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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

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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.

Current Research
Adaptive FIR

UPDATE ON SHELTERWOOD OVERSTORY REMOVAL STUDY

Damage to regeneration during overstory removal continues to be an important problem in shelterwood management, especially on steep ground where skyline logging systems must be used. The Fall 1984 issue of the FIR REPORT (6(3):2-3) described an Adaptive FIR study that would concentrate on determining the relationships between reduction of stocking and the characteristics of the overstory and understory stand, terrain, and logging system on steep terrain in southwest Oregon. Data have been collected on this study for the past two years and we want to report our progress.

Study Methods

Thirty-eight cutting units on thirteen different Bureau of Land Management and Forest Service timber sales were selected for observation. A stocking survey of understory conifer seedlings and overstory stand conditions was, or will be, conducted before and after harvest on each unit. Overstory stand conditions are being determined from agency cruising records. The before- and after-harvest understory survey data on the units that have had the overstory removed have been compared to determine seedling damage resulting from harvesting.

Stocking surveys were conducted by establishing 3 survey lines across each cutting unit. Survey lines were placed parallel to the contour, across the upper, middle, and lower third of each unit. Circular 1 mil-acre plots were located at equal intervals along each survey line, spaced to provide a sampling intensity of 5 plots per acre. The intent of this design was to allow an assessment of the spatial relationships between seedling damage and slope position within the unit and along the skyline corridor.

Pre- and post-harvest surveys collected the following data from each sample plot: number of conifer seedlings by size class (12-inch increments); brush cover estimated by cover class (0-25%, 26-50%, 51-75%, 76-100%); average estimated brush height (feet); and the slope percent by slope class (0-30%, 31-40%, 41-50%, 51-60%, >60%). The preharvest survey included a measurement of distance from each sample plot to the nearest overstory tree. The post-harvest survey included measurements of slash depth (nearest 0.5 foot) on each plot and the distance in feet to the nearest skyline corridor.

An assessment of seedling crop-tree status was made during the post-harvest survey. A plot was considered stocked if an undamaged conifer seedling of crop-tree status (at least 1-foot tall and free to grow from surrounding aboveground competition) was present. As part of this survey, trees damaged by logging were classified according to the type of damage incurred. The following categories were used to characterize seedling damage:

1. No visible aboveground damage
2. Top damage, broken terminal leader
3. Stem breakage below terminal leader
4. Wound to bole of tree, bark stripped off
5. Tree pushed to ground, but not pinned by debris
6. Tree pinned to ground by logging slash
7. Lateral branches missing
8. Tree chlorotic
9. Tree dead

These are the same damage categories that are being used in the Seedling Damage Recovery Study (FIR REPORT 6(3):2).

Summary of Damage Data

Table 1 presents the information available on cutting units that have had the overstory removed. Overstory removal has not been completed on all units but regression analysis was used to determine the preliminary relationship between seedling damage and overstory gross volume. The percentage of seedlings per acre damaged during logging was strongly related to overstory volume ($r^2 = 0.77$). This relationship is displayed in Figure 1. The resulting regression equation is:

% Seedlings Dam. = 16.13 + 1.56 (Gross Vol.(MBF)/Ac.)

The percentage of seedlings that were damaged during logging was calculated by the following formula:

$$\% \text{ Seedlings Dam.} = 100 - \frac{\text{Undam. Seedlings/Ac.} \times 100}{\text{Total Seedlings/Ac.}}$$

The statistical relationship between these two variables and the resulting regression equation will change slightly as more data are added, so this should only be considered as an interim report.

TABLE 1.--Summary of overstory stand characteristics and seedling damage (all species) following overstory removal by skyline logging system.

Sale name	Unit	Size (Acres)	Gross Vol/Ac. (MBF)	TPA	Average DBH(in.)	% Regen. Damaged
A	1	27.3	11.0	14	24	32.0
	2	14.0	12.9	15	28	37.1
	3	12.0	17.7	15	28	37.3
	4	21.0	14.3	13	24	43.6
	5	12.0	14.6	16	24	37.0
	6	7.0	17.7	15	28	35.8
	7	15.6	13.2	14	26	45.1
B	1	10.0	11.4	7	28	43.1
C	1	22.0	8.1	13	22	36.4
	2	36.9	8.5	14	22	37.3
	3	13.7	7.4	13	22	33.0
	4	15.0	6.2	11	22	25.8
	5	12.0	6.9	12	22	27.7
D	1	18.3	29.6	29	24	62.9
	2	17.3	22.5	18	24	43.7
	3	18.4	27.5	27	24	59.6
	4	8.5	25.5	25	24	58.1
	5	6.0	23.2	21	24	54.9
	6	16.0	20.5	21	24	41.8
E	1	19.0	5.7	6	28	21.3
	2	27.7	6.2	6	28	23.2
F	1	14.0	35.1	13	37.9	79.5
G	1	8.0	11.0	15	18	10.6
	2	7.0	13.0	15	18	15.2

Observations

We have made some qualitative observations on the 24 harvested cutting units during the process of completing the surveys and looking at the results. Subsequent verification and testing of these observations will be completed as the analysis continues.

Five of the already harvested timber sales contained two or more overstory removal units. The difference in percentage of seedlings damaged between one cutting unit and another within the same sale was relatively small. However, the percentage range of seedlings damaged between units of different sales was substantially greater (Table 1). This is not surprising, and we think it can be explained in part by the fact that within individual sales there were relatively consistent volumes per acre, overstory tree sizes, and understory stand characteristics for all of the overstory removal units. By comparison, the variation in these factors between the five different sale areas was much greater. Using these data, we hope to explain how much of the variation in stocking reduction is attributable to on-site conditions versus operational conditions, such as the yarding system used.

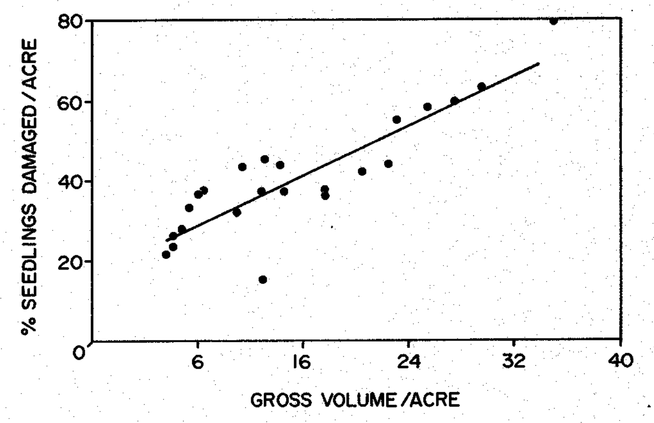

FIGURE 1.--Relationship between gross volume per acre (MBF) and percentage of seedlings damaged per acre.

