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. The FIR Program assists 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,

David H. McNabb
Extension Watershed Specialist

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Current Research

Adaptive FIR

SEEDLINGS IN DELAYED REPLANT ARE FAILING TO "CATCH UP"

Successful reforestation programs occasionally have sites where reforestation fails or is anticipated to fail because of poor stock quality, poor planting, or adverse weather during or following planting. Replanting of these sites is justifiable when stocking is low but what happens when initial seedling survival appears adequate but growth is slow? Such a situation occurred at the Silvercat machine site preparation study location in the western Siskiyou Mountains and the site was replanted three years after the first planting.

Although survival of seedlings originally planted in 1982 was greater than 90 percent, seedlings were slow to break bud and growth was poor. First year growth was poor but second year growth was worse; competition from other vegetation was insignificant. A combination of factors contributed to poor seedling performance including a heavy snowpack that restricted access until after mid-May, a spring drought of over six weeks following planting, poor quality stock and poor planting (FIR Report 8(1):3-4; 9(3):3-4). Annual height and diameter growth did not exceed the first year rate until the fourth year.

Even though the seedlings exhibited poor growth on all treatments, the original site preparation treatment that removed soil still provided excellent control of competing vegetation three years after treatment. Consequently, the three replications of the soil removal treatment were replanted in 1985. Stock, planting, and precipitation were much improved although the seedlings were not planted until early May.

Three years after replanting, the seedlings in the second planting are following a growth trajectory approaching the original planting but at an older age (Figure 1). At this time, the replanted seedlings are nearly two years ahead of the original seedlings in size. The replanted seedlings, however, are not anticipated to catch up with the original planting because of increasing competing vegetation.

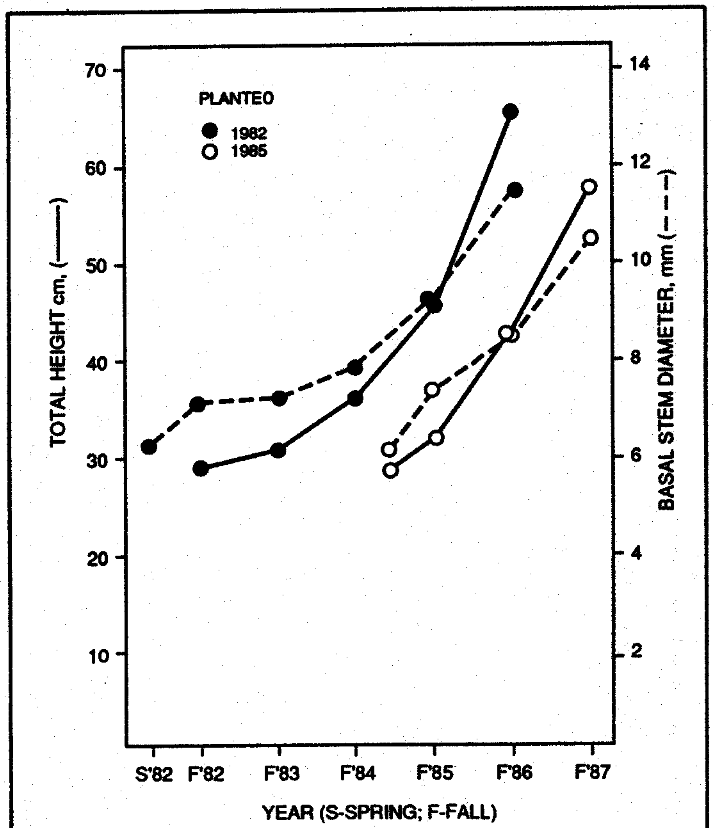

FIGURE 1.--Total height and basal stem diameter of Douglas-fir seedlings planted on the same site three years apart.

If this site had been replanted the first year, the replanted seedlings most likely would be larger than those in the original planting (replanting of seedlings in a nearby unit the following year appear to be larger than those planted at the same time that Silvercat was originally planted). On this site the three year delayed planting succeeded because of the excellent control of competing vegetation on the site; after six years, competing vegetation covered less than 10 percent of the plots. Such sustained control of vegetation is unusual in the area.

