FIR Report

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The Southwest Oregon Forestry Intensified Research Program (FIR) is a cooperative effort between the College of Forestry at Oregon State University and the Pacific Northwest Research Station of the USDA Forest Service. It is designed to assist foresters and other resource management specialists in solving complex biological and management problems endemic to southwest Oregon. FIR specialists organize, coordinate, and conduct educational programs and research projects specifically tailored to meet the needs of this area.

Established in October 1978, the FIR Program is supported jointly by Oregon State University, the Bureau of Land Management, USDA Forest Service, O&C Counties, and the southwest Oregon forest products industry. It represents a determined effort by the southwest Oregon forestry community and county governments to find practical solutions to important forest management problems.

The "FIR REPORT" is one of the principal methods of reporting recent technological advances and research results pertinent to southwest Oregon, and alerts area natural resource managers to upcoming continuing education opportunities. Comments and suggestions concerning the content of "FIR REPORT" are welcome and encouraged. This newsletter is prepared quarterly and is mailed free on request by contacting us at this address: FIR REPORT, 1301 Maple Grove Drive, Medford, OR 97501.

For the FIR Staff,

Steven D. Tesch
Silviculture Specialist

Inside

OREGON STATE UNIVERSITY
EXTENSION SERVICE

FORESTRY INTENSIFIED RESEARCH

SERVING SOUTHWEST OREGON THROUGH RESEARCH AND EDUCATION

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Because of space limitations, results appear as extended abstracts. Readers who are interested in learning more about an individual study are encouraged to contact the principal investigator or wait for formal publication of more complete results.

Editor's Note

I want to thank Dave McNabb for the nice job he's done as editor during the past year. I'll be responsible for the four issues comprising volume 8.

Once each year we reiterate that the goal of this newsletter is to share the best and most current information on forest management issues in southwest Oregon. Many of the articles report preliminary, hot-off-the-computer results that would not be available so quickly without this outlet. We also keep you informed of new studies, so you'll know who to contact when questions arise.

I know that many administrative studies are underway on districts and resource areas. Please keep us informed of their progress. The FIR Report is a good way to share those results with other resource managers. We are interested!

We recognize and appreciate our northern California readers. Its clear that ecological and operational boundaries are not as distinct as the political one. Please help us keep track of activities south of the border. Don't be bashful!

Steve Tesch

Current Research

Adaptive FIR

DAMAGE RECOVERY STUDY - UPDATE

During this past summer, four additional transects were installed as part of a study to assess seedling recovery from overstory removal damage. This brings the number of transects under observation to nineteen on seven different harvest units. More than 720 damaged and undamaged Douglas-fir seedlings have been tagged along the transects. The trees are being observed for comparison of growth rates and their ability to recover from different kinds of damage.

We conducted an inventory of the tagged trees last fall (1985) to record mortality. Table 1 summarizes mortality by height class for damaged and undamaged seedlings. These values represent the mortality which has occurred after two growing seasons for 68 percent of the trees and one growing season for the remainder of our sample.

TABLE 1.--Mortality of seedlings after overstory removal operations. Number in parentheses is number of seedlings in each size class.

Height Class	Mortality Of Undamaged Seedlings	Mortality Of Damaged Seedlings
	Percent	
0-1.0'	11(18)	31(97)
1.1-2.0'	0(27)	11(98)
2.1-3.0'	0(28)	5(94)
3.1-4.0'	0(20)	4(77)
4.1-5.0'	0(14)	5(60)
5.1-10.0'	0(16)	7(141)
10.1-15.0'	0(5)	3(37)

The greatest mortality took place in the one-foot or less size class. However, 83 percent of the mortality in this size class occurred on one site. It was a steep, droughty south slope which had an overstory removal one year after underplanting with 2-0 Douglas-fir. Two years after logging, 50 percent of the damaged seedlings one foot or less in height on this site have died. The high rate of mortality is likely related to either the short period of time the planted stock were in the ground or the severity of the site or a combination of both of these factors. Results from a nearby transect on a north-facing unit in the same sale showed 22 percent mortality in the one-foot or less size class. It was a less severe site which also had been underplanted with 2-0 Douglas-fir one year prior to overstory removal. The comparison of our data from these two sites suggests the potential significance of environmental and site-specific factors on the survival of damaged seedlings.