Is Time-of-year an Important Factor?

Sales C and E each had a substantial component of ponderosa pine regeneration prior to overstory removal (48% and 61%, respectively). Sale E was harvested during the late spring and early summer when active seedling growth was occurring. Sale C was logged during the late summer and fall after the regeneration had set bud. Results of the post-harvest surveys indicate a much higher percentage of damage to the pine terminal leaders in the units logged during active shoot elongation (Table 2).

A higher percentage of the total number of seedlings was damaged in Sale C (Table 2). However, the percentage of damaged trees in this sale having terminal leader damage was between 0 and 8 percent. In comparison, between 45 and 67 percent of the damaged seedlings in Sale E had terminal leader damage. Size class distribution of seedlings in the two sales was similar. Most (about 90%) were less than 3 feet tall. The same logging contractor harvested both sales using the same yarding equipment. These data seem to indicate that, if terminal leader damage to understory ponderosa pine is important, it can be reduced substantially by conducting overstory removal during that time of year when active shoot elongation is not taking place.

TABLE 2.--Terminal leader damage to ponderosa pine seedlings in two different timber sales.

Sale	Unit	TPA	Total % of Damaged Seedlings	% of Seedlings With Term. Ldr.Damage	% of Damaged Seedlings With Terminal Dmg.
E	1	590	24	16	67
	2	570	25	11	45
C	1	412	35	3	8
	2	326	46	3	7
	3	184	29	0	0
	5	158	44	0	0

Seedlings Pinned Under Logging Slash

One of the most common types of damage to seedlings less than 3 feet tall is becoming "pinned" beneath logging slash. Table 3 summarizes data on pinned regeneration from 5 units of Sale C, where from 70 to 298 seedlings per acre were pinned under slash. This represents between 25 and 60 percent of the damaged trees. Recognizing this as a regeneration problem on this sale, managers sent crews into these units following logging to uncover the pinned trees. Production rates of this uncovering work show that on unit 1 eight acres of pinned trees per man day were uncovered. Fifteen acres per man day were uncovered on unit 3. We looked at these data to assess the increase in stocking that could be realized by such a practice. On this sale, a gain of up to 42 crop trees per acre was possible. This analysis was done by looking only at our stocking survey information, which considered only pinned trees that had no other damage and that occurred on plots not already having a crop tree present. It assumes a 100 percent success rate in uncovering trees meeting these criteria.

TABLE 3.--Analysis of seedlings pinned to ground by logging slash in timber sale C.

Unit	Pinned TPA	% of Damaged Trees Pinned	% TPA Pinned	Pinned Crop TPA[1]	% Increase in Crop TPA
1[2]	298	60.3	21.9	30.0	9.6
2	138	37.9	14.1	42.5	15.4
3	79	25.0	8.0	13.1	4.7
4	82	29.3	7.5	15.1	8.3
5	70	30.7	8.4	0	0

[1] This column represents the potential increase in crop tree stocking attained by uncovering pinned trees. In order to be included, a sampled tree that was uncovered must have had no other visible damage, be at least 1 foot tall, and occur on a plot without another crop tree.

[2] The timber in this unit was yarded downhill.

The crews that did the uncovering work, however, did not use these same guidelines. Instead, they uncovered all pinned trees encountered, regardless of other damage or proximity to undamaged crop trees. The gain in individual tree stocking (trees per acre) following this procedure would be more closely approximated by the figures in column 2 (Table 3). The long-term gain in both methods, of course, would be reduced by any mortality occurring in uncovered trees that had other damage from which they will not recover. The projected increase in stocking presented here (column 6) is therefore a conservative estimate.

Forest managers may want to consider this practice, particularly when crop-tree stocking levels are low and moderate-to-heavy slash loadings have been generated. Size-class distribution of seedlings should also be considered since smaller seedlings (<3 feet tall) are the ones most susceptible to being pinned. This information would come from preharvest stocking surveys. Uncovering pinned trees may be a more cost effective way of achieving target stocking levels than the more common practice of interplanting. Logistically it is a simpler process to implement. We don't have any data on survival and recovery of unpinned trees yet, but managers from southwest Oregon and other parts of the state report favorable results. In planning such an operation, minimizing time between logging and unpinning is important.

Future Plans

There are still 13 units to be harvested. Those that are logged during 1986 will be included in the data set that we will begin analyzing this fall. The ones that are not logged until later will be used for testing the predictive equations.

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James Kraemer, Adaptive FIR

Fundamental FIR

HERBICIDE APPLICATIONS: PATTERNS OF DEPOSITION AND DEGRADATION

Aerial application of herbicides in 1979 and 1980 to sclerophyll brush types in southwestern Oregon led to some residue patterns that are similar in many respects to residue data reported elsewhere. This article summarizes these results.

Helicopters deposited five-sixths or more of their spray on the immediate target when using drops of about 1,000 micron average drop size. Drift occurred only when strong gusts of wind occurred while the helicopter was releasing the spray, and potentially plant-damaging quantities of drift were restricted to the immediate vicinity of the sprayed plots. Most of the time, there were no measurable deposits outside sprayed plots. Of the spray landing on the target vegetation, dense tanoak sprout communities 6-8 years old intercepted most of the spray in their upper foliage. Foliage at the browse level had one-third the concentration of the upper crowns. Concentrations in crowns were 44 mg/kg for each kg/ha applied, and in the browse layer, 17 mg/kg per kg/ha applied. Concentrations in litter were midway between crowns and browse layers.

In the above-ground vegetation, concentrations of 2,4-D, triclopyr and picloram decreased rapidly at first. After foliage turned brown, degradation was very slow in dead leaf material, but rapid in litter. Apparently the herbicides are all immobile and decomposers are not very active in aerial parts of hardwoods. When the foliage falls and becomes litter, degradation is rapid. In no situation is leaching an apparent factor in herbicide loss. Deposits on soil remain near the surface, and are apparently degraded in place. When contaminated litter falls, it is degraded in place without apparently contributing to soil residues.

