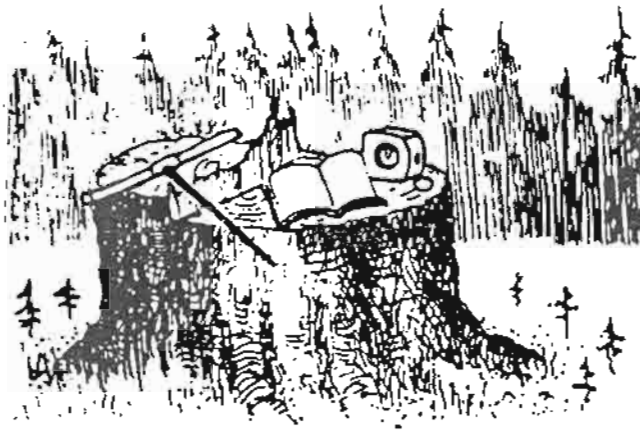

JDSF Newsletter
Jackson Demonstration State Forest
State of California Dept. of Forestry P.O. Box 1185 Fort Bragg, CA. 95437

No. 44 January 1992

Commercial Thinning Prescriptions in Redwood - A Challenge to Conventional Practice.

by Hugh Scanlon 1/

In the redwood region, tree and stand growth is limited by site quality and the amount of light which can penetrate the dense timber stands. Trees can be "released" from the light limitation when competitors are removed or "thinned." Thinning operations are designed to leave the most desirable trees with the best opportunity to grow. The major goals of most thinning operations are to: capture anticipated natural tree mortality, increase stem diameters and value, improve stem quality, and alter stand composition. By thinning, the remaining trees are allowed greater growing space and sunlight than was available when the stand was densely packed. A proper thinning prescription applied to a timber stand can be instrumental in achieving management goals.

Developing the best thinning prescription for a timber stand is an important, and perhaps the most difficult, element in making the decision to thin. The prescription guidelines need to recognize stand complexities and produce a residual stand which will use the site effectively. Equally important, the prescription must be cost-effective and easy to implement. The most common prescriptive guideline used is setting a residual basal area (BA) target for the stand. Basal area is easily measured and is used as a surrogate index for stand density. But a BA target alone does not ensure a quality residual stand. "Forester's bias" is an important factor in determining the residual stand' s ap pearance. Unfortunately, this factor may vary greatly for each timber marker. One stand may be marked to remove trees in groups whi'e another is marked for even spacing. Stands may be marked with more emphasis being given to the quality of the take trees instead of the residual stand. And all of these are possible within the BA target prescription. Here on Jackson Demonstration State Forest (JDSF), researchers have been studying a thinning prescription method and model which uses the concept of "tree growing space" as its basis. Although this study is ongoing, some of the concepts and preliminary results are worth considering.

Growing Space.

In the simplest terms, thinning is an effort to increase the growing space available to the residual trees. This allows the site's growing potential to be captured on fewer, larger trees instead of many small trees. This concept is fundamental to forestry and is hardly revolutionary. However, establishment of growing space - growth rate relationships have been difficult and illusive. Historically, spacing trials have been used by silviculturists to establish these relationships. Unfortunately, the time and investment required to carry out spacing trials make them impractical. Also, self-thinning in dense stands makes determination of tree growth with very small growing spaces virtually impossible. As a result, the complete relationship between growing space and tree and stand growth cannot be established for the full range of growing spaces. Although this may seem trivial, it is exceedingly important. The growing space trees have on one or more sides of their crowns is often very small. We must be able to predict the effect that