The general trend was for decreasing mortality with increasing size of the seedlings. This coincides with the results from our Grub Gulch study site, where damaged seedlings less than 1.3 feet in height recovered poorly and suffered the greatest amount of mortality (FIR Report 5(4):6-7). In the current study, all mortality occurring in trees greater than 5 feet in height was the result of multiple types of injury to the regeneration.

Future work on this study will focus on differential rates of recovery from various types of damage as well as comparisons of growth rates between damaged and undamaged trees.

James Kraemer, Adaptive FIR
Steve Tesch

MINIMUM STRESS WITH NO COMPETITION

During 1985 the first brush slashing treatments were installed as part of the Non-chemical Methods of Brush Control Study, which has been described in previous issues of the FIR Report (5(2):6, 6(2):2, 6(4):2-3, 7(1):4-5). As you may recall, the intent of this study is to evaluate slashing as an alternative method of controlling 2-4 year-old brush sprouts in new plantations. Several additional treatments were also installed to establish a continuum of competitive conditions, ranging from none to severe, experienced by Douglas-fir seedlings. These included the complete and continuous control of all competing vegetation, continuous control of herbaceous vegetation only (brush sprouts left undisturbed), and an untreated control.

On August 7, we measured Douglas-fir seedling maximum and minimum plant moisture stress (PMS) over a 24-hour period in each of the treatment areas (Table 1). This was done during the peak of the summer drought in one of the driest years on record (FIR Report 7(2):-5-7). In environments where moisture is the primary limiting factor, PMS is a good measure of the competition experienced by seedlings, particularly during summer drought conditions.

TABLE 1.--Mean maximum and minimum plant moisture stress (PMS) of Douglas-fir seedlings on August 7, 1985 by vegetation treatment.

Treatment	Mean PMS (-bars) Maximum	Mean PMS (-bars) Minimum
Complete vegetation control	15.48	6.98
Herbaceous vegetation control; brush undisturbed	23.72	13.94
Brush cut in early April 1985	28.61	17.83
Brush cut in late May 1985	28.64	15.51
Untreated control	32.12	23.02

Maximum and minimum PMS were least where competing vegetation was completely eliminated by repeated slashing and grubbing. Stress levels were severe in the untreated control where competition from brush sprouts and herbaceous vegetation was greatest. This was not unexpected, however, and has been reported in other competition studies. Slashing did result in less severe levels of stress, but reductions did not begin to approach those measured in the complete vegetation control treatment. The lack of any substantial response to slashing can be attributed partially to rapid resprouting after cutting. In fact, these sprouts did not set buds until the end of August, which was surprising given the unusually dry conditions that prevailed.

When the PMS values for seedlings that experienced brush competition alone are compared with those in the untreated control, we can calculate the proportion of stress due to herbaceous competition. Using the data presented, approximately 26 percent of the maximum (8.4 bars) and 39 percent of the minimum (9.1 bars) PMS experienced by Douglas-fir seedlings in the untreated control can be attributed to herbaceous vegetation. This suggests that herbaceous vegetation, although perhaps less obvious than sprout clumps, represents a significant source of competition that should not be overlooked.

The differences in PMS between the various treatments will undoubtedly affect Douglas-fir growth, although to what extent remains unclear. In all likelihood, several years will have to elapse before a definitive evaluation of treatment efficacy can be made. Given the wide range of treatment conditions established, however, some striking differences are probable.

S.H.

MACHINE SITE PREPARATION STUDY SITE PLANTED AGAIN

"Seedling survival good, but growth poor..." has been the conclusion of past summaries of seedling performance at Silvercat, the first location of a multiple treatment investigation of machine site preparation in the Siskiyou Mountains about 23 miles west-northwest of Grants Pass (FIR Report 4(4):2-3 and 6(4):5-6). Height growth during the second and third years was less than the relatively poor, first-year growth (Figure 1). The growth was not related to the intensity of the machine site preparation, although the soil removal treatment provided better sustained control of competing vegetation.