This is but one example of comparing seedling response to planting the same site in different years. I have observed sites where severely 'J' or 'L' rooted seedlings are even slower to accelerate growth than these and properly planted seedlings were growing faster. Delays in replanting generally will result in severe vegetation competition that may not justify replanting without additional site preparation; this has most clearly been demonstrated from planting seedlings in brush at the Negro Ben FIR study site (FIR Report 10(1):2-3).

From the small benefits generally derived from replanting, it would appear that emphasis should be placed on obtaining quality planting stock and planting it correctly the first time, rather than relying on replanting to insure an adequate rate of seedling survival and growth.

DM

FIVE YEAR RESULTS FROM HACK AND SQUIRT STUDY

This study was initiated in 1981 to test the feasibility of converting currently low-value stands of hardwoods to Douglas-fir by underplanting. Two stocktypes, 1-0 container grown plugs and 2-0 bareroots, were planted under hardwoods that had been injected with triclopyr amine (Garlon 3) or left uninjected. Thus this study was designed to compare the performance of these two commonly used stocktypes and the effect of using an herbicide for this type of stand conversion.

The study is located in hardwood stands on south-facing slopes (30 to 50 percent) approximately ten miles west and six miles north of Galice, OR. The skeletal soils are derived from sandstone. Basal areas of the hardwoods (madrone, chinkapin, tanoak, and canyon live oak) exceed 200 square feet per acre. The hardwoods were injected with triclopyr in September, 1981 and underplanted the following spring in 1982. Because of extensive deer browsing of unprotected seedlings, the site was replanted in 1983, and the seedlings immediately protected with vexar mesh tubes. Deer browsing of exposed lateral branches has been extensive.

Results after five growing seasons for the 1983 planting indicate that a potential for stand conversion exists and that it is silviculturally feasible with herbicide injection. Seedling size and survival differed by stocktype and whether the seedlings were under herbicide treated hardwoods, with the differences between the herbicide treatments being larger than the differences between stocktypes. The differences in size and survival between the two stocktypes were statistically significant for some variables, but probably are of negligible importance from an operational perspective.

However, size differences between the plot treatments were dramatic and clearly indicate that control of hardwoods enhances seedling growth. Seedling heights and diameters under the injected stands were more than double those under untreated hardwoods, and seedling stem volumes (cone formula) were 16 times greater for seedlings under herbicide treated stands. Survival was poorer for seedlings under untreated hardwoods, but not significantly so. Survival continues to decline under the untreated hardwoods; whereas under the treated hardwoods, survival has changed little since the first growing season (Table 1).

TABLE 1.--Size and survival of Douglas-fir seedlings planted under treated and untreated hardwood stands.

	Hardwood Treatment			
	Control		Herbicide	
Seedling Characteristic	1-0 plug	2-0 bareroot	1-0 plug	2-0 bareroot
Diameter (mm)	4.7	5.7	12.6	14.4
Height (m)	.55	.50	1.13	1.26
Volume (cm³)	3.4	4.9	54.7	78.1
Survival (%)	83	73	100	97

Interesting comparisons exist between the preliminary results from this study and those from other Adaptive FIR studies. The spindly, etiolated-like appearance of the seedlings under the uninjected stands is markedly similar to that noted by Steve Tesch on seedlings growing under brush on his study of brush competition on Negro Ben Mountain. Next, the seedlings under the treated hardwoods on this mesic site were smaller after five growing seasons than the Douglas-fir seedlings growing in the open on the drier Tin Pan Peak site (FIR Report 9(3):2). Seedlings there were approximately 1.2 times greater in height, nearly three times larger in diameter, and more than two and one-half times greater in volume. Annual precipitation at Hack-and-Squirt is at least three times higher. This strongly suggests that the presence of much standing dead overstory and resprouts, droughtier soils, and deer browsing of lateral branches has slowed the growth of seedlings under treated hardwoods, although timber productivity may ultimately be greater on the hardwood site than at Tin Pan Peak.

For other reports on this study, see FIR Reports 7(2):2, 6(3):5, 5(4):5 and 4(4):3.

OH

FEW SEEDLINGS UNTOUCHED BY RAVEL ON STEEP SLOPES

Burial of seedlings by ravel, including slash, is often considered an important factor contributing to reforestation failure on steep slopes. The number of seedlings buried is difficult to determine because the same group of seedlings is seldom observed over time and the need to mark and periodically check the condition of seedlings can alter the movement of material on steep slopes. As part of the study to determine whether devices installed around seedlings will protect them from ravel, some interesting observations and data are accumulating that reveal ravel effects on seedlings to be a dynamic process, changing over time for both individual seedlings and the site.

