REFORESTATION AND TIMBER STAND IMPROVEMENT

Reforestation and timber stand improvement (TSI) are basic elements of intensive forestry. The foundation of good forestry must provide positive methods of quickly establishing new stands of timber on lands that are deforested by wildfire, logging, or natural causes. Timber stand improvement is necessary to put young stands, below commercial size, in good growing condition much as a gardener thins and weeds carrots to provide maximum growth and produce a crop for harvest in a limited space of time. Ever since Europeans came to America, they has been dependent on its forests for fuel for heating and cooking, timbers for shelter, wood for ships, ties for railroads, planks for roads and bridges, paper for communications, and other uses. The first white men that came to California built a stockade in San Diego in 1769, with native trees found at the site. The people of California have been dependent on the forest resources of the State ever since. As forests are used, they must be cultured to provide the ever-increasing demands for wood products.

In the early history of California there was plenty of everything; it was truly a paradise. Millions of acres of fertile valley land, millions of acres of forests, thousands of miles of streams and rivers, wildlife was plentiful, grasslands as far as the eye could see, and climate that was ideal for enjoyment and well-being. There was over a thousand miles of coastline with excellent harbors. All of the necessities of life were available, but not all in the place many people chose to be their principal place of occupation -- southern California.

By the time Forest Reserves were established in southern California, starting in 1891 (which were among the first in the Nation), the population of California had reached a level of over 1,200,000 people. Over a quarter of a million people resided between the Mexican border and the Tehachapi Mountains and were mostly confined to the Los Angeles Basin of a few thousand acres. Compared to the rest of California, the density of population at that time was high. It was a semiarid climate. Water for irrigation and domestic use came from local watersheds. These natural reservoirs, the mountains, had been burned repeatedly and their capacity for retention of water lessened to the point that flooding of the valleys was common during high-intensity rainstorms that occurred periodically. Every drop of flowing water was used, and tunnels were driven into mountains to increase water flow. Wells in the valley lands had been sunk in great numbers. Pumps in the valley wells ran constantly and were lowering the water table at an alarming rate. Many wells and homes had already been abandoned because the local water supply was exhausted.

Two thoughts were prevalent at this time (Decade 1890’s) and were deemed foremost to sustain life in the area; (1) control of wildfire on the mountainous areas to prevent flooding and (2) the creation of forests on the chaparral slopes to alter the climate, because people had observed that where forests existed, the rain is more constant, of less intensity with more percolation and reduced flooding; while in arid, treeless regions the extremes of drought and flood are the rule.

First Tree Planting Work in Southern California

T. P. Lukens, an agent of the Bureau of Forestry, had been assigned to Southern California. In 1902, he reported on "Seed Collecting and Seed Planting in Southern California." He said in part:

> "I began planting seed of this pine (Knobcone pine) on the first of November 1901 and worked with five men through November and December. I also furnished B. F. Allen, Forest Reserve Superintendent, nearly 800,000 seeds which he has had planted by the forest rangers.
>
> "The areas planted (seeded) this winter were selected with the view of making a severe test. We have planted all told about 1,000 acres in lots of from five to eighty acres, in nearly every case on southerly exposures that were denuded by fire the past two years.
>
> "Twenty-five percent were planted in the San Jacinto Reserve, forty-five percent in the San Gabriel Reserve, and 30 percent on the Pine Mountain and Zaeka Lake Reserve."

Lukens concluded his report with a statement concerning some previous work, which must have been the first of its kind on National Forest land in California:

> "Of the last year's planting we have very few trees to show. In the first place they were planted late, January and February, 1901, after which there was little or no rain. Many came up, but there was not moisture enough to carry them through the long hot summer .... To our great disappointment we are having another dry winter. Unless rain comes soon and the ground is kept wet for two or three months, our work will be in part lost, but I am not in the least discouraged. I desire to continue to plant seeds, trusting we will have a wet winter, then success will be assured. Many of the seeds planted this winter are up, and I will watch and care for them with the hope of carrying them through the summer."

With this planting work as a start in California, a small nursery was established in Pasadena in 1903 and abandoned because of lack of water. In 1904, Henninger Flats was rented from the Mt. Wilson Toll Road Co. and a nursery established which was in operation by 1905. The following year another nursery was established in San Marcos Pass about 16 miles from Santa Barbara by George W. Peavy, then in charge of tree planting in California. These two nurseries were to furnish young trees for experimental planting in the mountains of southern California with a capacity of 800,000 seedlings and transplants in 1907 for the San Gabriel, Santa Barbara and San Luis Obispo Reserves, or the Angeles and Los Padres Forests, as they are called now.

It was about this time that an order went out from Washington that all Rangers who occupied permanent stations must establish nurseries for local species of trees. This was

not so much for the practical value as it was educational. In order to get the Supervisors extension-minded also, they were expected to establish nurseries at their headquarters.

This idea bloomed between 1906 and 1908 and then faded. Several Rangers' nurseries were established in northern California as well as in the south.

Section of transplanted ground newly cleared land, Pasadena, Cal 1904. The Pasadena nursery was established c 1903.

Hamiger Flats nursery established c 1905. San Gabriel Forest Reserve. Photo about 1906.

The eucalypts were being widely publicized as a wonder tree and exactly suited to all of California. Between 1908 and 1912, the following nurseries were established for the purpose of growing eucalyptus and then abandoned: Oak Grove on the Cleveland; Los Prietos, Santa Barbara; Merrick Canyon, Angeles; and San Bernardino, then a part of the Angeles. All but the Oak Grove were started in 1909, and most of them only lasted two years.

The two conifer nurseries, San Marcos and Pasadena, were moved in 1908, *[John Buck note: 'something haywire']* San Marcos to Santa Ynez Valley (Los Prietos) and Pasadena to Lytle Creek.

The cost of planting conifers in 1906 was $15.82 per thousand and in 1907 the cost was $10.76, according to a report by Samuel N. Spring. He indicated the planting results to be rather poor and said:

"The plantations made in 1905 and 1906 show great loss, which is attributed wholly to damage by rabbits. Only a few scattered trees of the 1905 planting remain, but those that have escaped are in good condition, being from 24 to 36 inches in height. Out of the 33,000 trees planted in 1906, less than l0 percent are alive, but the living trees of the more hardy species are in good condition. Nearly 50 percent of the 1907 plantings have been destroyed. Of those in the brush, 95 percent have been seriously injured."

These comments were for the planting work associated with the Pasadena Nursery and the 59,000 trees out planted from the San Marcos Nursery at the same time met with the same generally poor results.

Rangers eucalyptus nursery. Ranger Simons wife 1908, Cleveland N.F.

Eucalyptus planting on the Cleveland N.F. — 1908

This early planting work in southern California included most of the native conifers from seed collected locally. In addition, many different exotics were grown and planted including deodar, cedar, acacias and several species of eucalypts.

A search of records for these earlier years of planting do not reveal acres planted. For 1909 and 1910, the two-year total is 376 acres. Most of this work must have been in southern California as very little planting stock was available in the north.

San Marcos Nursery showing section of transplant bed, Santa Barbara N.F. 1906.

George W. Peavy was in charge of the planting program in District 5 from 1906 to 1910 and apparently, he wrote the first Annual Planting Report for the year 1908. He proposed to the Chief the following program for the next 5 years:

1. "The planting of 160,000 conifers (each year) on the watersheds of southern California Forests for the purpose of continuing the experiments now being carried on there, to determine the feasibility of improving the cover by supplementing chaparral with trees;
2. The planting of 300 acres of eucalypts on the Angeles, Cleveland and Santa Barbara Forests to determine the desirability of using this tree for combined watershed and commercial purposes;
3. Seed sowing on 100 acres on each of ten of the commercial timber Forests of the District, to determine the wisdom of reforesting cut-over areas and burns by this method;
4. Conduct a seed sowing experiment on clearcuts;
5. Collect 7,625 lbs. of seed; and
6. To provide conifer stock for planting experiments on the commercial timber Forests of the District, a Forest nursery should be established on some site, from which the plants can be most economically distributed. "

Peavy also questioned the idea that the Service should be putting all the planting effort into trying to convert the chaparral to tree cover on watersheds when there was 1,500,000 acres of timberland that was brush-covered in northern California. He proposed that a man be sent to Australia to obtain first-hand knowledge of the eucalypts and estimated there was 33,000 acres of Forest Reserve land upon which eucalypts could be grown. Peavy's report, written in February, 1909, was approved by District Forester Olmsted.

Tree planting on the San Gabriel Reserve about 1904

On April 19, 1909, Gifford Pinchot replied to the District Forester. He left no doubt that in his mind, "Watershed planting is by far the most important just now." He agreed with the conclusions regarding chaparral, but Pinchot wrote,

> "I feel that even in Southern California there are large chaparral areas where planting of timber trees is practical and most desirable and will serve the double purpose of protecting the sources of city or town water supply and of producing wood, for which there is such a need in that region.... There are certainly sufficient areas in southern California where watershed planting will produce valuable results to consume all the time and money, we can possibly devote to them in the next ten years.... I do not feel that we should hesitate to devote most of our planting resources to it until it is completed."

Pinchot did not agree that the District was justified at present in resorting to artificial reforestation on cutting areas, nor did Pinchot agree to sending a man to Australia. He did agree to the idea of establishing a small nursery "to raise stock for planting experiments in northern California as soon as you can find a suitable site for it."

This ended Pinchot's contribution to solving planting problems in California; H. S. Graves became Chief. Woodbury had become active in reviewing the planting policies for the District and in May, 1910, a new District 5 policy was developed which called for termination of planting conifers in the chaparral zone and discontinuing most of the nurseries in southern California. Some eucalyptus planting would continue.

By the winter of 1911, Converse Flat on the Angeles was the only active nursery (experimental) in the south, and it was proposed to settle the future of conifer planting by a series of careful experiments, continued through a number of years, and carried on at Converse Flat and the Pilgrim Creek Nursery, founded in 1910 in the north. The frost of December, 1912, killed most of the eucalyptus plantations in southern California and settled that project. The Pilgrim Creek Nursery on the Shasta became the laboratory for planting experiments in the north.

District Forester Coert Du Bois' annual planting report for 1912 gives a whimsical resume of planting results up to that time and is quoted here.