The most plausible explanation for the poor growth was a combination of late planting followed by nearly a seven-week drought. This resulted in budbreak being delayed nearly two months in late spring and early summer, the period when most growth should have occurred on the site.

A decision was made to interplant one treatment of the original study in the spring of 1985, in anticipation that the distribution of precipitation would be

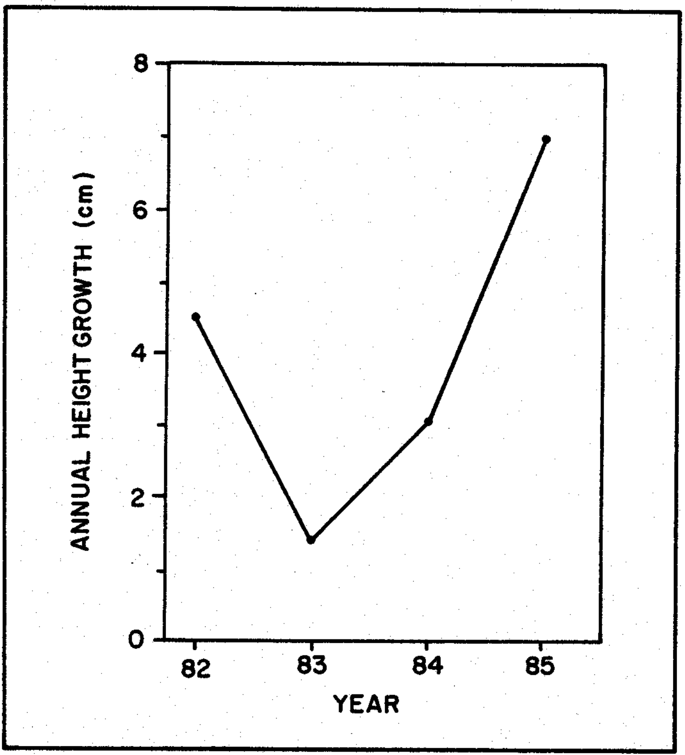

FIGURE 1.--Annual height growth of 2-0 bareroot, Douglas-fir seedlings planted in 1982 on the soil removal treatment plots at Silvercat.

different. The soil removal treatment was chosen for replanting because it had been effective at sustained control of competing vegetation. Fifty, 2-0 bareroot Douglas-fir seedlings were interplanted in each of the three replications of this treatment.

Replanting of this site did not occur until May 8, 1985 which was later than desired and only 10 days earlier than the original planting. Fortunately, more precipitation occurred before and after the replanting than occurred around the first planting date.

At least two weeks of dry weather preceded the May 18, 1982 planting, which was followed by 8 mm of precipitation on June 4, 3 mm on June 21, 10 mm on June 27, and 23 mm on June 29. Only the latter two precipitation events, totaling 33 mm (1.3 inches) were sufficient to recharge the soil profile in the seedling root zone.

Three days prior to the May 8, 1985 planting, 15 mm of precipitation fell; this brought the soil to field capacity when the seedlings were planted. Some precipitation occurred during the first 10 days following planting; 1 mm of precipitation fell each day on the 12th and 13th and 3 mm fell on the 18th; this kept evapotranspiration low. A storm producing 15 mm of precipitation occurred on May 30. Early June was wet, with 2 mm or more occurring during 5 of the first 7 days of the month, 14 mm on the 8th, and 36 mm on the 9th. The remaining days of June and first 4 weeks of July were dry.

First summer survival was not affected by the year of planting; original survival was 98 percent and the replant survival was 98.7 percent. However, height growth of the replant was 44 percent better, 6.58 cm versus 4.51 cm for the original planting. Height growth of replanted seedlings in their first year was significantly better (α=.05) than the original seedlings in each of the first three years. Only the fourth-year height growth of the original seedlings is comparable to the first-year height growth of the replanted seedlings.