The study site, Rocky Ravel, is in the western Siskiyou Mountains west of Grants Pass. The site is a northerly exposure of 77 percent slope at an elevation of 1100 m. The site was clearcut harvested and the slash left unburned. Seedlings (2-0 bareroot Douglas-fir) were planted with special care to maintain spacing so that they could be located without any stakes or tags for identification (such devices could affect ravel and protect seedlings from burial). Seedlings were planted in long rows (downslope) to allow access from the site and minimize pedestrian effects on ravel.

Ravel included soil, coarse fragments, woody debris, and logging slash. A distinction was made between woody material (including slash affecting seedlings), soil and coarse fragments, or a combination of the two. Four impact classes were recognized: seedlings unaffected by ravel; leader bent or seedling tilted <45° to vertical; seedlings bent >45° to vertical and including partial burial; and buried seedlings with less than 10 percent of the foliage visible. Seedlings were observed eight times in the first 2.5 years following planting. Initially, observations were made every two months of the first summer and fall but the period lengthened to about six months before the last observation.

Ravel impact on unprotected seedlings increased rapidly the first summer and fall (Figure 1); the greatest increase was in the slightly bent category. The greatest increase in seedling burial occurred in the first year with a larger increase during the winter, apparently the result of snow creep on steep

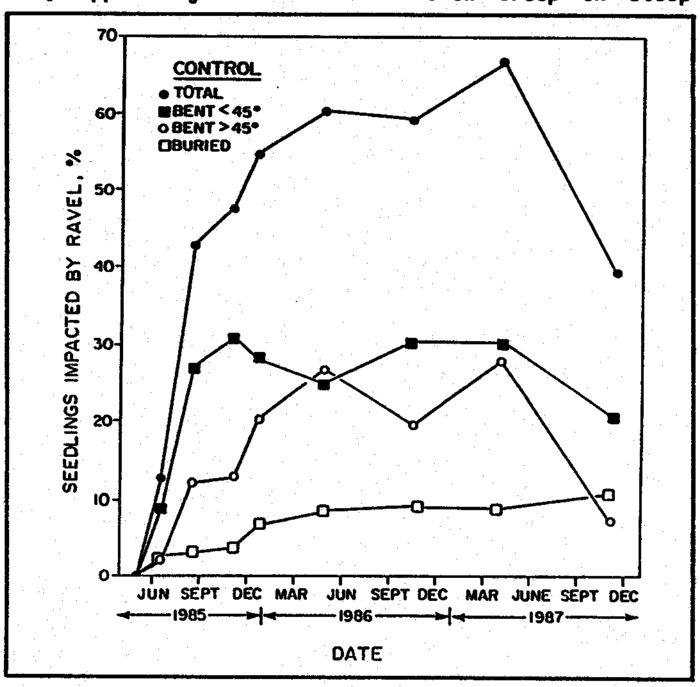

FIGURE 1.--Percentage of unprotected seedlings affected by ravel in different impact classes at Rocky Ravel.

slopes at this elevation. After the first six months, the total proportion of seedlings affected by ravel stabilized at approximately 60 percent. After the third summer, the proportion of seedlings affected by ravel declined markedly (this trend is confirmed by recent data not shown in the figure).

The summary of point-in-time observations (Figure 1), however, does not illustrate the dynamic effect of ravel on seedlings as does a check of whether an impacted seedling changes class from the last observation (Figure 2). During the first year, the proportion of seedlings which remained at the previous impact class or were more severely impacted increased rapidly. For about 1.5 years after the first summer, about a quarter of the seedlings remained at the previous impact class, another quarter were unaffected by ravel during either observation, and about half were increasing or decreasing in class. The last observation shows a decrease in both severity and numbers of seedlings affected by ravel.