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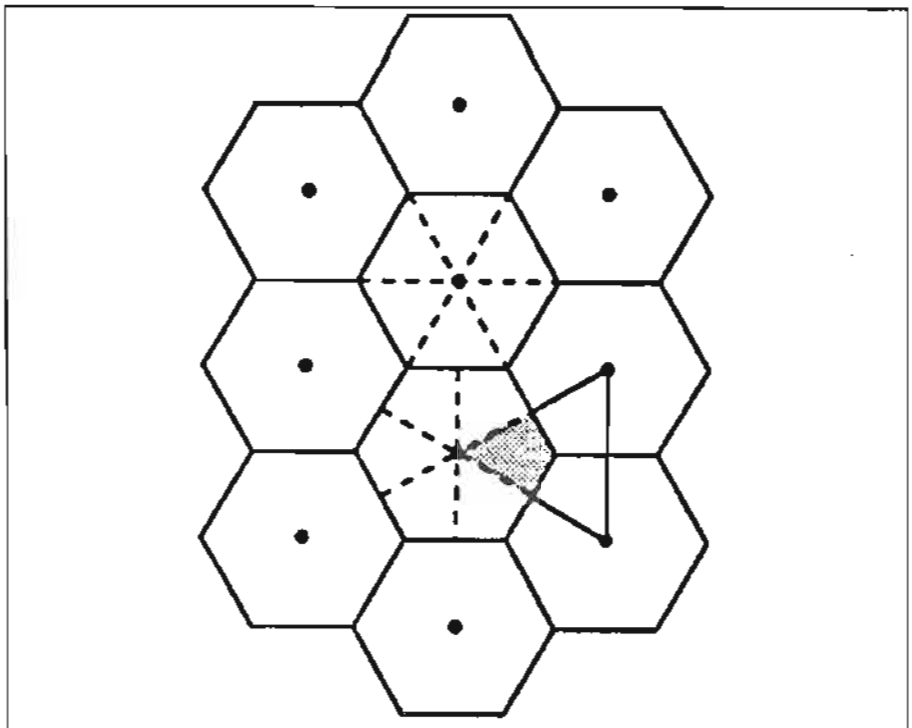

Figure 1. The symmetrical growing spaces of trees when they are all equidistant. They can be viewed as a composite of six equilateral triangles (upper) or six trapeziums (shaded).

these small size growing spaces have on tree and ultimately on stand growth because these small growing spaces are the very ones we want to eliminate by thinning.

Dr. Edward Stone and Dr. Janet Cavallaro have worked to overcome the difficulties inherent in spacing trials by simulating growing space - growth rate relationships for equally spaced trees on the basis of crown wedges with a range of growing spaces. Then, from these relationships they have developed a simulator - GSPACE - to predict how unequally spaced trees with asymmetrical growing spaces will grow.

Their work has built upon ongoing agricultural and botanical research dating back to the late 1940s and early 1950s. Watson (1947,1952) first defined a plant's growth rate to be the product of its leaf surface area (LSA) and its net assimilation rate (i.e. the amount of growth it produces per area of leaf surface). In other words, a plant's growth rate depends on the size and efficiency of its factory. A number of researchers have carried out hundreds of experiments to determine how various environmental variables or cultural practices affect a plant's LSA and its net assimilation rate (NAR). Consequently, a plant's growth rate can be linked to the influence of these environmental variables. Since the mid-1970s, forest ecologists have picked up on various aspects of this work. The most notable work relative to silvicultural practices was Brix (1983) in studying the effect of thinning and fertilization on the LSA and NAR of codominant Douglas-fir growing in British Colombia.

Dr. Stone and Dr. Cavallaro have used these two variables, LSA and NAR, to simulate the relationship between a tree's growing space and its growth rate to determine the growing space 125-150 ft. codominant redwoods require to grow at particular rates. They did this by establishing a relationship between a tree's growing space and its LSA and then multiplying the trees LSA's by their efficiency (NAR) on a particular site (Newsletter #10).

Determining a Tree's Net Assimilation Rate - Net assimilation rates were determined for twenty-three trees and validated by another twelve 125-150 redwoods growing on sites in the Casp Creek Watershed. These sites ranged from a site index of 80-95, 95-110, and 110-125 (Krumland and Wensel, 1977). The sample trees were climbed and limbed. Leaf surface area and volume were measured for each tree and their NAR's were calculated. When analyzed by site class, trees growing on the different sites had significantly different NAR's; the higher sites had higher NAR's.