The ability to replant this site after 3 years with only small differences in competing vegetation creates a study which replicates planting over time. More importantly, it is providing a rare opportunity to study the field performance of seedlings when planted under two different sequences of precipitation events on the same site. While dry soil around the time of planting is the most plausible explanation for the poor height growth of the original plantation, several other factors, including differences in stock and planting quality, cannot be ruled out. The growth of both sets of seedlings will continue to be measured until both are 5 years old; this will determine if a decrease in height growth of replanted seedlings also occurs during the second and third years.

D.M.

Fundamental FIR

MANZANITA COMPETITION WITH DOUGLAS-FIR AND PONDEROSA PINE

This study was initiated in 1982 to examine the competitive effects of whiteleaf manzanita and herbs on Douglas-fir and ponderosa pine. Water use and growth measurements have been made beginning in 1983 [FIR Report 5(1):5]. This article will report on conifer height and diameter the third year after treatment. At this time the conifers have been through five growing seasons.

Conifer measurements are shown in Table 1 and Table 2. The treatments are different levels of

TABLE 1.--Douglas-fir diameter and height after 1985 growing season, over all replicates.

Treatment	Douglas-fir			
Manzanita	Not hoed		Hoed	
Spacing (ft^2)	Ht(cm)	Diam(mm)	Ht(cm)	Diam(mm)
Herbs+8	107.7	21.7	--	--
4	146.3	29.4	162.9	31.7
8	142.0	28.9	165.2	33.4
16	162.7	33.8	174.0	36.9
32	167.8	31.3	194.3	41.5
64	170.4	36.5	190.3	40.1
No Manzanita Trees Only	163.5	35.2	172.6	36.9

TABLE 2.--Ponderosa pine diameter and height after 1985 growing season, over all replicates.

Treatment Manzanita Spacing (ft^2)	Ponderosa Pine Not hoed Ht(cm)	Ponderosa Pine Not hoed Diam(mm)	Ponderosa Pine Hoed Ht(cm)	Ponderosa Pine Hoed Diam(mm)
Herbs+8	123.7	36.7	--	--
4	134.1	43.9	150.1	49.2
8	138.8	46.6	147.6	49.0
16	151.7	51.0	184.5	58.9
32	156.8	53.7	162.0	59.2
64	158.3	54.7	165.4	60.0
No Manzanita Trees Only	164.5	54.9	168.8	61.3

manzanita competition, expressed as one bush per number of square feet. Highest numbers of manzanita would occur in the 4-ft^2 treatment. Herbaceous competition was controlled through 1984 in all treatments except the herbs+8 ft^2. In this treatment, manzanita spacing was one bush per 8 ft^2 and the natural herb community was left intact. During the 1985 growing season, three trees of each species in each plot received a hoeing treatment. All herbs were removed in a circle 4 ft in radius around each tree. The rest of the plot was left undisturbed and varying levels of herbaceous competition invaded the treatments.

Over all levels of manzanita, the trees that remained free of herbaceous competition (hoed) grew more in height and diameter than the trees where herbs were allowed to reinvade (not hoed). Those differences have not been statistically analyzed, but they suggest that herbs may reduce growth even in well-established five-year-old plantations.

Heights and diameters of both Douglas-fir and ponderosa pine are smallest in the treatments where herbs have continually been present. Conifer growth is reduced as the density of manzanita bushes is increased.

These preliminary data suggest that both manzanita and herb competition will slow conifer growth in young plantations and that herbaceous competition is a very important factor in conifer growth in southwest Oregon.

Diane E. White
OSU Forest Science Dept.