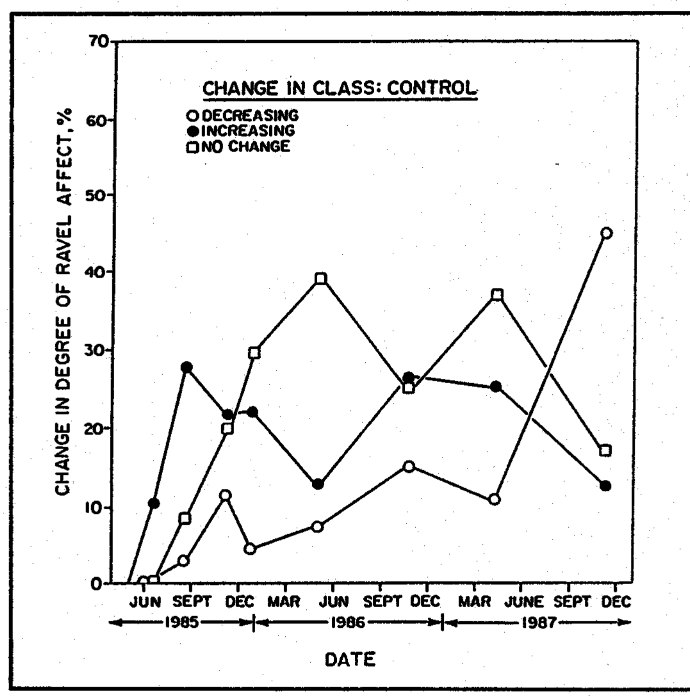

FIGURE 2.--Percentage change in seedlings impacted by ravel with respect to the condition of the seedling at the previous observation period. Difference in sum of percentages and 100 percent is the percentage of seedlings unaffected by ravel in any two consecutive observation periods.

During the first 2.5 years following planting, 92 percent of the unprotected seedlings were impacted by ravel during at least one observation period. Of this high percentage, 34 percent of the seedlings was only slightly impacted while 58 percent was more severely impacted or buried. About 12 percent of the seedlings was buried but burial did not always result in seedling mortality. On several occasions, ravel covering seedlings continued to slide downslope, freeing the seedling; seedlings were observed to be buried for at least 4 months without any apparent damage.

At this time, ravel has buried 10.5 percent of the seedlings; nine percent are considered to have died because of ravel burial. The difference is seedlings which have not been buried long enough that they may yet be uncovered. Most of the seedlings are buried by soil and coarse fragments, but slash was responsible for initially bending or pinning the seedling to the ground so that it could then be covered by inorganic material about 75 percent of the time. Thus, prescribed burning of the slash may lessen the burial of seedlings on steep slopes.

The potential for ravel to impact seedlings, particularly to bury them, is declining. After three summers, seedlings are reaching a size that can withstand the force of small branches pushing them over and when pushed over have sufficient foliage that they cannot be easily covered. The exception is seedlings which have been browsed or are still relatively small.

Although ravel may contribute to the burial of a few seedlings, it is unlikely to be a serious factor affecting the reforestability of a site. Ravel will be more of a factor when container seedlings are used because of their small caliper and lack of branching. Broadcast burning slash may reduce burial because slash appears to be responsible for pushing most seedlings over so they may be covered with coarse fragments. Broadcast burning would also increase the number of planting spots so that microsite planting could reduce burial by avoiding those locations where movement is most likely to occur. Finally, these estimates of seedling burial are probably higher than anticipated operationally because seedlings were sometimes planted in areas of heavy slash or recent movement to maintain the rigid spacing necessary to keep track of unmarked seedlings.

DM

Continuing Education

1988-1989 SILVICULTURE INSTITUTE MODULES

The Silviculture Institute begins its 11th year of providing training for experienced silviculturists. The objective is to develop and refine participants' capabilities for making sound, cost-effective management decisions through application of basic concepts of biology, statistics, and economics. The Institute is comprised of 6 two-week modules that take place over a 12-month period; however, individuals interested in individual modules rather than the year-long series are encouraged to apply. The schedule for the next series is:

Forest Autecology............................Sept. 88
Ecosystem Approach to Forest Manipulation.......Oct. 88
Statistics and Forest Mensuration...............Jan. 89
Economics and Problem Solving..................Mar. 89
Forest Regeneration and Stand Management.........May 89
Preparation of Silvicultural Prescription.......Aug. 89

The Institute is presented jointly by the University of Washington and Oregon State University. CONTACT: H. N. Chappell, Silviculture Institute Coordinator, College of Forest Resources, University of Washington, Seattle, WA 98195. (206) 543-9527.