> "When in the distant future Forest Service historians chronicle planting in southern California that particular chapter will, I fear, be cited as an excellent exposition of "how not to do it." First will be told the story of T. P. Lukens' efforts (commencing in 1904 on the Angeles) to establish forests of Sierra species in the granitic soil of the hard-baked lower foothills where nothing but dense brush had ever grown. The fight was a losing one from the start, but if perseverance is an indication of valor, then was it waged right valiantly since the cause was abandoned only recently with the establishment of the Converse Flat Nursery and Experiment Station in the true timber belt at higher altitudes. Parnay picked up the work where Lukens left it and carried it on in accordance with the same hopeless policy until James M. Grant loomed on the horizon in 1909. He was welcomed as a savior and had a brief but brilliant career during which nurseries sprang up, like mushrooms in the night, on the Angeles, and Santa Barbara as well. This period will doubtless be known as the "Eucalyptus Era." Owing to the discovery that eucalyptus cannot be grown successfully in pits in the brush, it is rapidly drawing to a close but not without having left an impression, even though slight, on the scenery of southern California foothills. Even the remote Cleveland felt the inspiration of this period and plans were almost matured at one time for covering stern San Miguel mountain with beautiful (?) groves of eucalyptus.
>
> "In 1906, the Santa Barbara enters the lists with Peavy and d'Allemand as champions. The San Marcos Nursery was established in the brush zone and plantations principally of Knobcone and Jeffrey pine were scattered here and there throughout the areas about the nursery. Later the Los Prietos Nursery was established in the same brush zone and further efforts were made to court success under the most exacting

conditions with ill adapted or valueless species and rodents to cope with. This chapter is now a closed one since the abandonment of the Los Prietos Nursery a year ago.

"While the Cleveland has played a minor part, yet it cannot be ignored. In 1908, Clifford started activities there. The Oak Grove Nursery was constructed soon after and was continued up to 1910. For the work done there we have three of four partially successful eucalyptus plantations on plowed land and numerous small failed plantations and seeded areas of conifers in the lower scattered timber belt.

"It is estimated conservatively that to date, planting on the Angeles has cost the Service $45,000, on the Santa Barbara $25,000 and on the Cleveland $10,000, or a total cost of $80,000 for the southern California Forests, not including a little sporadic work which was done on the Monterey during the same period. We have absolutely nothing to show for this work except negative results save only a few acres of eucalyptus on agricultural land and a few dabs of Knobcone pine. The knowledge gained, to say the least, has been dearly bought."

Du Bois concluded his report with two important recommendations:

1. The abandonment of experimental eucalyptus pit planting in southern California.
2. The concentration of planting and seeding on the Plumas Forest under the direction of the Feather River Experiment Station.

In "Breaking New Ground," Gifford Pinchot wrote - p. 238

"When this century began it was clear to us that forest planting would grow in importance as time went on. Enormous areas on the Forest Reserves, and on public lands not yet reserved but likely to be, needed planting, and each year new fires enlarged the areas. In southern California, for example, where water was the main consideration, we were confronted with the task of making many trees grow where none grew before. And in the Forest Reserves that was one job which the General Land Office was more than glad to have us take over.

"To replace the chaparral of southern California with timber trees turned out to be impossible. But the effort was not wasted. We were learning all the while not only where to plant but where not to plant, and how to select the right trees. And we were training men to grow from seed great quantities of the trees we had chosen."

The Great Seeding Experiment

In the Fall, Winter and Spring of 1910 and 1911, came the seeding experiments on most of the Forests of District 5, totaling 3,117 acres for the two years. One hundred and fifteen acres had been sown in 1909 and for the three years 1912 - 1914 an additional 684 acres were sown. Secretary James Wilson of the Department of Agriculture had seen a

successful experiment - the Black Hills of South Dakota -- and had told the Chief Forester to get busy and sow seeds broadcast on all the National Forests.

In 1910, 4,600 lbs. of seed of all of the commercial conifers was scattered in various situations with various methods on 16 National Forests. Most of the seeding was done in the Fall of the year at an average cost of $7.18 per acre. Some of the work was done by the seed-spot method: a considerable part by broadcasting after a slight stirring up of soil with drags, or without preparation on recently wildfire burns. Even some of the seeding was done by broadcast methods in the dense brushfields.

Nearly all of these experiments were reported as total failures. The two main causes of failure were (1) the extremely dry summer conditions which come on before the seedling has established its roots in the deeper moist layers of soil, and (2) rodents and birds which destroy large quantities of the seeds before germinate or during germination.

Showing method of seeding done by Forest officers and laborers, San Bernardino N.F. about 1911.

Planting (seed) seed spot method in heavy stand of fire killed manzanita. Dalo 4,7. Photo 11/30/10.

Rangers planting western yellow pine seed in a burned area. Fresno Flats, Sierra National Forest 1910.

The section of the Annual Planting Report for Calendar Year 1910 to the Chief concerned with direct seeding concluded as follows.

"From the above review it will be seen that: (1) areas where artificial regeneration is most needed, are difficult to work with (for example, the dense manzanita brushfields),

and (2) where artificial regeneration by seeding can be undertaken more easily, we have a stand of hardwoods, or natural regeneration of conifers would take place gradually.

"In view of this showing, the question naturally arises as to whether or not we are justified in going ahead with the expenditure of ten to fifteen thousand dollars annually, or more in seeding work upon the National Forests of California. Personally, I do not believe that we are at the present time, and I find this view is shared by many of the Supervisors. The following reasons support this view:

(1) Results of direct seeding in the past show that the measures of success attained are not proportion to the expenditure.

(2) A large part of the money we are devoting to this work could be used advantageously in protecting our present resources. In other words, we are losing by fire each year, due to insufficient protection, more young growth than we can reasonably expect to produce by direct seeding, which young growth could be preserved by expending for protection the money which we are putting into seeding.

(3) Requiring Forest officers to do a large amount of fruitless work has a bad effect within the district organization and tends toward the creation of a feeling of lack of confidence in the policies of the Service, both among Forest officers and the public.

"As I see it, our great reforestation problem in District 5 is the dense brushfields of the North. Everything leads me to believe that costly and careful planting must be resorted to if they are to be restocked artificially."

This was followed with a plea to the Chief to reduce the amount of direct seeding the next year with the realization that he might be obligated to the Secretary to do the work. No relief was given and the next years seeding work continued at the same high level and then slacked off. Another twenty years went by until direct seeding was again attempted in 1934.

The first efforts to control rodents seem to have been made at the time of the Fall sowing in 1910, when seed was coated with repellents and poisons. These efforts were ineffective. Cooperation of the Biological Survey was sought in 1911 and between September and November of that year, S. E. Piper of the Bureau attempted to eliminate the rodents from two large areas by intensive poisoning prior to sowing. Examination in the early Summer of 1912 showed that rodent damage was not effectively reduced.

Hardwood Planting on the Inyo Forest

Another item of interest in the early history of planting was the planting of hardwoods in the Inyo Forest. In the Fall of 1910 and Spring of 1911, plantings were made for posts and windbreaks in the Owens River Valley. A wide variety of species were tried, including

locust, white ash, box elder, black walnut, butternut and several other eastern trees. The planting was done in planned furrows and in pits on fenced, agricultural land at Rangers' Stations in the valley where water for irrigation was available.

Early Experimental Planting in Northern California

District policy of 1910 indicated that planting and reforestation on California National Forests was to be strictly on an experimental basis. The Pilgrim Creek Nursery founded in 1910 was the work center and began to distribute planting stock in the Fall, 1911. The research work would be done at the Nursery and in the immediate vicinity on adjacent administrative plantings on the McCloud Flats and the Sisson Burn (now called the Mt. Shasta City brushfield).

Supervisor Richard F. Hammatt of the Shasta Forest was in charge, and technical direction for the research was provided by S.B. Show and E.I. Kotock. Fred W. Graham, an Assistant Forest Ranger, was the first nurseryman. Planting stock would also be provided to other adjacent National Forests.

S. B. Show in his USDA bulletin #92, *Forest Nursery and Planting Practice in the California Pine Region*", January 1930, said about this early period:

"At first it appeared that the essential job was simply to raise the trees and set them in the field. No great technical difficulties were anticipated. But the first planting experiments made in 1911 dispelled the illusion, for serious obstacles were encountered in nursery practice and in field losses from rodents, drought, and improper planting. Thus, by 1913 it became clearly recognized that before extensive plantings could be made with assurances of success systematic and detailed research would be required.

"The establishment in 1913 of a Forest Experiment Station at Feather River offered the opportunity to under-take such a program. At the same time, administrative planting was continued on the Shasta National Forest whereby the results of research were tested, and certain phases of brushfield planting were studied independently."

Planting long rooted ~~yearlies~~ western yellow pine with crowbar and forceps. Sierra N. F. 1907

The experimental planting work continued until 1920 when the Pilgrim Creek Nursery was closed. During the decade, it had been in operation (1910-1920), about 1,800 acres had been planted with little or no success. The reason given for stopping planting work in District 5 was that much better results could be secured in other Districts at less cost.

This experimental planting work, and other work done at the Feather River Station, became the basis for Show's Bulletin #92.

Results accomplished consisted of an improvement in the quality of the planting stock, the compilation of definite grading rules for stock, and application of results of experiments to nursery practice. In field planting, a great deal remained to be learned in spite of a promising beginning. The early work demonstrated the most suitable age class of each species, indicated the best season for planting, and threw some light on the conditions to be met in brushfield planting. Some information was obtained concerning the relative hardiness of the important tree species on different sites on the possibility of planting chaparral and sagebrush land, and on the role of brush cover as a heavy user of soil moisture.

Apparently when the Pilgrim Creek Nursery closed, there was a little excess planting stock. This plant material was outplanted in the nursery area at about 700 trees per acre. At the present, there exists a nice plantation at this location. Many of the trees have been pruned in the last few years and some of the trees harvested on a timber sale during 1972 or 53 growing seasons following planting. It is now called the "Show Plantation",

Scattered over the McCloud Flats are a few small areas containing trees from this early planting work done by Show and Kotok. They show up on present day aerial photos. All of the work was written off as failures as was the work done on the Sisson Burn.

Planting work on California National Forests was discontinued for the next ten years (1921-1930).

In March 1923, the Chief Forester requested a summary of the planting situation in Region 5. Woodbury prepared a report the next winter and transmitted it to the Chief on January 23, 1924. He indicated a total of 173,600 acres in need of planting of which 6,800 acres in burns or cutover land and 166,800 acres of brushfields on potential timberland. All of these lands were indicated as being pine timber type and in northern California.

Woodbury recommended a ten-year period of planting experiments under the direction of the Office of Research. During the ten-year period, planting should be confined to typical areas of burns, cutover land and brushfields in need of reforestation on the California (Mendocino), Eldorado, Klamath, Lassen, Plumas, Shasta, Stanislaus and Tahoe Forests. The work done both in the nursery and in the field should be on a small scale so that intensive supervision can be given it and results watched closely. It would not be advisable to raise over 30,000 trees a year or to plant more than 40 acres annually. After

the ten-year period, if justified by results, the planting program should be expanded with the objective of planting all areas in need of reforestation in the ensuing fifty years.