Continuing Education

ADAPTIVE FIR SOUTHWEST OREGON REFORESTATION WORKSHOP

September 18-19, 1986. Best Western Conference Center, Best Western Riverside Motel, Grants Pass, OR. For foresters and others concerned with reforestation. This program will present research updates on reforestation technology and regional reforestation issues. Attendance is limited to 100. Fee: $40 U.S. Accreditation for SAF-CFE program, and Oregon and California pesticide licensing. For further information, CONTACT: Ole T. Helgerson, Workshop Director, or Lenore Lantzsch, Secretary, Adaptive FIR, (503) 776-7116.

Of Interest

SURFACING OF LOW-VOLUME ROADS IN STEEP TERRAIN

In the United States, low-volume roads are defined by the National Highway Research Board as rural roads that carry less than 400 vehicles per day. The United States alone has approximately 2 million miles of rural, low-volume roads. The majority of roads built for timber hauling and other multiple uses on National Forest, Bureau of Land Management and privately owned forest land fit into this category. At the most recent international meeting of the Transportation Research Board, National Academy of Sciences (1983), road surfacing materials and techniques were identified as two critical concerns for low-volume road management.

Why should surfacing of low-volume roads be important to us in western Oregon? In the mountainous terrain characteristic of this region, constructing a short, steep section of road for timber hauling may be less expensive than building a longer section with more gentle grade. An important factor in determining the cost of hauling over such a road is the traction provided by the road surface. If traction is insufficient for logging trucks to climb the grade under their own power, an assist vehicle would have to be provided. This is often accomplished by having a rubber-tired skidder or loader push the truck through the steepest areas. The cost of such an operation can easily diminish any benefit of reduced construction cost that would be realized from building less road. Traction, from the viewpoint of the road manager, is dependent on the road surfacing material.

A 1985 OSU Forest Engineering Master's Degree paper by Paul Anderson, "A Survey of Design, Construction, and Operating Practices for Steep Roads in the Oregon Coast Range," examines the problem of surfacing on these roads, as well as other aspects of steep-road management. This article is a summary of the portion of Anderson's paper that deals with road surfacing. In reviewing the literature for his study, Paul found that very little had been written on this topic, consequently much of the information was acquired through personal interviews with industry and government construction engineers, and with OSU forest engineering faculty members.

General Requirements For A Low-Volume Road

The design surface for a low-volume road must satisfy three general requirements:

1. During construction, it must be feasible to prepare and place the surface. (This includes compacting the subgrade, and spreading and compacting the surface material).

2. The road surface must provide adequate traction and wheel-load support during the design life of the road.

3. The surface must be maintainable for normal wear during its design life. Maintenance of such a road surface normally consists of periodic blading, but the road surface must also provide a working platform for routine drainage ditch maintenance.

Extremely steep grades may present problems in any one of these 3 areas of requirement for a design surface.

Construction

Placing, spreading, and compacting surface material on steep grades often presents operational problems. If conventional dump trucks are used to haul aggregate (the rock surfacing material), they may require traction assistance to rough-spread (dump) the material on uphill (adverse) grades. Traction assistance here could mean any number of methods of improving traction; tire chains, assistance vehicle, increasing vehicle weight, etc. However, when a finished surface is the objective, the alternative most often used is an assist vehicle.

A motor grader used for fine spreading the surface material may also require traction assistance on such grades. For grading, traction assistance may be provided by an assist vehicle or by using a heavier, more powerful grader. The need for traction assistance will vary with grade and with the amount of material carried by the blade while spreading. The steeper the grade, the less material that can be carried by the grader blade without traction assistance. Thus more passes will be required to do the spreading job.

Gradation of the surface material can also influence the need for traction assistance. This refers to the distribution of rock aggregate particle size and is expressed in inches or millimeters of particle size diameter. The grader blade must carry the entire range of particle sizes in each pass, or else gradation specifications for the road surface will not be met. With larger particles, the greater the amount of material the blade must carry while spreading and the more likely the need for traction assistance on steep grades.

Compaction of the road surface, normally done with some type of weighted vibratory roller, increases the supportive capacity of the road and improves traction potential. A practical upper grade limit for self-propelled vibratory rollers is about 20%. At grades steeper than this, a tractor-towed roller or an assistance vehicle for the self-propelled roller is necessary. These options all increase construction costs.