ADVANCED WORKSHOPS IN SILVICULTURE: EVALUATING HARVESTING METHODS AS THEY RELATED TO SILVICULTURAL OBJECTIVES

October 10-14, 1988. Corvallis, OR. An advanced workshop of the Silviculture Institute to help silviculturists and other non-forest engineering resource managers develop a better understanding of timber harvesting as it relates to silviculture objectives. The course offers 1-hour of graduate credit to participants. CONTACT: H. N. Chappell, College of Forest Resources, University of Washington, Seattle, WA 98195. (206) 543-9527.

THE INTERFACE: FOREST MANAGEMENT IN SOCIALLY SENSITIVE AREAS

October 27, 1988. Southern Oregon State College. This one-day workshop jointly sponsored by the Siskiyou Chapter, Society of American Foresters and the Geography Department, SOSC, will address a particularly important topic for all land managers as well as homeowners in southwest Oregon - how to manage timber near rural and urban areas. Presentations will include a description of the interface, social concerns affecting forest practices in the interface and examples of successful forest management in the interface. Workshop director: Marty Main, (503) 488-2208. CONTACT: Gail Manchur, (503) 482-6251.

RISK AND ECONOMICS: CUSTOMIZING ANALYSES FOR NATURAL RESOURCE DECISIONS

December 6-8, 1988. Corvallis, OR. Course will provide managers and administrators with an overview of the fundamentals of evaluating economic returns, quantifying risk, and provide hands-on experience in integrating these into a systematic analysis of alternatives. CONTACT: Conference Assistant, College of Forestry, Oregon State University, Corvallis, OR 97331. (503) 754-2004.

INTERNATIONAL MOUNTAIN LOGGING AND PACIFIC NORTHWEST SKYLINE SYMPOSIUM

December 12-16, 1988. Portland, OR. Topics to include major aspects of timber harvesting and transportation in mountainous areas, with an emphasis on steep terrain. A call has been issued for papers and posters. Proceedings of the symposium will be published. CONTACT: William A. Atkinson, Program Committee Chairman, Department of Forest Engineering, Oregon State University, Corvallis, OR 97331. (503) 754-4952.

TECHNIQUES FOR VALUING ENVIRONMENTAL RESOURCES: RECREATION, WILDLIFE, FISHERIES, AND WATER

December 13-15, 1988. Corvallis, OR. The course is aimed primarily at agency personnel who are required to estimate or explain nonmarket values used in environmental assessments, project analyses, or resource planning situations. The workshop will begin with the concept of resource values and move quickly to advanced techniques for estimating nonmarket benefits. Cost: $350. CONTACT: Conference Assistant, College of Forestry, Oregon State University, Corvallis, OR 97331. (503) 754-2004.

PROTECTING THE HEALTH OF PACIFIC NORTHWEST FORESTS THROUGH INTEGRATED PEST MANAGEMENT: A SYMPOSIUM FOR FOREST MANAGERS

January 17-18, 1989. Corvallis. The symposium is designed for forest resource managers responsible for the stewardship of managed forests and the control of insect, disease, weed, and vertebrate pests that are a threat to the health and productivity of the forests. The program will blend pest management with other silvicultural considerations and present new techniques and strategies for dealing with pest problems. CONTACT: Conference Assistant, Oregon State University, Corvallis, OR 97331. (503) 754-2004.

FOREST VEGETATION MANAGEMENT

January 31 - February 2, 1989. Corvallis. The aim of this year's Forest Vegetation Management course is to explore the expanding information and tool base for determining the current and future intensity of competition, examine the impact of vegetation management tools on competition, and predict the growth response of conifer seedlings. The program will also include updates on new developments in vegetation management technology. CONTACT: Conference Assistant, Oregon State University (503) 754-2004.

REFORESTATION OF HIGH ELEVATION SITES IN SOUTHWEST OREGON AND NORTHERN CALIFORNIA

Winter 1989. Medford, OR. Program will address the general problems of reforestation of high elevation sites including the climate, soil physical, chemical, and biological environment, pests, and artificial and natural reforestation strategies. Workshop director: Ole Helgerson. CONTACT; Lenore Lantzsch, Adaptive FIR, (503) 776-7116.