Establishing the Relationship between Growing Space and LSA - When trees are equidistant, each tree is surrounded by six others and has a symmetrical, hexagonal shaped growing space. This growing space can be viewed as six equilateral triangles each facing one of the adjacent trees or as six trapeziums lying between pairs of adjacent trees (see Figure 1). In reality, such configurations of tree spacing are rare in nature; unequal spacing is the rule. Consequently, the researchers had to simulate the leaf surface area of trees with different size symmetrical growing spaces. This was done by using crown wedges for each tree. These wedges were trapeziums that were defined by two adjacent trees equidistant from the sample tree. LSA was then determined for the foliage which occupied that particular growing space. Different size growing space crown wedges were sampled. The resulting symmetrical growing space to LSA per tree regression produced an excellent predictor equation of this relationship.

Simulating the Relationship between Growing Space and Stand Growth - With the relationship established between a tree's growing space and its LSA, and the NAR's determined for trees on different sites, symmetrical growing space - volume growth rates could be simulated for trees growing on different sites. Growing space - stand volume growth rates for unevenly spaced stands could be simulated in turn by multiplying the growth rate of individual trees with different size growing spaces by the number of trees present per acre. Optimal spacing for maximizing stand growth could now be determined.

The issue becomes more complex by the uneven nature of timber stands. In order to obtain the maximum possible stand growth when trees are unequally spaced, the target spacing for a symmetrical stand must be modified. The symmetrical growing space - growth rate relationship was then incorporated into the GSPACE model to predict the growth of trees with unequal spacing. In essence, their asymmetrical growing space was subdivided into symmetrical portions and the growth expected from each portion was summed (see Figure 2). The use of the GSPACE model resulted in a tree specific thinning prescription which used the current spacing to predict an optimal stem arrangement for maximum growth. It was then used to develop thinning guidelines for a test stand on JDSF.

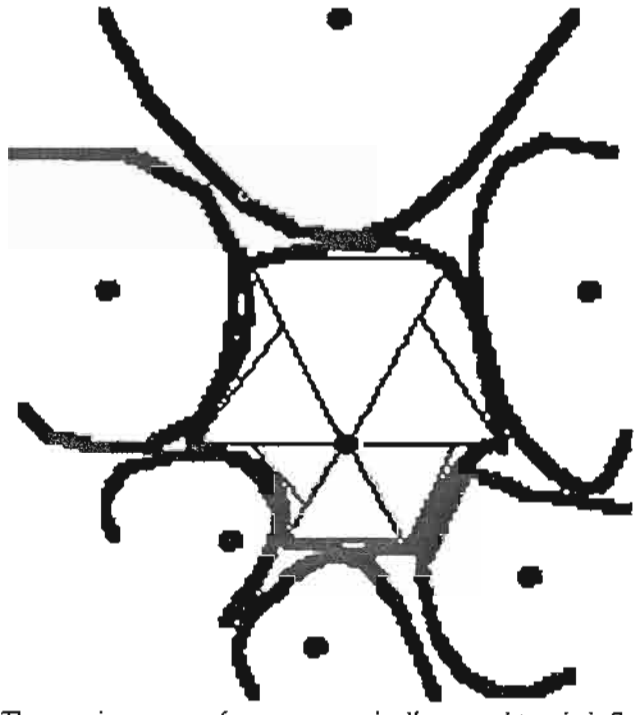

Figure 2. The growing space of an asymmetrically spaced tree is influenced by the proximity of adjacent trees. The sum of the symmetrical triangles can be used to define the tree's growing space.

Triangular Thinning Method

The triangular thinning method was developed as the product of the growing space - stand growth relationship research conducted by Stone and Cavallaro. This method was designed to make it possible to maximize the stand growth potential from any particular distribution of trees in an even-aged stand. By maximizing this potential, the researchers theorized that stand growth may actually be increased as a result of using this method of thinning. This method is currently being tested in the Parlin Creek area on JDSF.