Traction and Wheel Support

Crushed rock aggregate is the major surfacing material used on low-volume roads that must remain open for use in wet weather. On roads with gentle grades, the primary purpose of using crushed rock is to distribute wheel loads to the subgrade at low enough stress levels so that rutting will not occur. On steep roads, subgrade support is also important, but of equal importance is the traction provided by the road surface.

Experience in western Oregon shows that traction problems start to occur on crushed-rock roads at about 16% grade for straight alignments and at about 12% on curves. For these roads, the aggregate surface must be dense and tightly bound together. Improvements in traction beyond these grades can be achieved by careful control of the production, placement, and compaction of the aggregate mix. However, a practical grade limit on which crushed rock can be used without needing traction assistance appears to be about 18-20%.

On grades between 20 and 25%, the feasibility of using crushed rock aggregate is questionable. One contractor that Anderson interviewed told of adding a layer of finely crushed rock to promote better aggregate binding and improve traction on a road with 24% grade, but was still unable to haul without traction assistance. Above 25%, most engineers feel that crushed rock aggregate is not a viable option because the resulting traction coefficient is too low. Additionally, there is agreement that normal 25mm minus or 35mm minus crushed rock aggregate cannot be compacted by practical techniques on grades above 25%. It has also been observed that pit-run rock, that in which the particle size distribution has not been controlled, will segregate with coarser particles rising to the surface producing a traction coefficient that is even lower than with crushed rock.

The grade limit for unassisted adverse hauling appears to occur on roads with a soil surface. One logging contractor reportedly watered, graded, and compacted an unsurfaced road in non-plastic, sandy-silt soil every night and was able to haul unassisted on a 26% grade. From this experience, it has been suggested that adequate wheel load support and maximum traction on steep grades can best be provided by placing pit-run rock on the subgrade, and covering this with a soil surface layer.

The observation that crushed rock aggregate, pit-run rock, and soil provide different traction potentials leads to the conclusion that grain size distribution is important in surfacing steep roads. Vischer, in a 1979 study on the Willamette National Forest, showed that the fraction of fine soil particles in a crushed rock aggregate influences the unconfined compressive strength (Figure 1).

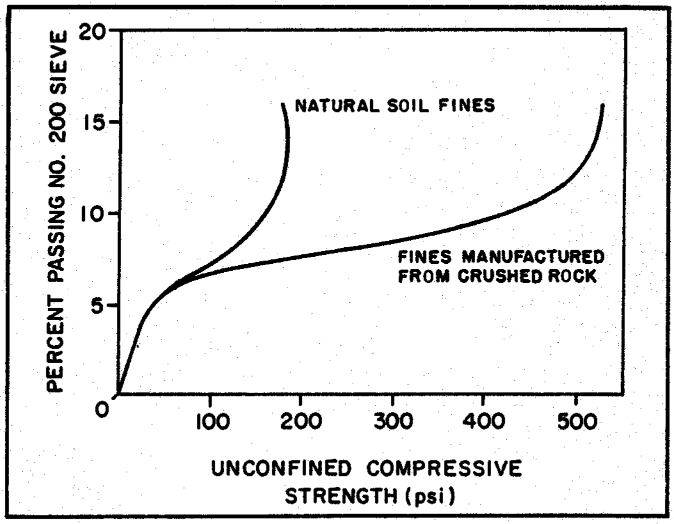

FIGURE 1.--Unconfined compressive strength of aggregate surfacing materials (Vischer, 1979).

This experiment, which sampled road grades ranging from near level up to 16%, also reported that acceptable performance was correlated with a compacted unconfined compressive strength of 75 psi for the surface material. Vischer contends that unconfined compressive strength is a more appropriate test than the traditional confined penetration tests (e.g., California Bearing Ratio) since a road surface is relatively unconfined. He used gradations obtained from successful roads and the test results from Figure 1 to develop suggested gradations as are shown in Figure 2. Other engineers have made observations that agree with Vischer's graph, although gradation bands may differ in width. This empirical work was based on the performance of fairly hard, durable rock. Softer aggregates would require different gradations at the time of placement.