APPLICATION OF FOREST SOILS INFORMATION TO FOREST MANAGEMENT IN SOUTHWEST OREGON

Winter and Spring 1989. Medford and Roseburg, OR. Two separate one-day programs to be held at each location. One program will discuss the soil physical environment and the second will discuss the nutrient and biological environment. The programs will review forest soils, the specific knowledge gained about forest soils in southwest Oregon in the last decade and the application of this information to forest management. Workshop director: Dave McNabb. CONTACT: Lenore Lantzsch, Adaptive FIR (503) 776-7116.

Of Interest

HEAT DAMAGE IN SEEDLINGS AND ITS PREVENTION

The scientific literature indicates that high surface temperatures and subsequent seedling damage or death are not limited to southwest Oregon. Damage from high soil surface temperatures was first identified early in this century as a cause of seedling mortality in nurseries and forests in Germany and in nurseries in the United States. High temperatures also have subsequently been observed to limit survival of natural and planted conifer seedlings throughout western North America, the Lakes States, and in the northeastern U.S.

In selecting stocktypes and species for planting in southwest Oregon, research provides guidelines for selection of species, stocktypes, or mitigative practices. This article focuses on seedling characteristics. Past research indicates that tissues of tree species tend to have very similar thermal death points and that physiological, anatomical, and especially morphological characteristics, better explain differences in heat resistance observed among seedlings. Lignification and hardening of the cortex, and self shading by cotyledons seem to be related to initial heat resistance of recently germinated seedlings (less than 6 months old). For older seedlings, self shading by foliage appears to become increasingly important for resisting heat damage.

Smaller seedlings are more prone to heat damage than larger seedlings. Some studies indicate that seedling diameter is related to resistance to heat damage, but it is not clear if this is so because of intrinsic characteristics related to stem diameter or of a relationship between stem diameter and the amount of foliage for self shading. Several studies have observed lower soil surface temperatures at the bases of young germinants and larger nursery-grown seedlings. Two studies also found that inclining the tops of planted seedlings to the south decreased heat damage, presumably by increasing self shading. Studies also indicate that cooling of the stem by the transpirational stream has a negligible or no effect on stem temperature, but that maintaining an adequate water supply may help prevent heat damage to foliage as well as decreasing the chances that a seedling will die from drought stress. Smaller seedlings are more prone to heat damage than larger seedlings, regardless of self shading.

With respect to southwest Oregon conditions, Adaptive FIR research indicates that among Douglas-fir seedlings, container grown plugs are most susceptible to heat damage, followed by 2-0 bareroots, with plug-1 transplants with bushy tops being little affected by heat damage. Ponderosa pine seedlings do not appear to be greatly damaged by high soil surface temperatures regardless of stocktype, although research elsewhere indicates that under some conditions, shading can prevent heat damage in pine.

This information corroborates observations made by southwest Oregon foresters. Natural regeneration is least likely to be successful on open clearcuts on south-facing sites with their greater amounts of incoming solar radiation because of the problem of heat damage (as well as other sources of seedling mortality). Natural seedlings less than two weeks old should be safe from heat damage when enough shade exists to maintain peak surface temperatures below lethal levels (approximately 126°F); lethal temperatures increases with size of seedling.

If 1-0 Douglas-fir plugs are scheduled for planting on flat or south-facing clearcuts, shading can increase survival. Shading the bases with inverted styrofoam cups seems to be as effective at lower cost as using shadecards or plastic mesh. Smaller bareroots, such as those used for emergency rehabilitation of burned areas, should benefit more from shade than larger bareroots, and bushy plug-1 transplants should be able to avoid heat damage without shading. All stocktypes of ponderosa pine generally do well without shade, although smaller stocktypes should also be more susceptible to heat damage and thereby benefit from artificial shade but this has not been documented.

In looking for stocktypes to plant on sites where high soil surface temperatures are thought to limit survival, seedlings with bushy tops with foliage close to the ground should do better than seedlings with thinner crowns, or with foliage located well above the root collar. If such seedlings are not available, then shading may be cost effective.

This information was abstracted from a review manuscript being prepared for publication. For details regarding specific studies, contact me at the Adaptive FIR office. Previous discussions on seedling shading have appeared in FIR Report 6(2):6-7, 6(3):4-5, 6(4):5, 7(3):11-12, and 8(3):9-11.