This report was written in January, 1924, a few months before the commencement of the worst season for forest fires California had known. Over half-million acres were burned over in the National Forests. In 1927, Woodbury sent a revised report to the Chief. By that time, another bad fire year in 1926 had added considerably to the burned-over acreage in the National Forests. In the 1927 revision of this plan southern California would come in for a revival of planting, largely because of experimental work done by the Los Angeles County Forestry Department which had been planting out of the Henniger Flat Nursery since 1918.

In the revised report Woodbury told about some recent experiments conducted in cleaning strips through brushfields by use of gasoline tractors and drags, or road graders. Woodbury felt this method offered great possibilities for preparing planting strips through the brush and stated they intended to use the equipment experimentally in the Fall,1927, for tree planting if source planting stock would be available.

Another recommendation in the revised report suggested that an administrative nursery should be established in some central location to be selected within or adjacent to the eastern boundary of the Plumas or Lassen National Forests. For the new proposed nursery, a Junior Forester should be employed to operate the nursery.

Brushfield Stripping Begins in 1932 and K-V Planting Begins in 1938

Woodbury's optimism and report writing paid off, and in the summer of 1928, the Forest Service moved onto a tract of 7.8 acres near the town of Susanville and commenced work to establish a new nursery (the Susanville Nursery). Junior Forester C. W. Carson was placed in charge of the operation and the Forest Service started on a new chapter of tree planting.

The first large planting in many years was in 1930, when 315 acres of experimental work was done, north on the Lassen in the old Antelope Burn of 1924 and on the Modoc on Sugar Hill. In 1931, 436 acres were planted at a cost of $18.02 per acre. This was the first two years of production from the Susanville Nursery. The Modoc plantings on Sugar Hill were showing really good survival and it appeared that things were "looking-up" in the planting business.

Planting on the Sugar Hill burn. Spring 1932, Modoc N.F. Each man ~~planting and~~ digging holes with a planting hoe and planting individually.

Sugar Hill Plantation general view taken June 1958. The first really large scale successful plantation in California.

In 1932, there was another trial at planting the brush fields as had been done in 1927. Three and a half miles of 6-foot wide strips were cleared of brush by a 1931 Cletrac Model 15 Crawler and a bulldozer. The alternate strips were planted with ponderosa and Jeffrey pine. There was a distance of 25 or 30 feet between the cleared strips. This was in the nature of an experiment on the Big Springs brushfield on the Lassen.

Lassen N.F. District Rangers planting 1-1 Western yellow pine, Antelope Mtn. Burn. Photo about ~~1928~~ 1930. The two man crew method, one digging holes with a shovel and the other planting the tree.

The amount of brushfield stripping increased, and in 1934 it was reported that 60 percent of the planting was done in previously prepared cleared strips in heavy brush ... 1,121 acres were planted that year. The brushfield stripping work was concentrated on the Lassen Forest in the Antelope Mountain Burn and the Big Springs area. A total of 219 miles of strip was cleared at an average cost of $32.04 per mile.

In 1935, the Lassen did some experimented control burning in a brushfield for planting. The object of this work was to:

- determine the practicability of the use of fire in brushfield clearing,
- reduce fire hazard on stripped areas,
- determine the effect of fire on the reduction of rodents,
- determine planting success on an area which had been cleared by fire without stripping, and to
- determine the advantages in stripping following burning.

Brush stripping work was started in 1936 on several other northern California Forests, and the designing and development of the "Plumas Brush Stripper" was completed by

Supervisor Rogers of the Plumas Forest. This same year considerable CCC labor was used in the brushfield work.

Strip completed after second pass of stripper. Plumas N.F. 1936

In 1938 the first Knutson-Vandenburg (K-V) funded planting was done on 55 acres on the Tahoe National Forest.

By the end of the decade, 1930 thru 1939, 13,753 acres of planting and 3,119 acres of seeding had been accomplished. These operations were conducted on the Eldorado, Lassen, Modoc, Plumas, Sequoia, Shasta, Sierra and Tahoe Forests. The capacity of the Susanville Nursery (now the "Durbin" Nursery) had been increased to over one million trees and a new nursery started at Mt. Shasta on the McCloud Flats (Spring, 1940) as a transplant nursery. Survival of 3-year-old plantations, planted Fall of 1937 and Spring 1938, examined late fall of 1940, showed an average of 72.3 percent living with 308 trees per acre. This tally of survival was on 1,572 acres.

The Calendar Year 1940 report contained a sorry note of what might happen in the future to these brushfield plantings:

> "Abnormal losses were sustained in planted areas this year. Approximately 600 acres of old plantations and 100 acres of current year plantations were completely destroyed by fire. At least half the planted trees on approximately 400 acres were pulled and burned as a remedial control measure to combat an insect infestation of pine weevil (*Cylindrocopturus longulus lec.*). The trees of current year planting on about 700 acres were severely clipped and damaged by rabbits. Many of the trees died as a result of this clipping, but most of the others will recover unless subject to further clipping.

There has been an alarming increase in rabbit damage to current year plantings in some localities during the past 2 years, which threatens the continuation of planting on these projects if adequate control measures are not developed."

Some of the plantations created during the decade of the 1930's that continued to show promise were the Sugar Hill plantations on the Modoc, Middle Creek salvage area on the Eldorado, Pine City Mt. on the Sierra, Lava Butte on the Sequoia, Lueck area on the Shasta, and some of the plantings and seedings on the Foresthill Burn on the Tahoe.

C. W. Carson transferred to the Regional Office as Regional Planting Inspector in 1935 and continued in charge of the planting program until his retirement in 1957. He took military furlough (1945-1947) and had a 2-year assignment in Pakistan (1955-1956). Harold E. Engstrom was in charge of the Region's planting program from 1945 - 1947.

The decade of the 1940's saw an interruption of the planting program due to World War II. The brushfield stripping ended in 1942 and planting work was shifted to planting on fresh burns. About the same time, the use of CCC labor terminated as most of the camps were closed. CPS labor (conscientious objector) was used for nursery work and some tree planting.

During 1945, the Durbin Nursery resumed normal operation. In addition to the Durbin Nursery production, one acre of seedbeds was sowed at the Forest Genetics nursery near Placerville to provide about one million seedlings. This 1-0 planting stock proved to be very satisfactory for the 1947 program.

The Durbin Nursery was closed in Spring, 1949, and henceforth all planting would be done with Mt. Shasta Nursery planting stock. Carl Lanquist was the nurseryman. The Durbin Nursery had developed a case of root rot, which could not be controlled.

Other highlights during the 1940's were:

- The preparation and publication of a regional seed zone map by Harry Fowells in 1946,
- In 1947 extensive measures were taken to control the reproduction weevil by aerial spray with DDT, and
- The Eldorado used 2-4-D to control mountain misery (bear clover) in 1947 as a site preparation measure.

In 1943, plantation release work on 2,398 acres by chopping out brush around the trees on older plantations.

Probably the most significant event to take place was the survey of planting made by Harry Fowells and Duncan Dunning in 1946. The results of this survey were detailed in an unpublished report dated June 1948, *A Survey of National Forest Planting in California since 1930.* The summary of the report showed the results of their examination of plantations in the Sierra, Stanislaus, Eldorado, Tahoe, Plumas, Lassen, Shasta and Modoc

National Forests in part.

1. Between 1930 and 1945, 23,000 acres were planted with 10.4 million trees and 4,700 acres were seeded. Direct costs were $342,000. Indirect costs and research doubtless increased expenditures to more than $400,000.
2. Of the total acreage planted and seeded, 12,300 acres of planting and 1200 acres of seeding were rated as satisfactory on the basis of 40 percent survival at the end of three years.
3. The 1946 survey shows that only about 7,000 acres (or 30 percent) of the total areas planted still has survival of 40 percent. About 58 percent of the acreage, rated satisfactory at three years would be rated as unsatisfactory by the same criterion in 1946. Of the total planted area, only 6,000 acres still have living trees at the rate of 200 or more per acre and only 1,350 acres have 300 or more.
4. Expressed in the more realistic terms of trees in condition to grow to crop size, only 2,950 acres (13 percent) of the total planted will have 300-500 trees per acre.
5. Direct seeding has been very unsuccessful. Seeding failed on over half the acreage in the first three years. Results of seeding on the 1,200 acres previously reported satisfactory are obscured by natural reproduction.
6. Competition has not been adequately controlled. In spite of expensive clearing, in the stripped brush plantations, nearly 80 percent of the area is dominated by brush. Freedom from competition in the small openings making up the remaining 20 percent is questionable.
7. Animal and insect damage were excessive. In some plantations 70 to 100 percent of the trees were damaged by rabbits or deer. Other plantations were destroyed or badly depleted by the reproduction weevil.
8. On the whole the 16-year planting program made little progress toward reclaiming the extensive deforested area or in developing successful new methods.

A number of recommendations were included, as were 12 items considered to be important needs for research to take action on as soon as possible.

In spite of the closing down of CCC camps, and short labor and funds for planting, the Region did plant 12,112 acres and seeded an additional 1,342 acres during the decade of 1940's.

At Last - Success 1950-1959

Planting operations in the decade of the 1950's opened on a note of progress. The year 1950 saw the first planting-machine work in the Region and the first planting contract. Both of these operations were conducted on the Shasta. About 150,000 trees were planted with a Lowther planter on the Sheepwell burn and some on the McCloud Flat area. Ten acres were planted under a small contract to an experienced contractor from the State of Washington also in the McCloud Flat area.

Mt. Shasta Nursery. Began operation in 1949 and was closed in 1970. Up until 1960 this nursery turned out 1-1 transplants, and then the the nursery production became all 2-0 seedlings.

In 1951, another promising move was made to overcome stock storage problems at Mt. Shasta. A 14.9-acre tract, 2 miles west of Oakdale, was leased for the year with an option to lease the next year. The level tract was within the Oakdale Sand soil series, was supplied with irrigation water, and was close to a good labor supply.

One of the problems of field planting in the Region had been that when planting operations should be in progress in the spring, trees were still under snow in the transplant beds at the Mt. Shasta Nursery. To avoid the long period of storage (over winter) inherent in this situation and to have fresh lifted planting stack available when needed for planting the Wrights Creek Burn on the Stanislaus Forest, it was decided to locate a transplant nursery nearer this burn, on a trial basis, in the Central Valley farm land section of California. It was also thought that the longer growing season in this locality might result in the development of sturdier stock. Furthermore, this additional transplant space would provide opportunity to transplant trees for which there was no space at Mt. Shasta, thus enabling the Region to keep its nursery production goal near the 5,000 M mark. 2,271M 1-0 and 2-0 seedlings from the Mt. Shasta Nursery were transplanted in the late Winter and early Spring, 1951.

The transplants raised at Oakdale the first year were of very sturdy development and showed good survival in the field. The few seed beds that were tested, indicated it was possible to raise good seedlings there also. The outlook at Oakdale was so good that it was

planned that planting stock would be raised for central California forests in addition to providing stock to the Stanislaus for planting on the Wrights Creek Burn.

