and tables have been made, which are very strong and do not warp, check or loosen at the joints. The wood takes a splendid finish and has been stained to imitate mahogany very closely.

Other Uses. In a few instances unstained panels, showing fine grain, have been used in the interior finishing of houses. The timber has also been manufactured into flooring and used in place of hard maple. It has been used for pulley blocks, belt wheels, saw tables, brakeshoes, for levers of house-moving windlasses, and, indeed, most generally where a durable wood of homegeneous structure is required.

BOTANICAL NAMES.

A list of the botanical names of the species mentioned in this report follows:

Common Names.	*Scientific Names.*
Blue Gum	Eucalyptus globulus.
Sugar Gum	Eucalyptus corynocalyx.
Red Gum	Eucalyptus rostrata.
Gray Gum	Eucalyptus tereticornus.
Manna Gum	Eucalyptus viminalis.
Lemon Gum	Eucalyptus citriodora.