OH

Recent Publications

Copies of the following publications are available from Oregon State University at the address below.

Forestry Business Office
College of Forestry
Oregon State University
Corvallis, OR 97331

BIOMASS AND LEAF-AREA ESTIMATES FOR VARNISHLEAF CEANOTHUS, DEERBRUSH, AND WHITELEAF MANZANITA by T.F. Hughes, C.R. Latt, J.C. Tappeiner II and M. Newton. 1987. West. J. of Appl. For. 2:124-128. To help foresters assess site occupancy of seed-established stands of varnishleaf, deerbrush, and whiteleaf manzanita, we developed equations for estimating their aboveground biomass and leaf area. From 9 to 14 pure stands from 2 to 20 years old were selected for each species in southwest Oregon and northern California. Individual stems of Ceanothus species and whole bushes of manzanita were destructively sampled. Regression equations for leaf and total biomass of manzanita plants and for stems of Ceanothus sp. showed that these variables were highly correlated with trunk or stem diameter. Total biomass, leaf biomass, and leaf area index (LAI) of stands can be estimated accurately from measurements of stem or trunk basal area. Stand age (yr) and average stem length (cm) are also reliable estimators. It appears that stands of varnishleaf attain a maximum LAI of 5.5 m^2/m^2 by 7 years, whereas the maximum values for deerbrush and manzanita were 2.8 and 3.5, respectively, at about 15 years. Stands of all three species apparently continue to produce net biomass well beyond 16 years of age.

STREAM TEMPERATURE INCREASES AND LAND USE IN A FORESTED OREGON WATERSHED by R.L. Beschta and R.L. Taylor. 1988. Water Res. Bull. 24:19-25. The Salmon Creek Watershed drains 325 km^2 of forested terrain in the Cascade Mountains of western Oregon. Over a 30-year period (from 1955 to 1984) average daily maximum and minimum stream temperatures, calculated from the 10 warmest days of each year, have risen 6°C and 2°C, respectively. In contrast, a small decrease in maximum air temperatures was found over the same period. Regression analysis indicated a highly significant ($p < 0.01$) relationship between a cumulative index of forest harvesting and maximum stream temperatures. Maximum temperatures also tended to increase for several years following major peak flow events. The interaction between harvest activity (logging and road construction), changing forest and riparian management practices and the occurrence of natural hydrologic events (peak flows and associated mass soil movements) tend to obscure specific cause-and-effect relationships regarding long-term changes in maximum stream temperature.

LOAD-CARRYING CAPACITY OF SECOND-GROWTH DOUGLAS-FIR STUMP ANCHORS by M.R. Pyles and J. Stoupa. 1987. West. J. of Appl. For. 2:77-80. In order to quantify the stump anchor capacity of small second-growth Douglas-fir trees, load tests to failure were conducted on 18 stumps from trees 7 to 16.5 in dbh. The tests produced ultimate loads that varied as the square of the tree diameter. However, the ultimate load typically occurred at stump system deformations that were far in excess of that which would be considered failure of a stump anchor. A hyperbolic equation was used to describe the load-deformation behavior of each stump tested and was generalized to describe all the test results.

RESISTANCE OF CONIFERS TO BARK BEETLE ATTACK: SEARCHING FOR GENERAL RELATIONSHIPS by E. Christiansen, R. H. Waring and A.A. Berryman. 1987. For. Ecol. Manage. 22:89-106. Bark beetles are among the few native insects that can kill large numbers of trees in a single year. The present paper reviews recent work on the relationship between conifer resistance to bark beetle attack and tree vigor, e.g. in terms of wood production per unit of foliage. Experimental studies in the Pacific Northwest and the southeast U.S.A., and in Norway, are drawn upon to show that tree resistance to attack may be closely related to the amount of current and stored photosynthate that is available for defense. An experimental approach is advocated to critically test the relationship between host-tree resistance and the limitations on the transfer of critical resources to the site of attack.