A total of 6,776 acres were planted on 15 Forests with 4,283 M trees during Fiscal Year 1952, a record year up to that time. All of this planting, with the exception of 4 acres, was done during the early and late Spring of 1952. Ninety percent of the planting was done with K-V funds. Planting efforts were primarily concentrated on treatment of three large burns in timber types, which had considerable K-V funds accumulated from timber salvage operations.

A limited amount of re-enforcement planting was done on timber sale areas. Principal species planted were ponderosa and Jeffrey pine. Nine percent of the planting stock was 2-1, 12 percent was 2-0, and the remaining 79 percent 1-1. Preliminary reports indicated that as has been true in the past on comparable sites, the 1-1 stock showed the best survival. The large burns planted in Spring, 1952, were on the Modoc, Plumas, and Stanislaus Forests, and accounted for over 5,000 acres of the planting effort. Planting success was improving, and this was particularly noticeable where Oakdale planting stock was used.

Planting on these burns continued until the K-V funds were exhausted. This burn planting was not the end. 1955 was another large timber fire year on National Forest land. The two large ones were the Magee Burn on the Sequoia and the Haystack on the Klamath. In total about 200,000 acres of forestland burned and a considerable portion of this was National Forest. Not all of the burned area would need planting but burned acreage continued to accumulate faster than reforestation work could keep up.

Timber sales in the Coast Range Douglas-fir started in a big way in the early 1950's. It wasn't long until clearcutting in blocks was the usual pattern. Early thinking was that these cut-over blocks would reseed naturally. This was not the case, however, and they soon became brushy areas with very sparse conifer regeneration. Volume cut on California National Forests increased from 409 million board feet in 1950 to 1,056 million board feet in 1956. Most of the increase was due to new areas being opened up for timber sales in the Coast Range Forests, primarily the Trinity, Six Rivers and Klamath.

For the first time Douglas-fir planting stock would be needed in large quantities to reforest the Douglas-fir timber sale areas. Arrangements were made with the State to grow Douglas-fir planting stock at their Parlin Fork Nursery near Fort Bragg. Attempts made to grow Douglas-fir at Mt. Shasta had been entirely unsuccessful for various reasons with high mortality in seed beds due to frost. The State nursery at Magalia was growing pine planting stock for the National Forests. The first planting stock grown by the State was for outplantings for 1957 and 1958 and was all the 2-0 age class as they had no facilities for transplanting nursery stock.

During this period of the middle 1950's, there was a growing concern among foresters on National Forests, and in the Regional Office, that planting was still not entirely successful. Wildfires were denuding high-quality forestlands at a rapid pace and the brushfield conversion program had stalled because of lack of appropriated funds with

which to do the work. If we were to continue clear-cutting in Douglas-fir, which was by far the best silvicultural practice for the old-growth even-aged stands, it must be followed with a quick and positive method of reforestation.

There were a few indications that things concerned with reforestation and silviculture in general would improve. Congress was beginning to recognize that increases in allowable cut depended upon getting denuded lands stocked with trees, precommercial thinning of young stands was needed to increase growth of useable wood, genetics of forest trees could be applied to increase growth of forest trees and that fertilizers could be applied to certain forest stands to stimulate faster growth. For Fiscal Year 1957, the Forest Service appropriation for reforestation and timber stand improvement was increased $620,000 over the previous year and Region 5's allotment was increased by $55,200 (63 percent) over the previous year. Instructions in the W.O. letter allocating the planting funds said, "We should look forward to an accelerated program on non-sale areas to be financed with appropriated funds."

Pilot Creek Plantation - Eldorado, ~~Photo~~
Planted spring 1957, Photo 1959
The first large area of full site preparation prior to planting

Plantations on the Eldorado, Lassen, and Sierra, showing excellent survival and growth on plantations, had been entirely cleared of competing vegetation for all species including sugar pine. This full site preparation, with piling or windowing of brush, was started on the Eldorado for test plantations in 1949 by John Buck and George Ramstad. Ranger A1 Mullin used the technique near Lake Almanor in 1954, as did Ranger Myron Horn in the Central Camp area of the Sierra. By 1956, all of the Eldorado plantations were on a full site preparation basis.

Regional Forester, Charles Connaughton, assists with planting on the 100,000th acre on the Georgetown Ranger District, Eldorado National Forest.

Ranger Spargo on the Stanislaus had some good survival on bear clover sprayed with 2,4-D in 1952. By 1956, seven National Forests were making major attempts at developing techniques to overcome the effect of brush or low vegetation on timber sites. Where this was done with bulldozer blades or rakes, and the area was completely cleaned, survival and growth vastly exceeded anything heretofore accomplished on planting sites.

1956 also saw extensive use made of contract planting on five of the Forests, and this technique really bloomed in 1957 reforestation work on the Magee Burn (Sequoia) and Haystack Burn (Klamath). Unfortunately, the planting was done without site preparation and losses were eventually very high even if the trees survived the first year. Contracting of planting work proved to be worthy of further testing. The Annual Report for FY 1957 states:

> "Some reduction in planting costs was possible on the Klamath and Sequoia by use of contractors. Several contractors who had been successful in Region 6 were particularly helpful on the Klamath. Without these contractors it is doubtful if the 2,800 acres planted by the Klamath could have been accomplished. The contractors were able to import experienced labor which the Forest would have been unable to hire."

"Penny Pines" plantation, San Gorgonio Ranger District, San Bernardino National Forest. Funds are deposited by individuals and organizations into a cooperative work fund for reforestation on National Forests. Much of this work was done in southern California.

Bernie Payne, then Chief of the Division of Timber Management, decided to reorganize the silviculture work in the Division and put John Buck in charge of reforestation and timber stand improvement in February, 1957. For several years Jim Averell had been in charge of a Division Branch that included reforestation, stand improvement, timber management planning, and some pest control activities. A new Branch of Pest Control had been formed and Averell moved into this group. C.W. "Doc" Corsan had been in charge of reforestation and stand improvement but would retire in June 1957.

By March, 1957, plans were made to construct and activate a pine tree nursery near Placerville on a l0-acre tract owned by the Forest Service Institute of-Forest Genetics. It was to be the first, warm climate permanent nursery in R-5. The first sowing was for ponderosa pine, Jeffrey pine and some sugar pine. All of the pine was to be grown as 1-0. In addition to the pine, some 1-0 and 2-0 Douglas-fir would be grown and tested. Sowing was to begin the Spring of 1958. Up to that time there had been only limited experience in the use of 1-0 pine planting stock in the Region on which to base the decision of growing 1-0 stock at Placerville. Those making the decision felt it was a good gamble based on what had happened in the past including some experience by the Genetics Research Group.

Another gamble was taken on the use of Oakdale for one more year because there was need for additional planting stock for Spring, 1958. All trees at this nursery site had been harvested and there was a need for about 2,000 M ponderosa and Jeffrey in addition to what was available at the Mt. Shasta Nursery. Here again, the decision was to grow 1-0. The trees were grown in the nursery at a low density of 15-20 seedlings per square foot.

The growing season was about 6 months, and the trees grew in one year to an average size probably greater than the 1-1 (2-year transplants) stock grown at Mt. Shasta. At lifting time, the entire tree was removed without root pruning. Root lengths were about l0 inches. Survival and growth of these trees in the field was far superior to anything experienced previously. Some of these plantings had 100 percent survival and a minimum of 6 inches of new height growth the first year, which had never happened before. One rather elaborate test of planting methods on the Stanislaus using Oakdale stock proved to be a failure, because all tests showed l00 percent survival. The test simply proved that if these 1-0 trees were planted, they would survive. After this planting there was no doubt that 1-0 planting stock to be grown at Placerville would be successful. The Oakdale Nursery was closed and future nursery work to provide trees for central California and Southern California would be centered at the Placerville Nursery.

Site Preparation

During the summer of 1957, John Buck spent considerable time in the field looking at the results of older planting work, as well as the recent work. He had many contacts with regeneration research people and studied their results. At that time, Douglas F. Roy (Pacific Southwest Research Station … PSW) was responsible for Douglas-fir regeneration research and Gilbert H. Schubert (also PSW) was working on the mixed conifer and ponderosa pine regeneration problems. The conclusions reached as a result of these many trips were centered on a few facts that were observed in most cases where successful natural or planted regeneration occurred.

1. Established vegetation, either annual or perennial, fully utilizes the available soil moisture during each growing season on most California soils.
2. The wilting point on many sites is reached long (several months) before the soil is recharged with moisture by fall rains.
3. The infrequent summer thunder showers usually are inadequate to increase effective soil moisture.
4. Establishment of abundant natural tree seedlings on fresh burns, road-fill slopes, cut-banks, landings, skid trails, and borrow pits were common.
5. On plantations, planted trees were established in cleared or disturbed spots free of vegetation with full sunlight, and were growing rapidly. However, elsewhere on the same sites, survival was poor and those few tree seedlings still remaining were suppressed and sickly appearing.
6. On the older brushfield stripped areas of the 1930's and 1940's, the occasional surviving trees showed signs of heavy suppression. Growth was nearly normal for those trees beside a road, fire line, or other cleared area. At one Mt. Shasta brush-field site, a double-stripping treatment had been done, and there was a fair stand of young trees. Also, at the Mt. Shasta brushfield, and again at Big Springs, there were a couple of acres of experimental plantings, in completely cleared areas, which showed good survival and nearly normal growth rates.
7. Animal damage to planted trees appeared to be less in cleared areas and was usually excessive in brushy areas.

8. The best planting stock was of large size and had developed a few secondary needles in the nursery.
9. Experimental tests had shown that 2-0 planting stock, grown at low densities in the Mt. Shasta Nursery, out-performed 1-1 planting stock in the field.
10. In every case where planting had been done in the small, cleared sites up to this time (1957), there was good survival and normal growth rates.
11. Trees planted on most fresh burns, where seedling brush plants, brush sprouts, or grasses, were present at the time of planting, showed poor survival, with many tree seedlings dead the first few months following planting.
12. On sites I and II where *Ceanothus* sp. brush plants were present, somewhat better tree seedling survival and good growth was evident, compared to results from poorer sites, and on those sites of equal quality where manzanitas were the dominant brush plants. This observation held true whether the disturbance was by stripping or wildfire.

The results of these observations were the basis of a 1959 illustrated paper by Buck, *Site Preparation for Forest Regeneration in California*, published by the Regional Office.

During 1958, the techniques of full site preparation were developed on large-scale operations on the Eldorado, Stanislaus, Sierra, and Lassen National Forests. Two week-long field training meetings were held, one in the pine region and one in the Douglas-fir regions. By 1959, most Forests had projects of full site preparation underway, and planning machines were in use on several of these projects. Over 2,000 acres of brushfields were planted in 1958, and nearly 4,000 acres in 1959, all with full site preparation. The same technique was also being used on current burn plantations by the end of 1959. During 1959, over 9,000 acres were planted, which far exceeded any other year up to that time. Not only was it the largest amount of work, but the most successful. The decade of the 1950's ended with the first really successful planting work ever done in Region 5 on a large-scale basis.