There is apparently considerable loss of herbicide from foliage through processes unrelated to microbial activity. In the first two months after application, while foliage and soil surfaces were completely dry, major losses were occurring in all three herbicides, probably due to breakdown by ultra-violet radiation. Picloram disappeared faster than any other herbicide. Ester and amine formulations disappeared at different rates, with the amines disappearing faster than esters. Because amines are nonvolatile and also do not penetrate into foliage as rapidly as esters, it is likely that photodegradation was the cause, destroying the unabsorbed deposits.

Rapid losses of salt formulations from foliage in direct sun suggests that amine or other nonvolatile products of this herbicide group will never be suitable for this use. The rapid penetration and tie-up of the esters, however, is a strong indication that volatility losses were extremely small, despite summer conditions.

Detectable traces of all herbicides and formulations other than picloram were present 325 days after application, at which time 1-3 percent of the initial deposit remained in soil. Their presence in surface soil and in the dead foliage that had not fallen attests to the immobility of herbicide residues in areas having 40-140 inches of annual rainfall and steep, skeletal soils.

The tenacity of the low residues against removal from foliage by heavy rains suggests that the residues will similarly not be removed by chance human contact. The low residues in reach of ground-dwelling herbivores and the generally unattractive nature of the dead foliage guarantees wide margins of safety for wildlife in sprayed areas.

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SEED ZONES FOR SUGAR PINE

The zones that are presently used to guide seed transfer and breeding of sugar pine in southwest Oregon are derived from a map printed by the Western Forest Tree Seed Council in 1966. The Council members developed the map from some "best guesses" by local foresters. The members attempted to classify the region into zones of homogeneous environment by using the foresters' common knowledge about climate, growth potential, and growth habit of indigenous tree species, primarily Douglas-fir. Seed zones ideally should be based on information about the long-term effects of seed transfer. An alternative basis would be information about the genetic structure and habitat of the species. Neither of these kinds of knowledge was available for sugar pine when the seed zone map was made in the early 1960's.

Comprehensive data about effects of seed transfer can come only from field tests carried to rotation age. In a heterogeneous region such as southwest Oregon, an experimental design that adequately samples genetic and habitat variation requires many transfers from many seed origins to many plantation sites. Any fewer origins and sites produces results that cannot be extrapolated from test to commercial sites. Long-term experiments on this scale, however, are generally not affordable or practical.

One alternative to the long-term field test approach is to map genetic variation patterns as they exist in the native stands. In this procedure, genetic variation is estimated in short-term nursery tests. The assumptions are: (1) genetic variation among local populations arises from natural selection within environments that differ among populations, and (2) the greater the genetic difference among local populations, the greater the risk in transfer of seedlings between the origins of populations. Given these assumptions, a map of genetic variation can be used to devise provisional zones.

We have completed an experiment to map patterns of genetic variation for sugar pine in southwest Oregon. For the experiment, cones were collected from 200 sample trees at 142 locations in the region. Seedling progeny from the open-pollinated seeds of each tree were grown as families in a common-garden nursery to evaluate the genotypes of the parents. Genetic variation among the families in several traits indicated that two principal components of genetic expression could be used to describe adaptive differences between populations. For each component, the variability among local populations accounted for about 50 percent of the genetic variability among all families. The remaining 50 percent of genetic variation was contributed by families within local populations.

Natural selection apparently has created local populations within the region which vary genetically in complex patterns along complex environmental gradients. Distance from the ocean, elevation, and latitude were the most effective indexes of the environments that have acted in natural selection to produce the differences among populations. Annual precipitation and aspect were less valuable as predictors of genetic variation patterns.

The zones we developed from the genetic variation patterns differed greatly from the zones recommended in the Forest Tree Seed Council map. If a zone is considered as having boundaries of latitude, east-west departure, and elevation, the new zones are larger in all three dimensions. Within southwest Oregon, two of the new zones were recommended at low elevations (<2400'), two at middle elevations (>2400' and <3800'), and four at high elevations (>3800').

Risks of poor adaptation, which were estimated by simulated transfers within a zone, suggests that 50 percent of seedlings may be poorly adapted in an extreme transfer within any of the new zones. In the average transfer, however, fewer than 25 percent are likely to be poorly adapted. This seems to be a reasonable goal, given common experience about the effects of poor adaptation on future productivity and, given that reasonable numbers of seedlings are planted per acre.

Our estimates of risk apply only to transfers from a sugar pine site to another sugar pine site within the zone. The provisional zones also are appropriate only for sugar pine. Zones for Douglas-fir or for other species may be greatly different in size and configuration.

The new seed zone maps are presently being drafted and will be published through the PNW Research Station. For interested people who need further information at this time, contact me directly at the Forestry Sciences Lab in Corvallis or call (503) 757-4342.

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THE WHITE FIR SERIES OF THE SISKIYOU MOUNTAIN PROVINCE

[Part II of a 2-part article. Part I appeared in the Summer 1986 issue of the FIR Report - 8(2):4-6. This part provides Association descriptions.]

The White Fir Series represents the ecological middle in southwest Oregon. The amplitudes of environmental, geological, topographical, and vegetational diversity meet and overlap in the associations described in this article. Elevations range from 600 to 1,830 m. Parent materials include ultrabasic peridotite and serpentine, acidic granitics and granodiorites, and fertile schists. Sites range from the Siskiyou and Coastal Mountain crests to stream draws and broad mountain valleys. Codominant tree species include mountain hemlock, Shasta red fir, Alaska-cedar, Douglas-fir, and ponderosa pine.

We have divided the Series into six groups: Shasta Red Fir, Sadler Oak, Alaska-cedar, Brewer Spruce, Moderate, and Warm Associations. Each group represents a shift in one or more of the above characteristics, resulting in different management requirements. Management within the groups may also have to be tempered, dependent on the particular association.

White fir is a highly productive species; it can be regenerated in all White Fir Associations. Although, the degree of purity will vary between associations, in almost all cases other species should be included to maximize site potential and insure diversity. Regeneration entries should take advantage of as much advanced and subsequent natural reproduction as possible. Precommercial and commercial entries should be well-prescribed and executed as white fir is particularly susceptible to rot if damaged.

Shasta Red Fir Associations

Shasta Red Fir and Sadler Oak Associations represent the cold, moist end of the White Fir Series. In the first group, Shasta Red Fir is the significant codominant with climax white fir. Soils are relatively deep and less rocky than in the Sadler Oak Associations. Both true firs produce volume well. Mountain hemlock presence indicates low ambient temperatures, where Douglas-fir growth will be marginal. Incense-cedar regeneration should be included in the regeneration mix on sites with either basic soils or significant root rot.