HEIGHT GROWTH RATE OF DOUGLAS-FIR: A COMPARISON OF MODEL FORMS by D.W. Hann and M.W. Ritchie. 1988. For. Sci. 34:165-175. Five model forms were evaluated for their ability to predict height growth rate of individual Douglas-firs (Pseudotsuga menziesii [Mirb.] Franco) growing in even- or uneven-aged stands of southwest Oregon. Three models had been previously used for Douglas-fir; the fourth was a simple modification of one of these, and the fifth was developed in this study by means of multidimensional graphing and modeling. Two forms were age-dependent, in that they used transformations of stand age, and three were age-independent. The model developed by multidimensional techniques provided the lowest mean squared error for both an even-aged data set (1,763 observations) and a combined even- and uneven-aged data set (2,242 observations). The five models were verified on a randomly drawn subset of the data consisting of 241 observations. Again the model developed with multidimensional techniques had the lowest mean residual and the lowest mean squared error. Independent variables in this model are stand crown closure at the top of the tree, crown ratio, and potential height growth rate as predicted by an existing dominant height equation. The resulting model is age-independent and can be applied to trees in both even- and uneven-aged stands. Multidimensional techniques were most useful in modeling this complex nonlinear surface.

TIMBER-HARVESTING MECHANIZATION IN THE WESTERN UNITED STATES: AN INDUSTRY SURVEY by D. D. Schuh and L. D. Kellogg. 1988. West. J. Appl. For. 3:33-36. A survey of mechanized harvesting operations in the western United States located more than 140 timber companies and logging contractors using nontraditional manufacturing or transportation equipment during 1985. The operations ranged from small contractors owning a single feller-buncher to completely mechanized firms operating delimbers, debarkers, chippers, and felling machines. Most of the mechanized logging was found in Washington, Oregon, and Montana. Equipment breakdowns were the most critical harvesting problem cited by the loggers, followed by decreased production on steep terrain. Few contractors provide formal training for their equipment operators, a factor that may increase the frequency, duration, and severity of equipment downtime. Monetary incentive bonuses were used to spur production by approximately 35% of the responding firms.

PATTERNS OF LOG DECAY IN OLD-GROWTH DOUGLAS-FIR FORESTS by P. Sollins, S.P. Cline, T. Verhoeven, D. Sachs and G. Spycher. 1987. Can. J. For. Res. 17:1585-1595. Fallen boles (logs) of Douglas-fir, western hemlock and western red cedar in old-growth stands of the Cascade Range of western Oregon and Washington were compared with regard to their physical structure, chemistry, and levels of microbial activity. Western hemlock and western red cedar logs disappeared faster than Douglas-fir logs, although decay rate constants based on density change alone were 0.010/year for Douglas-fir, 0.016/year for western hemlock, and 0.009/year for western red cedar. We were unable to locate hemlock or red cedar logs older than 100 years on the ground, but found Douglas-fir logs that had persisted up to nearly 200 years. Wood density decreased to about 0.15g/cm^3 after 60-80 years on the ground, depending on species, then remained nearly constant. Moisture content of logs increased during the first 80 years on the ground, then remained roughly constant at about 250% (dry-weight basis) in summer and at 350% in winter. After logs had lain on the ground for about 80 years, amounts of N,P, and Mg per unit volume exceeded the amount present initially. Amounts of Ca, K, and Na remained fairly constant throughout the 200-year time span that was studied (100-year time span for Na). N:P ratios converged toward 20, irrespective of tree species or wood tissue type. C:N ratios dropped to about 100 in the most decayed logs; net N was mineralized during anaerobic incubation of most samples with a C:N ratio below 250. The ratio of mineralized N to total N increased with advancing decay. Asymbiotic bacteria in fallen logs fixed about 1 kg N ha^{-1} year^{-1}, a substantial amount relative to system N input from precipitation and dry deposition (2-3 kg ha^{-1} year^{-1}).

TWO-DIMENSIONAL ANALYSIS OF LOGGING TAIL SPARS by M.R. Pyles and E.V. Pugh. 1987. For. Sci. 33:971-983. A beam-column analysis of a skyline-logging tail spar was formulated and an example analysis made of a second-growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) spar (15.-in dbh) rigged at 40 ft. The analysis takes into account the taper of the spar tree, the flexibility of the base of the spar, and the eccentric restraining load at the top provided by guylines. Allowable skyline tension on the tail spar is shown to vary with skyline angle and guyline pretension. An optimum guyline pretension that produces the greatest capacity in the spar tree was found to be within a range attainable by hand tightening. The variation of allowable skyline tension with rigging height and spar diameter also is shown.

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