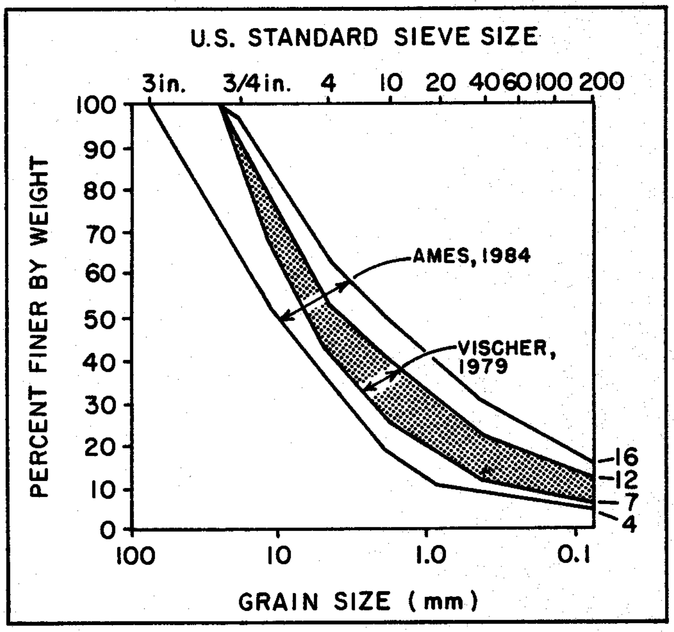

FIGURE 2.--Recommended ranges of aggregate gradations based on two studies (Anderson, 1985).

Maintenance

Maintenance is often cited as the reason that steep roads are used with reservation by some forest owners. Most road engineers share the opinion that maintenance costs increase markedly on grades above 16%, but no data exist to support this contention. Despite maintenance problems, new spur roads in excess of 16% grade continue to be constructed in the Pacific Northwest.

Steep road maintenance during timber hauling may include daily surface watering, blading and compaction. The equipment used for this work is less efficient on steep grades, just as in construction. Standard blading procedure on most aggregate roads consists of working a depth of the surfacing material equal to 2 times the largest particle size. Blading this amount of material on steep grades may not be possible without traction assistance. For this reason, some road managers have reduced the maximum crushed rock particle size on steep grades from 35mm to 25mm or 15mm.

Long-term maintenance activities concentrate on keeping the road surface smooth, controlling erosion, and keeping ditches and culverts open. As grade increases, both the road surface and ditchline require more maintenance. For grades above 20% where a soil road surface is used, maintenance problems are often more severe because the soil surface will likely be very erodible. Erosion control on such a road can consist of water bars, rolling dips, grass seeding, and rock surfacing solely to control erosion. As with construction, these extra efforts require additional investments.

Summary

Steep roads are routinely considered as a cost-effective option for timber hauling in mountainous terrain. Present surfacing strategies provide some general guidelines in selecting appropriate surface types, but these have an empirical basis and are often not useful in transferring experience from one location to another. Research is needed to help develop ways that will accurately predict the performance and costs of steep roads. This should include investigations of construction techniques, traction potential of surfacing materials, short- and long-term maintenance requirements, safety, and the effect on trucks and assist vehicles in order to fully develop the cost picture for steep road management.

John Mann,
Marv Pyles
OSU Forest Engineering

OVERSTORY REMOVAL IN NORTHERN CALIFORNIA: FACTORS RELATED TO SUCCESS

The Forest Service Region 5 Silviculture Development Unit (SDU) and the PSW Experiment Station in Redding, California have been cooperating in recent years to better understand the factors that lead to successful overstory removal operations. In many respects their work has paralleled that of the various FIR efforts, with some different twists. As we discussed many times, management of advanced or existing understory conifers requires at least two decisions. One must first determine that a suitable understory exists for management. Do ample, well-distributed small trees exist before harvest? Will these trees grow well after release? In northern California, the later issue has been addressed by John Helms and his students at U.C. Berkeley. They have published guidelines to project the future growth of understory trees, based on factors visible before harvest. The second concern - the ability to cost-effectively protect understory trees during overstory removal - has been addressed by Gary Fiddler (SDU) and Jim Laacke (PSW). They have shared results of that work with me, with formal publication following soon.