Brush rake used for site preparation

Rangeland plow used for site preparation, Goosenest
Ranger District, Klamath National Forest, 1965.

Reforestation in 1960-1969

During the three-year period of 1959-1961, the Region was again ravished with a rash of timber fires, which were by far the worst in modern times. Over 160,000 acres of federal commercial forest land were swept by fires. Ponderosa pine and mixed conifer forests of the southern Cascade and Sierra were the hardest hit. The greatest losses were on the Tahoe (75,000 acres), Shasta-Trinity (23,000 acres), Eldorado (17,000 acres), and Plumas (10,000 acres). All of these lands were salvage-logged and approximately 60,000 acres were left unstocked, and in need of reforestation. Most of the needed work was completed between 1960 and 1963. Funds collected from the sales of the fire-killed timber under the Knutson-Vandenberg Act financed the reforestation, and other burn rehabilitation work was financed from appropriated funds from Congress.

Fortunately, the Region had by this time accumulated the knowledge and planting practices to successfully cope with the situation. Most of these scorched lands now support excellent stands of young-growth instead of brushfields that were so common throughout the State because of past fire history. Some of the largest and most spectacular plantations on these burns are as follows:

Eldorado National Forest – Camp 7 and Ice House
Plumas National Forest – Twain and Mosquito
Shasta-Trinity National Forests – Lava, Jones, and Trinity Center
Stanislaus National Forest – Flora

Terraces for erosion control and planting of the Donner Burn, 1961.

In 1960, the Mt. Shasta Nursery shifted from 1-1 transplants to 2-0 seedlings, and severe root pruning, so common in the past, was discontinued. The result was much more vigorous planting stock that performed well when outplanted. Seed bed densities were reduced from as high as 120 to an average of 15 to 20 trees per square foot. The Placerville Nursery was enlarged to 30 acres by purchase of an additional 20 acres (Spencer Tract) and became a 50-acre nursery by purchase of another adjacent tract of 20 acres (Winkleman).

Placerville Nursery office, 1964.

In 1961 a tract of 46 acres was leased at McKinleyville (near Eureka) for a warm climate Douglas-fir nursery. Henry Doll, formerly assistant nurseryman at Mt. Shasta, was in charge. The first trees from the Humboldt Nursery were shipped to the field in 1963, and the planting stock was an immediate success in field performance. In 1964 the Forest Service purchased 130 acres that included the original leased land and has developed most of the area for nursery seedbeds and seed orchards.

Two-year-old Douglas-fir seedlings, Humboldt Nursery, 1972.

With the development of the Humboldt Nursery the Region was in a position to handle the reforestation needs of all National Forests in California, and the Siskiyou, Siuslaw, and Umpqua in southwestern Oregon. Both the Humboldt and Placerville Nurseries continued to expand production and the Mt. Shasta Nursery started to "phase out" in 1969 and was closed in 1970.

Reforestation work for the decade 1960-1969 began at a level of 14,000 acres, and continued to expand to 38,000 acres in 1968, and dropped back to about 30,000 acres annually, where it now remains (1973).

The use of planting machines expanded materially. Most Forests were using planting machines and soil augers expensively on "force account" jobs and later contracted for use of machines. Contracting of planting and land clearing expanded to where 75 percent of all planting work and 90 percent of the land clearing was done by machines. Early in the 1960's the Branch of Silviculture was developing contract clauses and procedures and issued the first contract administration handbook about 1963. This was revised later and reissued as a Regional Forest Service Handbook in 1966, which contains instructions for most all timber management activities currently handled under service contracts. The use of planting machines was short-lived, and now (1973) most of the work is done by hand planting. Hand planning proved to be just as cheap and as good as when done by

machines. The contractors never developed a labor force adapted to machine use; they prefer to use hand labor.

Demonstration of a Whitfield Planter by Bill Peterson, Plumas Forest Supervisor, at a National Equipment Development meeting, Placerville, 1959.

Planting holes dug by a Little Beaver posthole digger

Site preparation techniques were rapidly expanded from the exclusive use of bulldozers on the flatter brushfield slopes to crushing and broadcast burning, and the use of desiccants and burning the steeper slopes. Most all clearcuts in all tree types were broadcast-burned, which is nearly the universal practice in the Douglas-fir type. At the same time the use of 2,4-D as a site preparation measure became common after broadcast burning, primarily in the pine timber types.

Craig A. (Red) Giffen joined the Silviculture staff in 1961, and championed site preparation by burning and started work on developing spray techniques. Mitch Knight replaced Giffen, and under his leadership these techniques blossomed into stand procedures that are still in use, with modifications due to recent restrictions on use of chemicals on wildlands. The use of helicopters for spray work is now a common practice and all done under contract.

Preliminary guidelines for chemical use for site preparation and release were issued in 1963 as a result of tests made by Jay Bentley and Ken Estes, and finalized into a Regional Handbook in 1965, "Use of Herbicides on Timber Plantations", after a three-year program of development and testing.

For pine plantations the number of trees per acre was reduced from 680 to 450. Earlier requirements were set at 8' x 8' spacing, and in 1965 the specifications were changed to 10' x 10', and some more recent plantations have been spaced at 12' x 12' (302 trees per acre). The standard planting density for Douglas-fir remains at 8' x 8'. Other adjustments in planting densities are adjusted to achieve full stocking to allow for the established tree growth on the area.

Other important developments during the 1960-1970 decade had a material effect on planting success.

1. Fumigant use in nursery management. Probably this was the greatest development in many years. It was first tested in 1960-1961, and became operational in 1962. Not only does fumigation control root diseases, but it also helps with weed control. Seedlings grown in fumigated seed beds were in all respects more vigorous and less subject to death after outplanting. In addition, root rot organisms at the nursery are not transferred to field sites to become infection centers in the forest.
2. Nursery operations were managed under the Working Capital Fund, starting in 1961. This method of financing nursery operations and seed banks eliminated many of the confusing and awkward procedures of financing with appropriated funds.
3. Problems with long-term storage of seed were solved by using "deep freeze" procedures. Current seed crops in California conifers varied from no seed one year to bumper crops in another. Good seed years vary from 3-5, on the average, for most species, so large quantities of seed must be stored for use in years between crops. As a minimum, a five-year supply of seed must be available to meet the widely fluctuating reforestation program because of timber harvesting and wildfires. To maintain viability over long periods, the seed must be stored at low moisture content (below 10%) and at low temperatures.
4. Modern tree storage buildings were constructed at Placerville (1964), Humboldt (1966) and at several remote Ranger Districts. Considerable use of commercial storage for fruit and vegetables are used. Planting stock is now fresh-lifted in late Winter and stored for short periods prior to being taken to planting sites. Research had shown that Fall-lifted planting stock, stored overwinter, was nearly dead prior to planting. Stock-lifting at nurseries now is geared to the optimum time for lifting, which is just before root growth begins in late Winter.
5. Success with true fir planting stock grown at the Placerville Nursery. Early in the decade the need for true fir stock was increasing. After several trials to grow this stock at the Mt. Shasta Nursery had very little success, the work was transferred to Placerville in 1965. Although planting results were better, they still are not as successful as for the pines.

Reforestation in the First Four Years of the 1970's

The Regional program continues at about the level of 30 thousand acres annually. Environmental concerns involved with herbicide use for site preparation and release treatments now require a Regional Environmental Impact Statement, which is being developed (as of August, 1973). In the meantime, needed work has been delayed, and substitute, but more costly and less efficient, methods are being used on some acres.

Wildfires continue to plague the timber management program. The August, 1973 fires have consumed some 30 thousand acres.

By 1970, shelterwood cutting in true fir was being used on some timber sales. In September, 1971, cutting methods guidelines for the Region called for shelterwood cutting in stands to create conditions favorable for natural regeneration. The indications are this method will be particularly useful for regenerating old-growth true fir stands that do not have stocked understories. True firs seem to be best adapted to conditions favoring natural regeneration where true firs are the dominant species. The red fir forest (*Abies magnifica*) is regarded as a true climatic climax plant association. White fir (*Abies concolor*) is common – often dominant -- in the higher elevation phases of the mixed conifer forest. Near its upper elevation limits, white fir is often associated with red fir. Over one-third of the growing stock on National Forest lands in California is true fir. Hopefully the present methods to reforest with true fir will be satisfactory to meet the needs of management. Results to date are very promising.

Red fir natural regeneration in a strip clearcut at Yuba Summit, Tahoe National Forest, 1970. Logging and slash disposal about 1962 as part of a PSW snowshed research project.

Direct Seeding

See pages 148-151 for early seeding work. From 1934 through 1942, seeding was done on about 4,400 acres equally divided between brushfield strips and wildfire burns. Seed-spotting was the primary method used, along with poison baits and screens. 1,300 acres of this work was pronounced as satisfactory in 1946, but currently there is little evidence of this work.

Successful seeding was done on the McKenzie Mill Burn of 1936. The seeding was done with CCC crews in 1936-1937 by seed-spotting. Most of this work was burned out by two later wildfires, the Elliott Ranch Fire of 1950 and the Volcano Burn of 1960.

During 1955-1968, 12,685 acres were seeded on various National Forests in both the pine and Douglas-fir timber types. Endrin was used as a seed coating to repel rodents and strychnine bait was broadcast over the area reduce rodent populations. Aerial seeding was done on some Douglas-fir clearcut areas. In pine types the seed-spotting method continued to be the best. However, only partial success could be claimed. Likewise, attempts to use drill seeding on prepared sites have shown partial success. Some of the successful areas of these latest seeding efforts are:

1. Bluff Creek clearcuts, Six Rivers National Forest, by aerial baiting and seeding.
2. Manzanita Chute, Lassen, with seed spots and drilling.
3. Fingerboard, Plumas, by drilling.
4. Edison Creek and Pilgrim Creek, Shasta-Trinity, by drilling.
5. Cold Creek, Tahoe, by seed- spotting.

It takes about 10 times as much seed per acre for direct seeding than growing trees for planting, so the most efficient use of seed is for production of nursery stock. However, direct seeding has several advantages over planting trees when an adequate seed supply is available. Seeding can be started earlier in the Fall when it is still too dry to plant and before planting stock becomes available. Seeding is adaptable on fresh burns that are too steep, rocky, or impenetrable for planting. Also, areas can be seeding promptly after burns, other land-clearing catastrophes, or on fresh clearcuts. Total seed costs generally are less than one-half planting costs. Lastly, many problems associated with nursery operations and tree planting are avoided.