The method was used to thin fourteen 0.2-acre groups of coast redwoods. Another fourteen groups were not cut and serve as controls to determine the effect this method of thinning has on tree and stand growth. The thinning operation was performed in 1987 (refer to the Prescription Description attached). Although growth responses will be monitored into the future (the first remeasurement will be in 1992), an immediate comparison of the expected tree and stand growth responses to thinning was performed using a rudimentary version of the GSPACE model. Although this version of the model could not predict growth in the transitional period from release to full site occupancy, simulations were performed for the time period between fifteen and twenty years after treatment when the trees are expected to be completely released and fully occupy their new growing spaces. The relationships needed for an accurate prediction of growth during this period of release have not yet been determined. The simulation was performed for the time period between fifteen and twenty years after thinning when the trees are expected to be completely released and fully occupying their new growing spaces. The results of this preliminary simulation allowed a comparative analysis of some interesting thinning prescription scenarios.

Prescription Comparison

The data from the simulations were used to compare triangular thinning prescriptions with prescriptions that specified a basal area percentage removal, a target basal area, and with prescriptions generated with the distance independent CRYPTOS model. The analysis of simulated treatments produced some notable comparisons.

Removing a percentage of basal area - Since different percentages of the basal area were harvested from the 0.2-acre groups used in the thinning experiment, the researchers were able to analyze whether or not a relationship existed between the percent of the basal area removed and stand growth. No statistically significant regression could be established. Even when percent basal area removed and site index were run together as independent variables in a multiple regression, the regression coefficient for the percent basal area removed did not differ from zero. Thus, if the goal is to maximize stand growth, a thinning prescription based on removing a percentage of the basal area will not help achieve that goal.

Thinning to a target residual basal area - This is the most common approach to a thinning prescription. Since different residual basal areas were left in the 0.2-acre groups used in the thinning experiment, analysis of the residual basal area to stand growth relationship was possible. A regression was established between residual basal area and stand

Triangular Thinning Prescription Description

The study area is located on JDSF near the South Fork of the Noyo River, east of Parlin Fork Camp. The twenty acre area was composed of redwood interspersed with scattered Douglas-fir, madrone, and tanoak. The area was originally cut around 1920 and the site regenerated naturally. The site quality and stand density was highly variable acrosss the site.

The prescription was based upon the growing space requirements for residual 140 foot codominant redwoods. In general, the stand was marked so that the residual codominant trees would be in the configuration of lines and triangles; the residual trees needed to have good form and be vigorous codominants; and a poorer crown class tree (e.g., an intermediate) could not be used to justify the removal of a codominant. These rules are for marking the trees to be removed. The specific rules are as follows:

1.Mark any trees, regardless of crown class, along lines that have codominant end trees 27' apart.

2.Mark tree(s) on lines that are within 4' of the codominant end trees if the end trees are 27' and 35' apart.

3.Mark trees inside trangles with three sides 27'. Try specifically for traingles with sides between 19' and 27'.

4.Mark all trees inside traingles which have two sides 27' and one 27' except for trees that are (a) within 4' of the long side and (b) not within 4' of the codominant trees on the ends of the long side.

5.Mark all trees that are deflected 2' from a line 27'.

6.Mark all trees that are deflected 3' from a line 15'.

7.Mark trees forming a triangle with two or three sides 16' if a larger triangle with sides 41' can be made to include them.

The study site is available for tours by contacting Norm Henry at JDSF.

growth. However, a regression between site index and stand growth was considerably stronger. The residual basal area / stand growth relationship was believed to be a result of the correlation between site index and residual basal area. Thus, a residual basal area target also failed to provide a statistically sound basis for achieving a maximum stand growth goal.

CRYPTOS model treatment - For this exercise, the CRYPTOS model projected that the best treatment to maximize stand growth was no thinning. Both models had similar predictions of growth in the unthinned stands and were highly correlated. However, the GSPACE model predicted dramatically higher stand growth than did CRYPTOS for the groups thinned according to the triangular thinning guidelines. The researchers suggest that the CRYPTOS model's performance suffers in this application due to its lack of a database for thinned stands. Which simulator gives the more accurate estimate will be determined, in part, as a result of this research.