WHITE FIR - SHASTA RED FIR / CURRANT. This association is found primarily east of Cave Junction in the Illinois Valley. Several currant species occur making blister rust risk high. Overall volume production is moderate. Shrub and herb competition may be significant, especially where snowbrush ceanothus is present. Alaska oniongrass and Idaho fescue are two grasses well-suited for erosion control seeding.

WHITE FIR - SHASTA RED FIR / BALDHIP ROSE. This association occurs on mid-slope positions in the western and eastern Siskiyous. The temperature range is narrower and consequently the environment is less restrictive than in the previous association. Site potential is higher. Douglas-fir is more appropriate in the regeneration mix. Port-Orford-cedar is appropriate in draws and other sites, where morning fog reduces evapotranspirational demand, replenishes soil moisture, and maintains available moisture throughout the growing season. Current species are common, contributing to white pine blister rust risk. Shrub and herb cover is slightly less than in the previous association, but competition potential remains high. Duff protection on fragile granitic soils is critical for maintaining site potential and preventing erosion.

WHITE FIR - SHASTA RED FIR / CREEPING SNOWBERRY. This association is found throughout the Siskiyou Mountains and possibly in the coastal crest rain shadow. It is the least productive of these three associations. True firs are most appropriate for regeneration on wetter sites, indicated by coolwort foamflower. White-flowered hawkweed and several larkspur species indicate drier sites where Douglas-fir regeneration may be included. Rock and bareground are two to three times more common than in the previous two associations.

Sadler Oak Associations

Sadler oak is the major associate with white fir in this group. Sadler oak is restricted primarily to sites with shallower soils and larger amounts of surface rock. Sadler oak is a branchy, woody shrub very similar to Pacific rhododendron in appearance. It indicates cool sites and can be a tough competitor with regeneration. The four Sadler Oak Associations are slightly more productive than the Shasta Red Fir Associations. White fir and Shasta red fir are appropriate for regeneration in all four associations.

WHITE FIR - SADLER OAK / WESTERN PRINCE'S-PINE. This is the most productive of the four associations and is found throughout the western Siskiyous and portions of the coastal rain shadow. Soils are relatively deep, derived from granitics or other metamorphosed parent materials. Surface rock content may be high, although that layer is often alluvial and shallow. Thin-leaved huckleberry and Rocky Mountain maple indicate soil temperatures which may limit Douglas-fir survival and growth.

WHITE FIR - SADLER OAK/ DWARF OREGONGRAPE - OREGON BOXWOOD. This association occurs primarily at mid-elevations on northerly aspects of the western Siskiyous. Compared to the previous association, soil and air temperatures are less likely to limit growth and there is less surface rock present. Total shrub and herb cover is relatively high. Douglas-fir, incense-cedar, sugar pine, western white pine, and Port-Orford-cedar (lower-elevation concavities only) are also appropriate species for regeneration. Dwarf Oregongrape indicates deep, productive soils. White inside-out-flower indicates moist sites.

WHITE FIR - SADLER OAK / DWARF OREGONGRAPE. This association occurs broadly throughout the western Siskiyous and coastal rain shadow at mid-elevations on east to southeast-facing slopes. Douglas-fir, incense-cedar, and sugar pine are also appropriate in selected areas indicated by the absence or reduced cover of dwarf Oregongrape (shallower soils). Surface rock cover is relatively high (19 percent), which may be a barrier to planting.

WHITE FIR - SADLER OAK / GOLDEN CHINQUAPIN. This association occurs from the coastal rain shadow east through the western and eastern Siskiyous on southerly slopes. Surface rock is relatively low (3 percent). This association is the warmest, driest, and least productive of the Sadler Oak Associations. Golden chinquapin indicates shallower, sometimes nutritionally poor soils. Canyon live oak occurs less frequently, and is a strong indicator of shallow soils, hot sites, and poor moisture holding capacity. Douglas-fir, white fir, and incense-cedar should be preferred species for regeneration.

Alaska-cedar Association

WHITE FIR - ALASKA-CEDAR. This association is part of the "sensitive" list of the White Fir Series. Its rare occurrences are at high elevations in north-slope concavities on the Galice and Applegate Ranger Districts. Alaska-cedar is near the southernmost extent of its natural range in the Siskiyou Mountain Province. Sites are cool and are relatively moist. Because of the unique environment that Alaska-cedar requires, there are often other sensitive plants present, including Oregon Bensonia, Oregon bleedingheart, broad-scaled owl-clover, and Applegate gooseberry.

Brewer Spruce Associations

Brewer Spruce Associations identify a unique combination of parent material, elevation, and local climate. Brewer spruce competes well on shallow, infertile, cool soils and at low evapotranspirational demand. Where these conditions fluctuate, other species gain competitive advantage. Brewer spruce is a relict from a warmer, moister climate that once prevailed in the Province. Stands are open and differ significantly from surrounding forests. These three associations, then, make excellent wildlife habitat and provide important forest diversity.

WHITE FIR - BREWER SPRUCE / THIN-LEAVED HUCKLEBERRY. This association is the coolest and least productive of the Brewer Spruce Associations. It occurs in the Western Siskiyous. Brewer spruce, white fir, and Shasta red fir will out-produce Douglas-fir. Sadler oak will compete with any conifer regeneration. Thin-leaved huckleberry indicates cool, moist sites. Creambush oceanspray indicates either shallow or infertile soil conditions.

WHITE FIR - BREWER SPRUCE / SLENDER SALAL. This association is the wettest and most productive of the Brewer Spruce Associations and is found in the western Siskiyous on northerly aspects. Soils are relatively deep, derived from schist (one of the most productive parent materials of the Siskiyou Mountain Province) and other metamorphosed materials. Warm, moist-site indicators include Pacific rhododendron and golden chinquapin. Thin-leaved huckleberry is replaced by red huckleberry. Slender salal, a cool, moist indicator, is at the coolest extreme of its range. Douglas-fir and sugar pine are well-suited for regeneration in open conditions.

WHITE FIR - BREWER SPRUCE / WESTERN PRINCE'S-PINE. Extending from the western Siskiyous into the coastal rain shadow, these sites are the warmest and driest of the Brewer spruce trio. Shasta red fir occurs on the cooler site, while Pacific yew is restricted to warmer concavities or streamside situations. Currants are common, giving a high risk of white pine blister rust.