Direct seeding does have a place in reforestation. Under California conditions it is a gamble but is sometimes worth trying in years of large fires when planting stock is not available for the denuded acres. Normally on large timber burns, salvage logging and site preparation take at least one year, so planting stock can be ready when needed. Tree planting is considered to be the best method of reforestation and seeding is done only to supplement the planting work under special conditions.

Seed Collection

Most reports of early plantings on conifers mention using "native" seed. Usually this seed was collected locally. No thought was mentioned of the importance of seed origin in relation to the planting sites. T. P. Lukens used seed he collected from knobcone pine in the San Bernardino Mountains in the first reforestation work in November 1901. Early southern California nursery reports indicate that the native conifer seed used was local. Show (1930) reported that seeds of native species were used in the direct seeding projects (1910-1911). Since ponderosa and Jeffrey pines were the main species used, the term "native" may have had no particular significance as to the geographic source other than seeds typically were collected near the base of operations. Often seed used in the pine types were predicated on availability, rather than seed source.

Recognition of the importance of seed source in the United States was demonstrated in 1939, when the U. S. Department of Agriculture adopted a forest tree seed policy. This policy, as stated in the "Woody Plant Seed Manual", covers seed use, verification, records, geographic limits, provenance tests, establishment of seed zones, and a request to accept and adhere to the seed policy. Region 5 follows this policy.

Beating Jeffrey pine cones to remove seed
Keene Camp Ranger Sta. about 1905. Cleveland N.F.

In 1946 the forested area of the State was divided into 13 forest tree seed zones by Harry Fowells. The two main purposes of these seed collection zones were: (1) to insure that planting stock grown from any specific seed lot was planted in the area with an environment similar to that from which the seeds had been collected, and (2) to simplify record keeping by grouping many of the seed lots which had been kept separate by individual collections. The 13 seed collection zones established by Fowells were based on a vegetation map of the State and the composition of conifer species, site quality, and latitude. In 1955, the limits of the northern seed zones were extended to similar conditions in southern Oregon by Douglas Roy.

The original 13 seed zones exceeded the limitations of 100 miles latitude and 1,000-foot elevation set in the forest seed policy. Present knowledge of geographic variation in ponderosa pine and Douglas-fir, two of the major species, indicated that the 13 seed zones should be subdivided into smaller units. Nursery studies supported this conclusion. In 1969 the Tree Improvement Committee of the Northern California Section of the Society of American Foresters developed a new seed zone map, and zone numbering system, published and put into use in 1970. The Committee members were: John Buck, Chair, Ronald Adams, Jerrold Cone, Tom Conkle, William Libby, and collaborators Jay Edan and Mitch Knight. The State was divided into six physiographic and climatic regions, 32 subregions, and 85 seed collection zones. Seed collection zones were limited to about 50 miles latitude. Where possible, boundaries followed natural features such as crests of mountain ranges, ridge tops and rivers, or physical features such as highways, canals and railroads. Zones are numbered in three digits so that seed collection information may be handled by electronic data processing.

Up to about the time the Deer Fir Nursery closed (1949), seed collection was programmed by the nurseryman and collected under his supervision. This was the case when the first nursery started in 1903. Annual seed needs then were small and only a few National Forests had planting programs. Shortly after the Mt. Shasta Nursery started operations (1950), more Forests became active and the total program for the Region greatly increased. The Regional Forester delegated authority for seed collections to the Forest Supervisors based on quotas provided by the Regional Office. The quotas were predicated on maintaining a five-year supply of seed by zone, species and elevation band in accordance with the planned Forest reforestation needs. Currently, all seed stores are maintained and replenished under the Working Capital Fund procedures.

The first seed collection contracts were issued about 1956. Contracts can call for either delivery of green cones or processed seed. Much of the Regional seed is secured through contract procedures negotiated at the Forest level. As of June 30, 1973, the Regional Seed Bank at the Placerville Nursery contains 19,360 pounds of seed valued at $185,000. The seed used for nursery sowing varies between 3,000 ad 5,000 pounds annually. Recent use of seed for direct seeding is very minor.

Cone drying shelter, Placerville Nursery, 1963.

Modern seed cleaning equipment are located at the Placerville Nursery, and since this Nursery was established, all green cones have been shipped there for drying, shaking, cleaning, and storage. No longer is it necessary for each Ranger District to dry and shake cones on the District. Germination tests on all seed lots in storage are also made at the Placerville Nursery facilities. Ruth Dragroo performed this service at the old Mt. Shasta Nursery for about 20 years, and Kathie Jesperson now handles this work at Placerville.

First seed production area, Poison Lake, Bogard Ranger District, Lassen National Forest, 1960.

The Regional Genetics Tree Improvement Program

A tree improvement program was started on a limited basis in the California Region in 1957. The first work was done by Sid Mainwaring and Carl Fowler, who joined the Staff as the first Forest Geneticist in 1958. Technical direction was by John Buck at the Regional level. At first the field activity was all centered at Placerville, recently the work was divided, and John Alden added to the staff at Yreka. The Yreka group directs the program on the northern Forests and the Placerville group the central and southern Forests. Coordination of the Regional program is done by the Branch of Silviculture in the Division of Timber Management.

The early objective was to help solve two vexing problems: the Pine Reproduction Weevil (*Cylindrocopturus eatoni*) which was killing many young pines in plantations, and to develop hybrids of sugar pine that were resistant to White Pine Blister Rust (*Cronartium ribicola*).

During 1938 to 1942, the pine reproduction weevil killed between 70 and 90 percent of the small ponderosa and Jeffrey pines planted in 1932-34 on one brushfield plantation in northeastern California. Since then the weevil made serious inroads into other plantations. Studies conducted at the Institute of Forest Genetics at Placerville indicated that hybrid pines of Coulter x Jeffrey were resistant to weevil attack. There was a need to mass-produce the hybrid seed for planting stock which could be planted where the weevil was known to be active.

As had been envisioned at the start of the project to mass-produce the Jeffrey x Coulter hybrid, large quantities of seed could be quickly produced. Three years after the project began, nearly 50,000 weevil-resistant trees were planted in reforestation projects. About 1963, this project was discontinued when it was discovered that full site preparation in brushfield plantings produced such vigorous trees that they rapidly grew through the susceptible stage for weevil attack, and the pine reproduction weevil was no longer a problem. Small quantities of this hybrid are still grown at the Placerville Nursery for shipment to the southern California Forests where the hybrid vigor, evident in this species cross, is considered to be desirable.

Research had also shown that some eastern white pine intraspecific hybrids showed a high degree of resistance to White Pine Blister Rust. Indications were strong that the same resistance could be found in intraspecific hybrids of sugar pine. Eventually, it might be possible to develop resistant planting stock for Sugar Pine Management Areas. This, of course, would be a long-term project.

Another phase of the early program centered on mass production of the Knobcone x Monterey hybrid. The first conifer orchard to be planted at Badger Hill (Eldorado) was from 27 frost-resistant provenances tested by the Institute of Forest Genetics. With the exception of the first couple of years, these trees have been used to produce this hybrid. This stock is used throughout the Region for screening in recreation sites, soil stabilization,

and other projects where a quick cover is needed. Frost resistance is about median of the two species and its range for use is somewhat limited to lower elevations.

The 1963 Tree Improvement Program Statement. In February, 1963, the Regional Tree Improvement Program was formalized as a joint effort of Region 5 and the Pacific Southwest Forest and Range Experiment Station. The goals of the Program were stated as a four-point plan:

1. "Short-term goals are to improve growth and quality of future stands. To accomplish this for future crops, we must start now by improving our seed sources for planting stock used in forest regeneration. This portion of our program is to be carried out by supplying better geographic and parental sources of seed through the selection and subsequent management of seed production areas.
2. Long range goals are to develop quantities of superior tree seed at favorable prices. This phase of the program will provide species improvement through selection of outstanding individuals, rigorous testing of their ability to transmit these desirable characteristics; finally, the proven superior individuals will be propagated vegetatively in seed orchards.
3. Produce in quantities through tree breeding (controlled-pollination) interspecific hybrids showing insect resistance, disease resistance, improved growth on poor sites, or better stand establishment on moisture deficient and/or shallow soil sites.
4. Produce rust-resistant strains of sugar pine which will withstand infection by white pine blister rust and thus enabling foresters to obtain maximum production of this valuable species at less cost."

By 1963, Fowler and his assistant Leroy Johnson had accomplished:

1. More than 100 white pine blister rust-resistant sugar pine candidates had been catalogued. Archive plots had been established at Badger Hill and at Indian Creek on the Klamath.
2. A start had been made on establishing ponderosa pine and Douglas-fir seed production areas. More than 150 acres were under management at various Forests.
3. A breeding orchard for mass production of two hybrids had been started from seedlings, and some trees were producing seed.
4. Seedlings had been planted to provide root stock for one Douglas-fir seed orchard.

As the work progressed and new knowledge was gained the program evolved in different directions. It always has been a developmental program, and probably always will be. There remain much to be learned, and changes will incorporate this new knowledge. The genetic gains in forest growth will have to be made in gradual steps. The first-generation seed orchards should produce trees with faster growth rates than trees grown from "run of the mill" previous seed collections. Likewise, second-generation orchard seed should increase growth rates over the trees produced from the first-generation orchards.

Some of these program changes were incorporated into the 1969 revised program. More emphasis was placed on superior tree selection, and an all-out effort to establish seed orchards. Lately, the trend is toward a goal of getting some genetic gain into all reforestation projects at an early date.

Current Manual instruction (June, 1973, Amendment 2475) recognize three principal operations: (1) designation of seed collection stands, (2) development and operation of seed production areas, and (3) seed orchards. Regional Foresters are instructed to determine the amounts of seed to be produced under the tree improvement programs, given due consideration to the time required for installation to come into full seed production, the area of deforested land that will have been reforested in the interim, and the effect that expected improvements in silvicultural practices will have on reforesting land under management by natural means rather than planting and seeding. Region 5 has a policy that all reforestation work will be done by improved seed by 1980. The level or degree of improvement has been left open, at least for the time being.

Ponderosa pine at the Forest Hill Seed Orchard
being grafted by Gaylord Parks, 1969

The opportunities for tree improvement appear unlimited for a long time in the future. Progeny tests of existing superior tree selections is just beginning. Once the progeny of these trees have been grown under forest conditions for a number of years, their relative wood-producing efficiencies can be judged and the better selects can be isolated. Breeding work among these better selects can be done to produce higher-quality superior trees than

the average of the original selections. The less-efficient superior trees in the orchards will be rogued, and the proven better superior trees will be introduced into the orchards. Orchards can continue to be upgraded by further breeding and testing. There is also strong indication that all species may be improved for insect and disease resistance, which would also increase growth rates under managed stand conditions, by reducing mortality and loss of growth from parasites, such as dwarf-mistletoe.