Conclusion

It is quite possible that triangular thinning prescriptions based on the growing space / growth rate relationships would be far superior to prescriptions based on the percent of basal area removed or the residual basal area. Prescriptions developed from a distance independent stand simulator such as CRYPTOS may also be suspect. With basal area based prescriptions, the stand and tree growth rates are not strongly related to the factors being modified in the thinning. This research has found a strong correlation between growing space and growth rate. The triangular thinning method provides an easy mechanism for taking advantage of this relationship.

What has begun as sound in theory must be further examined in practice. Future measurement of the test stand is scheduled. Specifics on this research project are in preparation by Stone and Cavallaro for future publication. We will keep you informed as to any additional information and publications on this project when it becomes available. The gauntlet has been thrown, the challenge to the conventional use of basal area as a thinning tool has been issued.

Both researchers are located in the Department of Forestry and Resource Management, 145 Mulford Hall, University of California, Berkeley, CA 94720. This article is the synthesis of Dr. Cavallaro's dissertation and several unpublished study reports submitted to JDSF by the researchers.

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TANOAK YARDING USING BELGIAN DRAFT HORSES IN FOURTEEN GULCH

by Norm Henry 1/

The Jackson State Forest is the most recent state forest to have some experience with horse logging. Last summer's project involved using horses for skidding logs on a commercial firewood sale. Latour State Forest, east of Redding, used draft horses for skidding logs on a commercial thinning timber sale (McNamara and Kaufman 1985). The same breed of draft horse was used there as was used on our operation.

Figure 1. Draft horse provides power for yarding tanoak.

Our project started because of several parties interest in removing standing dead hardwoods for firewood on an area just east of Parlin Fork in the Little North Fork of Big River drainage. We received an interesting proposal from one person who had two registered Belgian draft horses. Dale Bennet of Fort Bragg owned two mares and wanted to use them for logging the tanoak for firewood material to be sold commercially. He approached Forest Tilley, State Forest Manager with the idea of using them in this area. We had wanted to try horse logging as a demonstrational project for a number of years so we readily agreed with the concept. A class one sale permit was issued along with an approved exemption for removal of the hardwood component using horses.

The area which was opened for Dale was adjacent to a timber sale area harvested in 1988. The Fourteen Gulch timber sale consisted of twenty- eight small clearcut units averaging six acres each which were harvested as one of the three major timber sales for that year. After the sale, twenty acres near several of the cut units were selected for a pre- harvest conifer release treatment. The hardwoods were treated with a frill-herbicide application using Garlon 3A (triclopyr amine). This resulted in a standing volume of dead or partially dead hardwood trees.

Dale proposed to fell, buck and limb the treated standing hardwood stems and yard them to the roadside using his draft horses. At the roadside landing he planned to rebuck to a length which could be loaded by hand onto his trailer. Since the wood was already seasoned he could immediately sell the tanoak at current prices for cured hardwood firewood.

His mares are sisters who were born and bred at the Milkwood Farms in Vermont. They are named Elizabeth, who is nine years old and Jessica, who is eight. They weigh in respectively at 2040 and 2080 pounds. Elizabeth was definitely the more sedate of the two as was quickly noted when I came out at during the start of the project. Dale and Pedro, his Peruvian helper, had put a singletree harness on each horse. The horses were trained to pull on command and go back and forth between the loading and unloading points. Just below the loading point was a road gate and where Elizabeth would walk back down, Jessica would come running back from the trailer on the return trip. One return trip she couldn't stop at the gate and ended up half jumping over it, falling onto her side on the far side of the gate. Fortunately, she sustained no injuries except for some bruising. Dale did not work her again until she recovered. Similarly, Jessica would continue to try pulling a log for a short while even when she couldn't because of the slope or log size whereas Elizabeth would quickly give up pulling. The log would then have to be rebucked to a shorter length and they would try again.