Moderate Associations

The next group of associations represent the middle of the White Fir Series. There are various species which codominate with white fir. White fir and Douglas-fir are appropriate for regeneration in all associations. Phytophthera lateralis (Port-Orford-cedar root rot) presence and white pine blister rust potential (also infects sugar pine) should be considered in species selection.

WHITE FIR - TANOAK. This association occurs primarily in the coastal rain shadow (less often in the western Siskiyous) on westward-tending slopes. Tanoak is the major codominant indicating a relatively productive site, although it is a significant competitor with regeneration. Tanoak, Port-Orford-cedar, and sugar pine indicate productive, moist sites. Dwarf Oregongrape and western twinflower are corresponding indicators of high productivity potential and moist conditions. Creeping snowberry indicates the drier extreme of the association and sword-fern the moister extreme. Moisture may be available from soil reservoirs or indirectly from reduced evapotranspiration demand created by frequent foggy days during the growing season. Canyon live oak indicates shallow, coarse soils. Overall site productivity is dependent on surface rock depth. Sugar pine and incense-cedar are also appropriate for regeneration. Port-Orford-cedar is appropriate where red huckleberry is found.

WHITE FIR - PACIFIC YEW. This association is found primarily in the western Siskiyous, but also in the eastern Siskiyous and coastal rain shadow. Pacific yew indicates warm, humid growing conditions, as does the abundant ground cover of moss. Relatively deep soils (although some concavities may be covered with a rocky mulch), ample ground and atmospheric moisture, and moderate temperatures combine to produce good site productivity. Sugar pine is also well-suited in the regeneration mix. Tanoak and other shrubs may heavily compete with regeneration. The herb layer is rich and abundant (108 percent cover).

WHITE FIR - PORT-ORFORD-CEDAR. Limited almost exclusively to the Illinois Valley Ranger District, this association is found on northwest slopes at slightly higher elevations than the previous two associations. Parent material ranges from acid-igneous granitics to mixed metamorphic. Although granitic soils are typically less fertile, reduced evapotranspiration demands due to high humidity and frequent fog compensate, resulting in good productivity. Port-Orford-cedar and incense-cedar are also appropriate for regeneration. Vanillaleaf, trail-plant, threeleaf anemone, and western twinflower are moist indicators. Vanillaleaf is a cool site indicator while the remaining three are warm indicators.

WHITE FIR - PORT-ORFORD-CEDAR / DEPAUPERATE. This association occurs primarily on the Illinois Valley Range District at mid-elevations, on easterly facing slopes, and on granodiorite parent materials. Port-Orford-cedar presence indicates available moisture during periods throughout the growing season, usually in the form of morning fog. Douglas-fir is best suited for regeneration, followed by white fir, Port-Orford-cedar, incense-cedar, and sugar and western white pine; a mixture would be best. Dwarf Oregongrape and western prince's-pine indicate good productivity potential. Pinemat manzanita indicates the shallower soils.

WHITE FIR / DWARF OREGONGRAPE. This association occurs commonly throughout the Siskiyou Mountain Province, primarily in the western Siskiyous. Maximum tree biomass production occurs with a combination of Douglas-fir and white fir. Stocking level control is essential to maximize growth and minimize mechanical damage and mortality. These sites are floristically rich in both shrub and herb layers, consequently vegetation management may be required.

WHITE FIR - ROCKY MOUNTAIN MAPLE. This association occurs in both the eastern and western Siskiyous, although most commonly in the eastern portion. It is typically found at moderately high elevations with fairly deep soils derived from granitics and metavolcanic materials; the metavolcanic parent materials are more productive than the granitics because of the lower temperature extremes, high moisture-holding capacity, and decreased erosivity. Overall, the environment is cool and dry. Rocky Mountain maple and baneberry indicate cool temperatures; creambush oceanspray indicates dry conditions. Some sites are too cool for maximum Douglas-fir production.

WHITE FIR / HERB. This association is widespread throughout the Siskiyou mountains at moderately-high elevations, but most common in the central portion. Timber and forage productivity are higher than in the Rocky Mountain Maple Association. Parent materials range from ultrabasics to extremely fertile schists. The herb layer is floristically rich with no one species dominating. Threeleaf anemone and Oregon fairy-bell indicate cool sites. Opportunities for other commercial tree species include Douglas-fir, incense-cedar, and blister rust resistant sugar pine. Common species are mountain sweet-root, California brome, and leafy peavine; the latter two are excellent for erosion control application and soil stabilization.

Warm Associations

The remaining associations represent the warmer, drier end of the White Fir Series. Douglas-fir, with white fir, is typically the most appropriate species for regeneration. Sugar pine is also a good choice where there is little risk of white pine blister rust infection or where rust-resistant stock is available.

WHITE FIR - DOUGLAS-FIR. This association occurs on both sides of the Siskiyous. It is present on a wide variety of environmental conditions and is not specific to a particular parent rock, elevation, or aspect. Productivity is average for the Series. This is one of the best sites for sugar pine production. Canyon live oak, California hazel, and creambush oceanspray indicate warm conditions. Creambush oceanspray cover is directly related to probability of moisture limitations.

WHITE FIR - DOUGLAS-FIR / DWARF OREGONGRAPE. This association occurs mostly in the western and eastern Siskiyous, and some in the coastal rain shadow. This association is similar to the White Fir/ Dwarf Oregongrape, but is less productive. More naturally-regenerated Douglas-fir occurs in this association. The drier environment makes Douglas-fir better suited than white fir for regeneration. Sugar pine and incense-cedar are also likely candidates for regeneration.

WHITE FIR - DOUGLAS-FIR / DEPAUPERATE. This association is located primarily in the eastern Siskiyous. A significant characteristic is the sparse, or depauperate, shrub and herb cover. Soil depth is below average for the Series. Granodiorite is the most common parent material, creating erosion control and regeneration difficulties. Ponderosa pine and sugar pine are also appropriate for regeneration. White fir establishment will be difficult, at best, as natural white fir regeneration is slow to become established. Although shrub cover is minimal in mid-seral to climax stands, vegetation management will be essential after a regeneration entry.