In 1974, the Region acquired a site at Chico, 210 acres of excellent agricultural soil. Eventually this will be developed for conifer seed orchards. The land had become surplus to the Department of Agriculture, Agricultural Research Service, and was transferred to the Forest Service in May, 1974.

Results to Date for the Use of Improved Seed. Records of outplantings are not complete. The available records show:

1. Hybrids shipped to the field, 1959-1973: Knobcone x Monterey, 377,423; Jeffrey x Coulter, 274,500; for a total of 651,923 hybrids produced. At 400 trees per acre, this total would plant 1,630 acres.
2. During 1966-1970, 2,287,000 trees were shipped from the Mt. Shasta Nursery, grown from seed collected in Seed Production Areas. At 400 trees per acre, this would plant 5,718 acres. In 1973, 148 million trees were shipped to plant 370 acres.
3. In 1973, 193 million trees were shipped that were grown from superior tree seed collections, primarily Douglas-fir – 483 acres.
4. At present, the nurseries are growing stock from superior seed for 1974 outplanting, 184,000 Douglas-fir and 50,000 ponderosa pine, sufficient to reforest 528 acres. The Regional total planting will then be 8,729 acres reforested with improved stock. This is, of course, a small percentage of all reforestation being done, but it is a start.
5. The seed bank has 893 pounds of seed from seed production areas, and 56,282 hybrid seeds.

Timber Stand Improvement

Early Precommercial Thinning and Pruning. The Annual Stand Improvement Report – 1934 (dated (February 4, 1935) stated:

> "Practical cultural work in second-growth stands in the California Region prior to 1934 was a rather nebulous idea. Small crews from two CCC camps had done some thinning during the 1933 season, but only on an experimental basis. On October 15, 1933, here small crews were started on projects under the direction of the California Forest and Range Experiment Station. Camps were established for two of these, and the third crew worked from their homes. The two camps were closed after six week's work because of weather conditions. The third project was able to continue through the winter due to light snowfall.

> "Early in 1934, the Branch of Forest Management took charge of all stand improvement activities in connection with a much-enlarged program. Up to this time the field men in charge of the projects had only a general outline to go by. Methods and procedures had not been standardized. A much more definite set-up was needed, and conferences between the field men and concerned personnel of the Experiment Station and the Branch of Forest Management led to the issuance of the Handbook, "Instructions and Information Concerning Stand Improvement Work, California Region", dated March 23, 1934."

The precommercial thinning work described here was the removal of excess trees in stands in which most of the trees were below commercial size for sawlogs, less than 12 inches DBH.

A small amount of work was done 1933 to 1935, with almost all of the work done in 1934. During this period, 37,815 acres were treated on 23 projects on seven National Forests. Gross areas (acres) treated by Forest were: Sierra 14,190, Shasta 7,480, Plumas 4,264, Lassen 3,526, Stanislaus 4,540, Eldorado 1,880, and Modoc 1,935. This work was financed from National Recovery Act funds. No stand improvement work was done by CCC crews. The work consisted of precommercial thinning and cleaning, liberation tree cutting, sanitation tree cutting and snag felling. No acreage figures are available for the entire period for cleaning and thinning, but it was about 10,000 acres. All the work was done on acquired cutover lands that dated from 1874 at Soquel on the Sierra National Forest. Most projects were on land that been cutover more than 20 years previously. The files indicated that the 1935 program was expected to be rather large, but apparently funds were not available, and the program was stopped early in the year.

The experience gained by this initial thinning and cleaning work served as a basis to resume the program with K-V funds in 1944. No detailed account of kinds of work done between 1944 and 1950 is available, but a summary of K-V work performed during this period was prepared by J. L. Averell on August 15, 1951, which shows a Regional total of 82,892 acres of TSI work for an average cost of $7.50 and ranging from $3.25 in 1945 to $9.44 in 1950. The files indicate that before 1944, conifer pruning had been considered appropriate for California so that this early K-V work must have included pruning of crop trees. Woodbury had seen pruning being done in Region 3 in 1935 and said:

> "So far we have done no pruning in this Region. I am convinced that it would be a good idea in similar stands (similar to ponderosa pine in Arizona) and I believe we should undertake it this summer."

Mention is also made by Woodbury on December 12, 1938, of a small pruning job, probably the first of its kind, on the Lassen at Westwood Junction.

Unfortunately, no regional summary of TSI work is available for the years between 1936 and 1944. Some work was done and financed from Emergency Work funds available to the Service. Regional accomplishment reporting of TSI was not required until 1951

when this activity was incorporated into the Annual Reforestation and Stand Improvement Report for the Chief's Office. Since then, records of acres treated have been kept for the Region.

The first formal training was conducted by Paul Kevin at Feather River over 11 days, June, 1944. Twenty-three trainees from 12 northern California Forests participated. About half of the participants were District Rangers. others were members of the Forest staffs.

In March, 1945, a K-V Stand Improvement Handbook was issued by the Region. It was a revision of the previous instructions, issued in March, 1934, and covered K-V TSI work. A copy of this 1945 Handbook could not be found in the Regional files.

In August 1945, the Regional Office envisioned a large post-war labor force that could work on TSI projects and ordered 40 dozen Fanno saw blades to be distributed to nine northern Forests. This was done with the expectation that pruning would be an important element of all TSI work. TSI work did expand rapidly beginning in 1947 with pruning acreage far exceeding any other treatment and was so for the next 15 years until 1962, when thinning was given priority over pruning, and a moratorium was placed on pruning.

Demonstration pruning with McCullough power pole pruner, Shasta-Trinity National Forest, 1959.

During 1947-1962, most all selected crop trees were pruned. Usually very little thinning was done in the same area. If done at all, thinning took the form of cutting a few of the competing trees in a narrow circle surrounding the crop tree. It was also common to thin in a stand where mature and over-mature trees in the same stand had been partially cut. This meant that most areas had an overstory consisting of 1/3 to 2/3 of the original volume over 12 inches DBH, depending on the type of marking used. With the exception of stands on the mixed conifer sites in Site Classes I &II, most of the pruned trees indicated little or no release in growth rate. These higher Site Classes are most uncommon in the ponderosa pine type, which usually are in Site Classes III, IV, and V, and it was in this timber type that most of the TSI work was done.

The primary reason for calling a halt to the extensive pruning program in 1962 was to put emphasis on the much more important program of thinning in young stands. Funds were limited. It was granted that some surface clear lumber would always be needed, but technological progress in laminating, plywood, and gluing had been made to overcome much of the decline in quality (caused by knots, pitch seams and other blemishes) of lumber cut from young-growth stands. Plywood, particle board, and plasterboard had replaced wood paneling and siding in dwellings and other wooden buildings. Metal window sash was almost universal, and most doors were plywood. The facts were that the growth rates for usable materials in young stands on the National Forests were far below the capacity of the lands. Control of stocking levels became paramount, to achieve higher levels of wood production to meet the needs of a growing population dependent on wood for housing. Pruning of trees to raise lumber quality became low priority, when it was recognized that a high yield of usable wood was much more important to the needs of the people.

All the early cleaning and thinning work done in the Region was very conservative. The earliest work, 1933-1935, was planned that a return-thinning job would be done in 15 years. Later inspections of this early work, even on good sites, showed a very low level of increased growth response in the leave trees. On sites with mixed species, pine was favored, and these thinnings did result in a higher proportion of pine trees in the understory.

Thinning Guidelines. Published guidelines (1957) for thinning were in Chapter II, Silvicultural Practice, Timber Management Handbook. The leave spacing guidelines were:

> "Dense stands of reproduction should have the 'crop trees' spaced a distance about equal to the average diameter plus 4, expressed in feet. For example, if the average tree diameter were 5 inches, average leave-tree spacing should be about 5' plus 4', or 9'. Let the spacing vary to select the best-formed trees that qualify as crop trees. All of the trees left will not be in the final harvest cut. But the next thinning is hoped to be a commercial thinning which will not be an expense item."

Under "Purpose and need for thinning", the following statement was:

> "Dense stands of pine reproduction are good sites generally [and the best trees can express] dominance. In such cases, thinning to improve growth is unwarranted. On the other hand, pine stands on poorer sites virtually stagnate. Such stands need thinning. For example, 40-year-old trees of 4 to 5 inches D. B. H. can be changed from slow growth of 15 rings per inch to 8 rings per inch. The purpose of thinning slow-growing pine reproduction is to speed up the growth on individual selected crop trees. It shortens the time when they will reach merchantable size."

Thinning by bulldozer (partial success), Anderson Valley, Groveland Ranger District, Stanislaus National Forest, 1965, four years after the thinning.

As more experience and research became available, wider spacing of reserve crop trees was provided in the thinning rules. Thinning under an overstory is not condoned, and usually is a waste of time and money. Pruning of crop trees is not done, except in special circumstances. Stocking adjustment to achieve maximum potential growth of crop trees is most essential to meet present goals of timber production. Both administration and research thinning plots had shown that growth response to thinning could be gained when a much wider spacing of crop trees was maintained, than under the previous rules. At about the same time that the moratorium was placed on pruning (1962), thinning guidelines emphasized wide spacing, and the cutting of all surplus trees to provide maximum soil moisture to the crop trees. Thinning was done only on those areas where all the overstory had been removed. (Guidelines in tabular form were provided) for various species and site classes to show numbers of crop trees, approximate spacing, and basal area per acre. Only one precommercial thinning should be planned with the record; a later thinning a commercial cut. The levels of stocking remaining at the time of thinning was estimated to provide 80 percent of normal (maximum) stocking at the time of the second entry into the stand for the species, age, and site class.

The results to date indicate that these stocking levels do provide accelerated growth rates, both in height and diameter. Vigor of the released crop trees is very pronounced after thinning. One outstanding example was the suppression of bark beetles in a young stand at

Joseph Creek on the Modoc, through thinning in 1968. A heavy stand of suppressed understory ponderosa pine was being ravaged by an infestation of mountain pine beetle. Hundreds of trees per acre were being attacked and killed. The original stand had 2,000 to 4,000 trees per acre and formed a "dog hair" thicket over much of the area. Thinning to reduce stocking to between 300 and 400 trees per acre was indicated. This was done after a timber sale removed the overstory trees. The bark beetle attacks stopped almost immediately after thinning. This experience not only showed the benefit of thinning to control bark beetles, but at all young stands of trees should be maintained at low levels of stocking to prevent future bark beetle attacks.

Thinned area of Joseph Creek insect control project.

Stocking Guidelines for Small Sawlogs (including the 55 Percent of Normal Guide and "LOGS Plots"). About 1965, work commenced on setting stocking levels for young stands of commercial size, 12" DBH, and sales for these small sawlogs were on the increase. The first formal guides were printed in 1966, and reviewed in 1969 and 1973, to set stocking levels at 55 percent of normal basal area for the species, site, and age class (see following Table *Density of Crop Trees Recommended in 1957, 1965, and 1973 for Ponderosa Pine* – recommendations for 6-inch average DBH reserve trees per acre; basal area values are square feet per acre).