The estimated 3-4 acres Dale completed during the summer period was predominately on ridgetop flats or on slopes less than 10 percent. A few localized areas had up to 30 percent slopes and those were all downhill yarded. A similar area on the opposite slope where we had used a small zig-zag cable yarding system (Henry, 1990) to harvest hardwood for firewood the previous year we estimated had up to thirty cords of tanoak per acre. Dale calculated that he had removed 70 cords of tanoak from the area he worked and estimated his production at four cords per week. It was understood from the outset that he did not have much experience doing this with his horses and they were not in top condition so potential full production was probably never achieved.

1/ Lead Forester, Demonstrations & Experiments Program, Jackson Demonstration State Forest

The yarding distances varied from 10 to 400 feet with the majority less than 100 feet. The logs he yarded ranged up to 45 feet for the very small diameter boles but most of the logs ranged between 16 and 24 feet in length. The largest log he skidded with one horse was a 12 inch diameter by 30 foot long log which is approximately 1000-1200 pounds depending moisture content. This would have been done on the flat or a downhill skid. Any adverse skidding or extra resistance from ground debris decreases the payload significantly. The author observed one of the horses attempting to skid a tanoak log approximately 10 inches by 16 feet up a road with a adverse grade of 10-15 percent and it could not pull it more than a few feet so they had to buck the log to a shorter length. Dale would cut the leading face of the log on a taper to minimize the skidding resistance since their was no lift using this harness arrangement. The typical load averaged 400-600 pounds and Dale would try to size the log to the skidding difficulty as having to stop and rebuck really slowed production down. Dale's wife told me that two trained Belgian draft horses in top shape, pulling in tandem, have moved 6000 pounds in a weighted sled competition which equals pulling 1.5 times each horses body weight. Dale would work the horses singly, alternately giving each horse a rest period while working the other. He and Pedro were very careful to not over tire the horses and watered and fed them frequently during the work day.

As Figure 1 shows, a padded harness belt arrangement called a collar and hames was buckled around the horse near the withers and chest area. This area of the horse takes most of the strain of pulling a load. Traces or pull lines were attached to this harness on either side and were kept in line both by a trace carrier harness arrangement on the hip of the horse and a breeching seat. These two lines were led back to a 34 inch steel singletree spreader bar from which a ten foot choker was attached at the center. One of the difficulties in yarding was keeping the lines out from under the horse when moving the animal into position for the hook up phase of the yarding. Although the horse would pull on command, to have better control Pedro would ride the horse from the loading point in the woods to the roadside landing area. This worked the best for production as he would have to position the log and unhook the choker at the landing since they had no landing person. He would then remount the horse and return to the area being yarded. Dale would stay and select the next log to be skidded and do any preparation work needed.

Although they yarded just a few of the acres, it was an interesting and informative introduction to horse logging. Similarly to the Latour experience, little if any damage was noted to the residual conifer stand and little ground disturbance except under the direct path of the log was observed. Production would be expected to improve given the increasing experience in working with the horses and their improving physical condition.

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Timber Sales Activity
1991 Summary

The following is an update of timber sales activities on JDSF during 1991. The report for the previous years can be found in Newsletter 40 (Jan. 1991). The sale year indicated reflects the year a sale was prepared and intended for sale. During the past year, all '91 sales were sold in 1991. Major sales are generally two year contracts. Activity on sales may be limited due to weather conditions or contract provisions.

Active Sales

Tramway '91 - The final sale in the Caspar Creek Watershed Study. This sale was awarded to Georgia Pacific for a high bid of $375.00/Mbf in July 1991. Two units are designated for clearcutting with 22 acres tractor yarded and 110 acres of skyline cable yarding. Timber operations are nearly completed on this sale. Cruised volume of 10,260 Mbf. Volume harvested during 1991 of 9,384 Mbf for a revenue of $3,519,000.

Volcano '90 - This sale had just been sold as of our last report and is nearing completion. Removed volume of 6,671 Mbf in 1991. Cruised at 6,100 Mbf. Revenue generated for 1991 of $1,475,000 at $221.10/Mbf.