WHITE FIR - DOUGLAS-FIR / CREAMBUSH OCEANSPRAY. This association is hotter and drier than the previous two, ranging from the eastern Siskiyous to the coastal rain shadow. Site productivity is about the same and regeneration establishment is difficult. Dwarf Oregongrape indicates better sites and tall Oregongrape indicates shallow, coarse-textured soils with high coarse fragment content. Burning may degrade soil structure and fertility. Additionally, Ceanothus invasion after burning is likely. Western starflower, woodland tarweed, and leafy peavine are good choices for erosion control and cutbank stabilization seeding.

WHITE FIR - PONDEROSA PINE. This is the hottest and driest of the White Fir Associations, occurring in both Siskiyou Mountain climatic regimes. Timber productivity is fair. Douglas-fir, ponderosa pine, and incense-cedar are best suited for regeneration. White fir growth will be retarded by environmental conditions, although it will survive and eventually dominate the stand. Creambush oceanspray indicates hotter sites and creeping snowberry drier sites. Soil protection is important and shrub control may be necessary.

WHITE FIR / CREEPING SNOWBERRY. This association occurs at mid-elevations in the eastern and western Siskiyous. Soil depths are average, derived from all rock types. Regeneration may not be as difficult as in the Douglas-fir and ponderosa pine codominated associations but potential for soil instability and seedling establishment problems is present. Ponderosa pine, sugar pine, and incense-cedar are also appropriate species for regeneration. Ceanothus species may invade burned sites.

Summary

The White Fir Series is one of the most widespread in southwest Oregon, encompassing a broad range of environmental conditions. Consequently, the diversity of species and associations is also high. Mixed-species stand management is probably the best way to insure long-term productivity, maximize site potential, and buffer the stand against common pests and diseases.

A list of scientific names for common plant names used in this article is available from the authors. If there are any questions or comments, please contact us at Siskiyou National Forest, Grants Pass, OR 97526, (503) 479-5301 or at Forestry Sciences Lab, 3200 Jefferson Way, Corvallis, OR 97331, (503) 757-4361.

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Continuing Education

STREAMSIDE MANAGEMENT: RIPARIAN, WILDLIFE, AND FORESTRY INTERACTIONS

February 11-13, 1987. University of Washington, Seattle. Topics include riparian community characteristics, alterations resulting from forest management, ecological relationships of wildlife and riparian habitat, current riparian management practices, and social aspects that influence forest management decisions. Contact: Continuing Education Office, College of Forest Resources, AR-10, Univ. of WA. Seattle 98195. Phone: (206) 543-0867.

EDITOR'S NOTE: The following FIR-related workshops are planned for 1986-1987. As detailed information becomes available, further announcements will appear in this newsletter and program announcements will be mailed to all FIR Report recipients. In the meantime, questions should be addressed to the Adaptive FIR secretary, Lenore Lantzsch, or the workshop directors.

SOILS, SITE CLASSIFICATION AND FOREST PRODUCTIVITY IN SOUTHWEST OREGON

Spring, 1987. Medford. Details to be announced. Workshop director: Dave McNabb.

OVERSTORY REMOVAL: SEEDLING DAMAGE AND FUTURE GROWTH

June, 1987. Medford. One-day workshop will discuss overstory removal, seedling damage recovery and release potential. Workshop directors: Steve Tesch and John Mann.

OPERATION OF THE SOUTHWEST OREGON VERSION OF THE ORGANON GROWTH AND YIELD MODEL (SW-ORGANON)

July, 1987. Corvallis. This two-day workshop will provide hands-on instruction in the operation of SW-ORGANON, and a detailed explanation of how the model operates internally. Workshop director: Dr. David Hann, College of Forestry, OSU. (503) 754-4673.

INTRODUCTION TO THE SOUTHWEST OREGON VERSION OF THE ORGANON GROWTH AND YIELD MODEL (SW-ORGANON)

July, 1987. Medford. One-day introductory workshop for people interested in using the output from SW-ORGANON for decision making. Workshop director: Dr. David Hann, College of Forestry, OSU. (503) 754-4673.

FOREST WEED CONTROL WORKSHOP

Summer 1987. Details to be announced. Designed for silviculturists and others seeking to update knowledge of forest weed control technology. Workshop director: Ole Helgerson.

Of Interest

ARTIFICIAL SHADE -- HOW SHOULD IT BE USED?

Foresters know that excessive heat kills newly planted Douglas-fir seedlings. Indeed, the fact that heat can kill seedlings contributed to the shift from clearcutting to shelterwood management in the late 1960's and early 1970's. But, with advances in seedling quality and weed control, reforestation of hot, dry, south-facing sites has improved, regardless of silvicultural system. Now, clearcutting and planting these sites offers reasonable certainties of meeting stocking standards. However, observations continue that heat kills some seedlings planted on south-facing clearcuts. This article reviews available knowledge of artificial shading, to help refine our site-specific prescriptions of this technique.

Experience and research show that shadecards or other shade devices nearly always increase seedling survival on south aspects. The increases can be large, but at other times, seedlings survive very well without shade. In the recent past, Douglas-fir seedlings planted on south-facing sites have been almost routinely shaded. But now, constrained reforestation budgets often prevent shading of seedlings on south-facing sites. The question arises, under what conditions are the costs of artificial shade justified? The answer to this question is complex; however, a review of operational experience and the literature suggests situations when and what type of artificial shade will be most beneficial.

How Heat Kills Seedlings

Foresters have debated whether Douglas-fir seedlings are killed by high temperatures within foliage, the stem or the roots. Fundamental FIR studies indicate that foliage temperatures are within three degrees Celsius of the surrounding air temperatures. Although water use increases with foliage temperature, these temperatures appear to generally remain below the threshold for direct damage of cellular protoplasm. Research and observation indicate that the most likely spot for lethal tissue temperatures to occur is the root collar area just above or below the soil line. Heat damage can be clearly identified by stem swelling or lesions at or slightly above the ground line, although damage below the soil may be less apparent.

When and Where - Environmental Factors

Little research exists to precisely predict the "when and where" of shadecard use. But, existing information corroborates the observations of many foresters.

Aspect. Experience from all who work in the woods certainly indicates that south-facing slopes are hotter and seedling mortality is greater there than elsewhere. Indeed, Don Minore of the PNW Research Station (PNW), found that reforestation in the Siskiyous becomes more difficult as solar radiation increases. In a study of artificial shade and seedling survival on different aspects, Steve Hobbs of Adaptive FIR observed that shadecards significantly increased survival of 1+0 Douglas-fir plugs on a south-facing slope (controls, 60 percent; shaded, 87 percent) but did not significantly increase seedling survival on east-, west-, or north-facing slopes.