	1957 Guidelines		**1965 Guidelines**		**1973 Guidelines**	
R-5 Site Class	**Number of Trees**	**Basal Area**	**Number of Trees**	**Basal Area**	**Number of Trees**	**Basal Area**
I	-	-	400	77	260	50
II	-	-	400	77	230	45
III	430	85	360	71	200	40
IV	430	85	280	55	170	35

During 1957 to 1973, it had been determined that heavy thinning was necessary to achieve the desired growth response in the reserve stand. Many more trees are now being cut than were thought to be necessary in 1957. For example, in 1957 on Site III in a 6-inch DBH stand, the average reserve stand stocking should be 430 trees per acre, and by 1973 the reserve stocking was reduced to 200 trees per acre. This requirement has added to the slash disposal problem.

At the same time, a system for establishing "Levels of Growing Stock Plots" was developed, consisting of three levels of stocking plots placed side-by-side, which hopefully would bracket the ideal densities to maintain stands of this small sawlog material. Once results of these studies are available, stocking standards for the various species can be adjusted to a more factual-based thinning guide, than the present more-or-less arbitrary 55 percent of normal basal area.

The "Levels of Growing Stock Plot" (LOGS) Program is divided between research and administration. Sawlog stands are being studied on plots developed by administration, and research is developing a number of plots to study the younger age classes and smaller size classes. Bill Oliver of the Redding Research Center heads the program for research, and the various Forests are responsible for the program in small-sawlog-sized stands. The plot design for all plots is according to plans developed for research studies.

The need for maintaining a proper density of trees in small-sawlog stands has been demonstrated recently on the McCloud Flats, Shasta-Trinity National Forests. The western pine beetle has been exceedingly active in many of these young stands and has done extensive damage to the growing stock. A series of salvage sales have been made to utilize merchantable material, and green timber sales were made to reduce stocking in other stands. This infestation, started in 1967 and 1968, was considered to be the most serious ever experienced in California in young sawlog-sized stands. The Miami Creek and Bass Lake areas, on the Sierra National Forest, recently have experienced serious outbreaks of bark beetles. Both of these areas primarily are small-sawlog-sized stands.

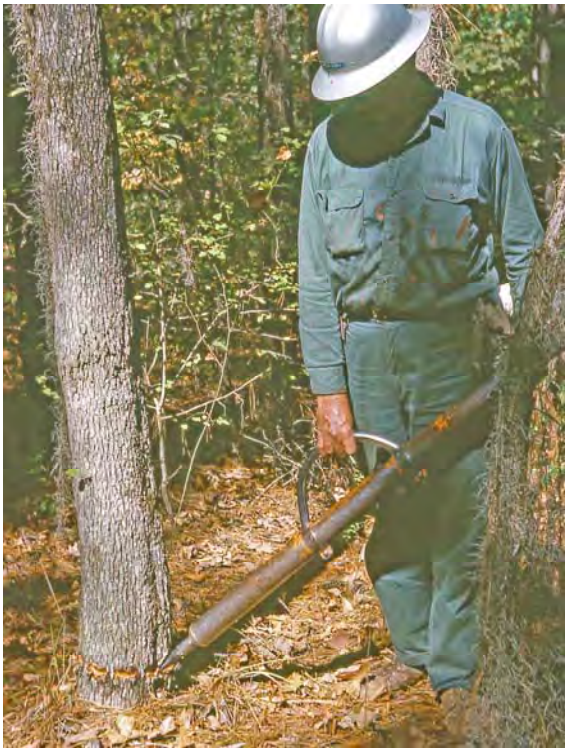
Slash Treatment on Thinning Areas. TSI slash has always been a problem in the Region and has never been handled satisfactorily to all parties both in and outside the Forest Service. Most parties agree that the thinning work should be done by, but seldom all agree on the amount of slash disposal necessary to protect the remaining stand from fire, and to reduce the visual impact to an acceptable level. Within the Forest Service, people working in the various disciplines, primarily fire management, timber management, and recreation management, have had to compromise and accept slash abatement policies that are not always completely ideal from their (respective) viewpoints.

In earlier thinning work (in the 1930's and 1940's), thinning slash was comparatively light because of only a few trees per acre were cut. Generally, Forest Supervisors and others accepted the slash accumulations and lived with them. However, some piling and burning of TSI slash was done, following the same practices in use on timber sale areas at the time. Later, when top-lopping and scattering was the slash disposal method common on timber sales, TSI slash was lopped and scattered. Under this method, the lopping costs

were about 75 percent of the total cost of the TSI operation. To timber management people, this disposal cost was excessive, and they were constantly searching for cheaper methods of slash disposal. Hand labor using axes or brush hooks were used to cut the trees, and hand-operated saw blades on long poles were used to do the pruning.

With the advent of the gasoline chain saw to do the tree cutting and slash lopping, the same proportionate amount of time was spent in lopping slash.

Two innovations for treating TSI slash, or reducing slash on the ground, have been developed and used in recent years. First, chemicals are injected into the tree to kill it. The dead tree remains standing until it rots at the base and falls over. It is left to disintegrate naturally. This method has been criticized because it looks bad for the first few years. The second innovation was the development and use of a crushed compactor, a mechanical device to crush the slash to reduce the slash height above ground and push some of the slash into the soil. This machine is limited to use on level ground and moderate slopes at the present time but is considered to have good potential and deserves additional development.



Thinning hardwoods by 2,4-D injection.

Cleanup of TSI slash along roads was always done, and after tractors became common in woods-work, the fire lane system was used in many places, particularly in eastside Forests. These lanes were also put in TSI project areas. Forty-acre units were surrounded with fire lanes, cleared to mineral soil by bulldozers.

The slash treatment specifications in the Region's 1957 Timber Management Handbook (from Chapter II, Silvicultural Practices) were:

"The smaller-sized trees thinned out are left on the ground with limbs lopped. Along roads, the thinning must be run through a chipper, or piled and burned. Slash on the balance of the area is left lopped. If continuous areas of slash occur without open breaks, then firebreaks may be needed."

During the decade of the 1950's, thinning work averaged 6,000 acres per year, and was scattered in small areas throughout northern California Forests. Thinning was generally

light in character. The added risk for thinning slash was small in most areas. The primary recreation uses of the timbered areas, outside of improved recreation areas, came from hunters and fisherman. Tourists generally stayed on paved roads. Early in the decade of the 1960's, thinning projects more than doubled, and averaged more than 13,000 acres annually. Work areas were larger, and slash on the ground was much more dense, due to much heavier thinning. Recreation use was much heavier, and the chance of a fire-start was much greater. More good surface roads gave people access to all corners of the forested areas. Recreation vehicles (pickups, campers, and four-wheel drive) became very common. Many more people had more time to visit the forest than ever before.

Present slash disposal guidelines (1973) have been developed to deal with the above new problems, and, in addition, the greater concerns for the environment both in the Forest Service and by forest users.

> "Basic slash policy calls for treatment when the slash is rated as having *High* or *Extreme* resistance to control levels. As an example, cutting of approximately 800 or more 3 to 5-inch stems per acre would result in a High resistance to control. Under these conditions, slash will be modified to result in a *Moderate* resistance to control. This will usually be accomplished by mechanically treating the slash, using a crusher compactor."
>
> "When it is not possible to mechanically treat the slash, any or all of the following measures will be taken as necessary to reduce the resistance to control to a Moderate level:
>
> 1. Limb all cut trees.
> 2. Fall stems parallel to achieve better contact with the ground and reduce slash height.
> 3. Do not allow cut stems to remain hung up in standing trees.
> 4. Dispose of all slash along system roads (usually 50 feet on either side).
> 5. Breakup all large slash areas with blocks no larger than 30 acres in size with fire lanes."
>
> "*Resistance to control* is defined as an estimated of units of manpower required to construct and hold a unit of fire line perimeter. Moderate resistance to control is a condition under which one man could construct and hold 1.4 to 2.5 chains of fire line per hour of work."

In 1968, George R. Fahnestock authored Pacific Norwest Research Station paper #57 *Fire hazard from precommercial thinning of ponderosa pine.* He concluded, in part as follows.

> "The conclusion is inescapable that precommercial thinning, to present and prospective standards in ponderosa pine stands of near-normal density, seriously increases fire hazard for at least five years. The years of extra hazard cannot be averaged against the remaining life of the stand, during which the hazard is less than it was before thinning.

Expectation of better times does not reduce present problems, but it may lead to a false sense of security.

"In general, fire occurrence rates and fire losses mount as fuel becomes more hazardous (Barrows 1951). However, such a generalization is not sufficient basis for evaluating the impact of precommercial thinning on the difficulty of fire control.

"It is necessary to learn, as specifically as possible, what changes to expect in fire occurrence rate, fire behavior, cost of control and damages as a result of the presence of the slash. Only when this information is in hand, can an effective fire control system be designed, and optimum division of expenditures be made between thinning and protection. The following brief, but intensive, investigative program should supply the missing answers.

1. Analyze fire experience. Compare fire cause, occurrence rate, final size, suppression cost, damage on areas of undisposed slash with the statistics for uncut areas and logged areas on which the slash was treated. Use mass statistics and case histories as appropriate.
2. Measure hazard experimentally. Develop hypotheses to rate of spread, resistance to control, and intensity of fires, in relation to initial quantity, distribution, and age of slash. Test hypotheses by experimental burning and line building in thinned and unthinned areas. Do experimental burning over a range of fire danger levels, including those high enough that dense reproduction could be expected to crown. Develop relative and, if possible, absolute ratings or measurements of hazard.
3. Inventory the fuel created by precommercial thinning. 'Cruise' slash experimentally before cutting, using the best crown and stem weight information available. Confirm cruise figures and develop adjustment factors by sampling after trees are cut. Measure deterioration by sampling areas thinned 1 to 10 years ago; special photography may be the most efficient method. Map slash distribution in relation to stand characteristics. Calculate areas in the several significant hazard classes.
4. Determine appropriate action. Develop alternative combinations of hazard-area dispersal, slash treatment, and fire control operations. Compare as to costs and benefits, taking into account compatibility with all uses of the forest.

"The suggested investigations should require not more than 2 years. The cost would be only a small fraction of the cost of either a damaging fire in slash or an unjustified program of slash disposal."

If a study of thinning slash were made as he suggests, it undoubtedly would help forest managers develop better standards to cope with the hazard created by TSI slash. Slash disposal guidelines will continue to be based on various individuals' experience and opinions, rather than on factual information, which is needed to make better decisions. The cost of a study does not appear too great; the payoff may be large.