Parlin Creek '91 - Awarded to Eel River Sawmills for a high bid of $375.10/Mbf, this sale sold in Sept. 1991. This is a transition harvest of 516 acres to an uneven aged structure by removing 30 per-

see Timber - Pg 8

Redwood Region Conservation Council
Annual Meeting and Conference
Friday, February 28, 1992
at Tradewinds Lodge, Fort Bragg, CA

"Coping with Political Forestry"

The keynote speaker will be CDF Director **Richard Wilson**
For additional information please contact:
RRCC office 589 Mendocino Ave #6
Santa Rosa, CA 95401 phone (707) 578-7377

THERE'S MORE THAN TIMBER FOR SALE AT JDSF

by Pam Linstedt 1/

Jackson Demonstration State Forest is managed by the California Department of Forestry and Fire Protection with the express purpose of demonstrating economical forest management with the intent to sustain production of forest products in a way that allows for other public values (PRC, section 4639). Public Access is permitted for such activities as camping, hunting, plant collecting, and the harvesting of various minor forest products, with little impact on the timber management program.

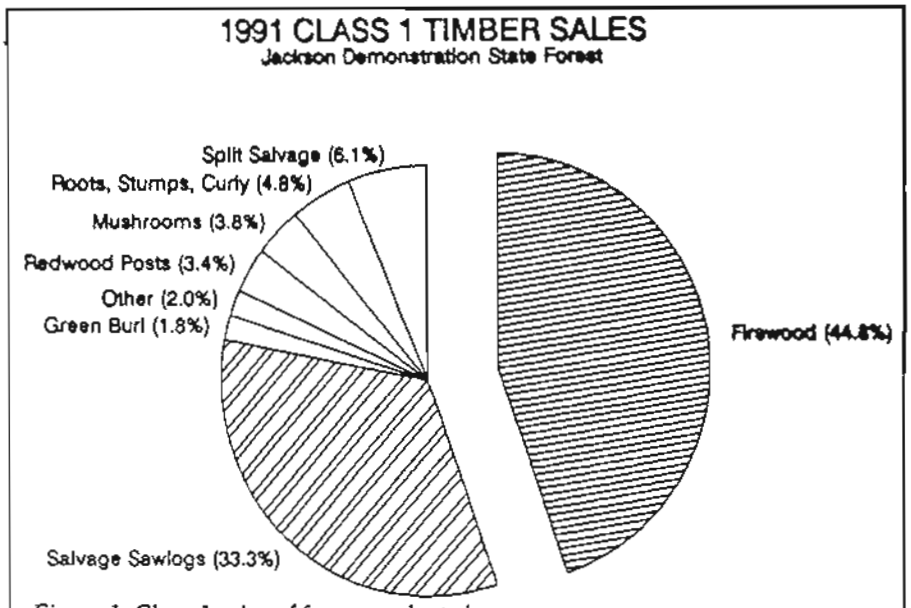

Figure 1. Class 1 sales of forest products in percent.

In order to account for the use of state forest products, a permit system is in existence. Permits provide a means of accountability and act as a contractual agreement that the user will abide by State Forest rules. Users are required to read regulations and sign stating that they understand the rules. Each permit states that the user must have the permit in his or her possession while gathering forest products. The permittees may be checked for compliance by the patrol officer or any of the State Forest staff.

Gathering of forest products is available year-round and forest-wide, except in areas of active logging or special treatment (study) zones. Access roads may be closed during the rainy season to prevent erosion and site disturbance. Closed roads and several other factors are used to limit the location and quantity of vegetative material available.

What kind of "minor forest products" are included in the State Forest permit system? The most sought after product is firewood, which can be obtained with a personal or commercial-use permit. Personal-use permits allow the user to cut four cords of dead and down material, excluding mechantable sawlogs, and may be purchased for $20 plus tax. These permits comprise 37% of our total revenue from Class I Sales. Commercial permits make up 10% of the total revenue and allow the permittee to cut 10 cords of firewood for $50 plus tax. In the latter case, the permittee must be a licensed timber operator (LTO) which provides a means of accountability to comply with the Forest Practice rules.