The goal of this study was to observe operational, business-as-usual practices. It appears no special efforts were made to protect understory trees. In fact, sampling was done without the operator's knowledge and sample plots were not marked.

Twenty-nine subunits within nine operational overstory removal timber sales were studied to determine what factors were related to satisfactory or unsatisfactory stocking following harvest. Stocking determinations were based on number of trees meeting minimum crop tree standards. The sales were located on the Plumas, Modoc, Klamath, Lassen, and Shasta-Trinity National Forests, and represented true fir, Sierra Nevada mixed-conifer, and "east-side pine" timber types. Overstory volumes removed ranged from about

7,000-50,000 board feet/acre, with numbers of overstory trees ranging from 3 to 22 per acre and mean dbh ranging from 24 to 53 inches. Most of the sales were on tractor ground. Understory trees were somewhat larger than those reported in FIR studies, with most preharvest mean dbh's of potential crop trees ranging from 4 to 10 inches, but one mean was 18 inches.

Understory trees were sampled using 1/80th acre plots; all overstory trees were recorded. Each understory tree sampled was judged acceptable or not acceptable by estimating its ability to release quickly (using Helm's criteria). These criteria included: 1) dominant or codominant status, 2) constant or increasing yearly height growth, 3) vigorous appearance, 4) no crown damage and 5) 30% or greater live crown.

After harvest, an acceptable stand met one of two criteria. For smaller trees, 100 acceptable trees per acre were required; for stands larger than 6.5 in dbh, 80 trees per acre were required.

Stepwise discriminant analysis was used to identify preharvest overstory variables associated with the acceptable and unacceptable stands. Two variables were significant: 1) arithmetic average dbh of the overstory trees and 2) total longitudinal cross-sectional area per acre of overstory trees (basically the footprint of felled trees laying on the ground before limbing). These variables correctly classified stands about 80% of the time. No understory-related variable was significant.

The following equation can be solved for a stand to obtain an index of risk associated with the overstory removal opportunity:

$$\text{Index} = -0.20244X + 0.01520Y$$

where X = ave. dbh of overstory (inches)
Y = longitudinal cross sectional area of overstory trees expressed in hundreds of square feet.

If the calculated value is greater than -4.22332 (less negative), the stand is classified as a good risk by the criteria used in this study.

We've heard before that the logging job is a critical variable in explaining overstory removal success. In this study, one explanation for the lack of significance of understory variables in overstory removal risk rating is the lack of control placed on the logger. Remember, this study reports on operations where no special controls were placed on the logger. There is no mention of contract stipulations, etc., that may have limited damage. I know that Jim and Gary have some information on special techniques that were tried in Northern California; I hope they'll share that information with us in future articles.

For further information on this work contact Jim Laacke or Gary Fiddler at the PSW Experiment Station in Redding.

S.T.

SOIL COMPACTION SLIDE-TAPE PROGRAM AVAILABLE

"Tilling Compacted Forest Soils," S-T 876, by P. Adams, C. Andrus, H. Froehlich, J. Garland, Forest Engineering Dept., Jeff Hino, OSU Forestry Media Center. 113 slides, 25 minutes. This new program introduces soil tillage as a means of alleviating forest soil compaction through a discussion of four tilling implements. Research examples are used to provide an overview of the relative tilling effectiveness of brush blades, rock rippers, winged rippers and disk harrows. Targeted at forest managers, engineers, equipment operators and forestry students, the program includes information designed to improve tillage management decisions and operations. To order, contact the Forestry Media Center (503) 754-4702.

Prices: Purchase = $140. Rental = $25 for 3 days' use.

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