Research results indicate that annual heat loads reach a second peak on south-facing slopes in mid- to late-summer, and that this is the time of greatest potential mortality for planted Douglas-fir seedlings. Research on natural germinants suggests, however, that these may be in jeopardy as soon as early June, particularly on unshaded microsites with a duff cover, dark soil or organic soil. Annual variation in heat loads is more difficult to predict. Heat events vary from year-to- year in intensity and duration. Calculating the probabilities of lethal heat events is further complicated because soils vary in thermal characteristics, seedling stocktypes appear to differ in their response to heat loads, and seedling mortality depends on soil temperature and duration of exposure.

Soil and Seedbed Characteristics. Research indicates that soils with low heat conductivity and low heat capacity increase heat loads on seedlings. As with dark soils or soils with much litter or organic matter, dry soils heat more quickly to lethal temperatures than damp soils. Dampened, light-colored mineral soils tend to stay the coolest.

Research by Roy Silen at PNW found that Douglas-fir germinants growing in peat or soil with duff were killed more quickly by radiant heat and at lower soil temperatures than germinants growing in yellow forest soil or white sand. Stuart Childs of OSU suggests that skeletal soils have lower rates of internal heat transfer and thus higher surface temperatures than non-skeletal soils and that for any soil, the hottest area will be at the surface. Two other studies indicate that survival increases from artificial shade are proportionally greater as soil rock content increases. But, in these studies, survival of shaded and unshaded seedlings declined as rock content increased.

Seedling Factors - Species, Stocktype, Vigor

Stem tissue damage from lethal heat loads appears to be related to seedling size, stocktype and species. Unfortunately, definitive studies do not exist that elucidate the relationships between heat damage and seedling characteristics such as stem caliper, foliage structure, and vigor.

Self Shading. Foresters and researchers have speculated that bushy stocktypes or seedlings with foliage near the soil line may adequately shade the stem. Seedlings with more self shading, with other characteristics such as root growth and plantability also being adequate, should withstand heat loads better than seedlings with less self shading.

Caliper. Caliper tends to be positively associated with foliage, but in general, larger caliper seedlings such as p+1 transplants and 2+0 bareroots appear to be more heat resistant than smaller caliper seedlings such as 1+0 bareroots and 1+0 plugs. Seedling stems appear to have the thermal characteristics of water-filled tubes, thus their ability to hold heat should increase approximately with the square of diameter. Even so, the ability of even large caliper seedlings (5 mm) to absorb heat seems small relative to potential inputs.

Species. A study in California showed greatly increased survival of shaded ponderosa pine. But in FIR studies, unshaded pine equals or surpasses survival of unshaded Douglas-fir. Another California study found that artificial shade (shingles) greatly increased survival of white fir seedlings planted on south-facing slopes. Because the temperatures at which various types of conifer tissue die differ relatively little, the greater resistance of pine likely results from morphological differences such as greater self shading, stem caliper, or reflectivity of its stem.

Vigor. Among 2+0 bareroots, late-planted seedlings of low vigor appear to benefit more from shading than earlier-planted, vigorous seedlings that can achieve higher survival without artificial shade.

Duration of Shading

Foresters have asked whether artificial shade provides any benefit in the second or subsequent years after planting. The previous discussion suggests an answer. Because a seedling's need for shade protection seems dependent on its stem caliper or its ability to shade itself, seedlings which produce thick stems and vigorous top growth in the first growing season after planting should not benefit greatly from the continued presence of artificial shade. Seedlings which produce little growth, e.g. bottle brush foliage, or which are browsed severely, should benefit more from continued shade. Shading from re-invading vegetation will decrease heat loads on a seedling, but will also greatly increase the probability of death from drought. Below the snow zone, artificial shade will likely do no harm, and will probably continue to help the seedling if left in place. In areas of heavy snow, flat shade devices angled over the seedling may collapse and injure the seedling.

Artificial Shade Devices

Artificial shade devices differ in effectiveness. The following descriptions summarize what is known about various methods that have been tried. Shade devices are typically installed within three inches of a seedling's stem, on its south side.

Rocks and Debris. *Advantages*: Piled near the south side of seedlings, rocks and slash have increased survival of small bare root Douglas-fir seedlings during the first two years. Material costs are low. *Disadvantages*: Material is non-uniform and may not be readily available on all sites. Probable costs are equivalent or less than for cardboard shade cards. Use is restricted to flatter sites with stable surface layer of soil. Shade material can fall on seedlings. If rocks are used they should not be placed in contact with the seedling stem.

Wood Shingles. Shingles or box stock, 5- to 7-inches wide, extending 10 to 12 inches from the soil, and angled over seedling at approximately 30 degrees from vertical. *Advantages*: Low cost and readily available; effectiveness for Douglas-fir, white fir and ponderosa pine equal to best results with shadecards. *Disadvantages*: Non-uniform width, handling and installation more difficult than shadecards. Easily damaged by cattle.

Cardboard Shade Cards. Most common size is 8 x 12 x 1/16 inch waxed fiberboard, held in place by tripod wire wicket or more commonly by a single lath stake either stapled to card or inserted in holes cut in card. Weight approximately 200 g. Also available are 8 x 16 inch cards, although the smaller size appears adequate. Theory predicts that placing the axis of a shadecard southwest of the seedling and angling it over the seedling while maintaining an east-west orientation of the device will maximize shade. Although, shade cards placed on the east side of seedlings have also increased survival. The bottom edge of the card should be as close to the ground as possible. *Advantages*: Several studies and operational trials have documented effectiveness. Survival increases range from negligible to major for Douglas-fir seedlings. Uniform shade provided. Readily available. May reduce deer browsing. *Disadvantages*: Expensive, heavy, somewhat difficult to handle. Costs (materials and installation) average more than $0.40 per seedling. On steep south-facing slopes with ravel, debris may collect behind card and injure seedling. Reflection from cards can increase radiation loads on seedling in morning. Cards held with lath stake threaded through holes, instead of being stapled, collapse under snow loads. Cards stapled to stake will curl around stake reducing shade if the curl is away from the seedling. Cards may thus provide effective shade for only one year.