LTO's have been permitted to harvest salvage sawlogs and standing hardwoods in association with special projects. Split salvage material may also be harvested by commercial operators as permitted. The regulations for obtaining salvage sawlogs or standing hardwood are more stringent than for other forest products. The permittee must be granted permission for specific trees or logs. Payment for salvage sawlogs is based on log value. The agreement for harvesting standing hardwoods includes specific guidelines for harvesting and completion of the sale. These guidelines may include: clearing all slash, constructing a fire line around the entire sale area, waterbarring where necessary, purchasing a minimum of ten cords, and obtaining a minimum of $100,000 personal injury liability insurance covering the State. With the rules being more strict, minimal availability of sawlogs, and the marginal profit return, these products comprise only a small percentage of sales each year.

Commercial mushroom permits accounted for six percent of Class I Sales last year. Picking mushrooms for resale has become a popular activity. Gathering mushrooms for personal or commercial use is allowed on the forest. A permit for personal use is good for one gallon/day and is free. A commercial mushroom permit can be obtained for $25 and has no constraints on quantity. The personal-use permit limit was recently reduced from five gallons per day to one gallon per day because the majority of people collecting more than one gallon were found selling the mushrooms without a commercial permit, and the State Forest needed a better way to differentiate between the two users. Special one-day use permits may be written if more than one gallon can be justified.

Other miscellaneous forest products for sale include: green burls, roots, stumps, curly, shrubbery, rhododendrons, conifer branches, ferns, fish poles, and posts. For the most part, each of these have their own permits with specific conditions outlined. The fee established for each of these permits is evaluated annually and contributes a minimal amount towards administrative costs.

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All funds received from forest product permits are put into the Forest Resources Improvement Fund (FRIF). Additional revenues are derived from grants, donations, and the repayment of loans all of which must be associated with forest improvement projects. FRIF was established in 1980 to reinvest revenues from timber sales (primarily) back into forest improvement and education. This special fund reimburses the General Fund first for state forest operating costs. Once the state forests have received their funding, other project funding is scheduled in accordance with the Budget Bill process.

Timber - from pg 6

cent of the volume. Cruised volume of 11,120 Mbf. Seventy-three percent of the acreage is slated for skyline yarding. Operations will not commence on this sale until after the winter period.

Tunnel '91 - This sale was awarded to Harwood for a high bid of $396.20/Mbf in Dec. 1991. Cruised volume of 5,718 for 171 acres. Silviculture is for shelterwood/preparatory step. Operations will not commence until after the winter period.

PG&E Right-of-Way - Sale of potential hazard timber along the Willits-Fort Bragg 90kv transmission lines. Revenue of $132,000 for 1991 in this lump sum sale. Operations expected to conclude this coming summer.

Completed Sales

Rice '90 - Second sale of the Caspar Creek Watershed Study. Sale completed in November. Final harvested volume of 14,219 Mbf. State revenue generated in 1991 of $3,045,000.

Berry Gulch '90 - Harvesting commenced and completed in October 1991. Revenue of $2,110,000 on 8,394 Mbf harvested. Cruised volume of 8,326 Mbf.

Class 1 permits for small sales of forest products yielded a revenue of $47,600 for 1991.

Prospective Sales

Gulch 23 '92 - In the Peterson Gulch area, estimated 8 MMbf volume from 310 acres. Commercial thinning or shelterwood/prep step probable silviculture. Target of early spring for bid date.

Hare Creek '92 - Approximately 450 acres of selection. Estimated volume of 10 MMbf. Bid date anticipated in late spring.

Berry Gulch '92 - Projected harvest of 10 MMbf from commercial thinning or shelterwood / preparation step on 335 acres.

Sales prepared for 1991 resulted in a total cruise volume of 27,918 Mbf. Total revenue for forest products sold in 1991 is $10,328,645.75. These funds, after in lieu taxes, revert to the State. Operating expenses for the State Forest are then reimbursed from these funds.

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