Polypropylene Shade Mesh. Available as 8 x 12 inch mesh envelopes in black, white, green or yellow mesh held in place with a U-shaped wire wicket fitted inside the mesh envelope. An envelope of two layers of black mesh (0.08 inch grid) blocks about 65 percent of light incident at a 90 degree angle. Blockage will be greater for light incident at angles other than 90 degrees, which includes nearly all solar radiation impinging on a seedling. *Advantages*: Operational use and theory suggests that shade is adequate for increasing seedling survival. Reflected and reradiated heat should be less than with cardboard shadecards, particularly with black mesh. The mesh screen weighs only 70 g (one third of cardboard shade cards), is less bulky, and costs less (approximately one half or less than cardboard cards). *Disadvantages*: Lack of testing comparing effectiveness against cardboard cards, and of various colors and mesh densities. Colored mesh or white mesh may not reduce radiation loads on seedling as much as black mesh. Mesh envelopes angled over seedlings on sites receiving snow may collapse on seedling.

Styrofoam Cups. Standard 6 oz. (volume) styrofoam coffee cups protect only the base of seedlings. They are installed by punching out the bottom of the cup and sliding the inverted cup over the seedling to the ground. *Advantages*: Based on use in research- and progeny-test plantations, effectiveness with 2+0 Douglas-fir seedlings appears to equal that of shade-cards. Costs (material and installation) range between 1/5 to 1/3 of cardboard shadecards. Small, lightweight (1.6 g) and easy to handle. Cups are readily available and last up to four years. *Disadvantages*: Some opposition to aesthetics of white cups, even though cups become light gray-brown after one year of exposure. Trials with more aesthetically-pleasing brown peat pots indicate that these decompose before the hottest part of the growing season providing no protection at that time. Fears of increased mouse damage associated with styrofoam cups have not yet been justified. Further testing is needed before broadscale application can be recommended.

Lath Stakes. Based on observation of small diameter 1+0 plug seedlings planted on an exposed south-facing slope, with very rocky soils. These seedlings were protected from deer browsing with vexar tubes held by lath stakes (2 x 18 x 1/4 inch) placed on the south (downhill) side of the seedlings with about 12 inches of lath exposed. First year survival exceeded 90 percent. All seedlings were healthy, with no apparent heat damage or mechanical injury from debris. *Advantages*: Lath stakes supporting vexar tubes may also protect seedlings from heat damage, achieving double seedling protection for a single application. *Disadvantages*: No comparative data exists for unprotected seedlings or seedlings protected by other means. Costly, approximately $0.40 per seedling (materials and installation).

The preceding discussion suggests scenarios when the potential for seedling mortality from heat is the greatest. A combination of south-facing slopes, rocky or skeletal soils, the absence of nearby ridges or tall timber to block solar radiation, and clear sky conditions appear to put conifer seedlings in greatest jeopardy. Under these conditions, artificial shade should benefit 1+0 plugs the most, followed by 2+0 bareroot and p+1 seedlings. Douglas-fir and white fir should benefit more than ponderosa pine seedlings. Applying shade to expensive seedlings such as 1+0 Douglas-fir plugs during the first year appears to be a reasonable "insurance policy." The additional cost of shade devices could easily be less than the cost of planting extra seedlings or fill-in planting the next year.

OH

MULTIDIMENSIONAL STUDY OF PINE PERFORMANCE IN CALIFORNIA

A cooperative study of site processes in plantations managed under regimes approaching "Garden of Eden" conditions has begun in California. Objectives are to examine the impact of complete control of vegetation competition, soil fertility, and shoot and twig insects--both separately, and in combination--on growth performance and physiology of selected families of ponderosa pine planted over a broad range of site qualities. Principal investigators are Bob Powers and Tom Koerber of the PSW Station, with John Helms of the University of California as a collaborator.

Plantations will be established at a minimum of 10 locations by 1988, with the first two established this spring. Ten families of ponderosa pine selected from ongoing progeny tests for their superior growth in a particular seed zone and elevation combination will be planted at each location. Treatments - eight in all - consist of presence or absence of (1) periodically applied herbicides; (2) multi-element fertilizer (N, P, K, Ca, Mg, S, Cu, Zn, and B) applied proportional to biomass gain over time; and (3) regularly applied systemic insecticide (dimethoate) in factorial combinations. Results should include findings of both applied and more fundamental nature. Responses are expected to be substantial, and should stimulate efforts at finding more efficient means for capturing the growth potential of the species.

Bob Powers
PSW Research Station
Redding, CA

Recent Publications

For copies of these publications, mail your request to: Forestry Business Office, College of Forestry, Oregon State University, Corvallis, OR 97331.

FOREST PEST MANAGEMENT IN SOUTHWEST OREGON by Ole Helgerson, Editor. Proceedings of a workshop held August 19-20, 1985, Grants Pass, Oregon. Fifteen papers address the biology and management of plant, insect and disease pests in southwest Oregon. Specific areas include integration of control measures with other forest management activities, and predicting the dollar value of weed control. Price: $10.00.

MORTALITY OF REGENERATION DURING SKYLINE LOGGING OF A SHELTERWOOD OVERSTORY by S.D. Tesch, D.H. Lysne, J.W. Mann and O.T. Helgerson. 1986. Journal of Forestry 84(6):49-50. A study was conducted in southwest Oregon to identify seedling characteristics and harvesting factors influencing seedling survival during removal of a shelterwood overstory by uphill skyline yarding. Seedlings between 80 and 100 cm in height survived best, but seedlings in the 41-60 and 61-80 cm height classes survived nearly as well. Smaller seedlings fared poorly, as did seedlings larger than 100 cm. Few seedlings survived within skyline corridors, which became increasingly wide as skyline cross slope increased. Unstocked areas also occurred where skyline corridors converged.

SEEDLING PROTECTORS FOR PREVENTING DEER BROWSE by W. Schaap and D.R. DeYoe. 1985. Forest Research Laboratory, Res. Bulletin 54, Oregon State University, Corvallis. The study compares the efficacy of eight protectors for minimizing deer browse: Vexar® tubes, heavy netting, light netting, Reemay® sleeves, paper bud caps, Reemay® budcaps, leader tubes, and No Nibbles®. Data were collected on browse damage, survival, terminal restriction, protector loss, and height growth. All protectors were effective in preventing browse damage. None of the protectors consistently reduced survival or height growth. However, on a high-elevation (4,500-foot) site facing southwest, seedlings inside Reemay® sleeves survived poorly compared to controls following a week of daytime temperatures above 100°F. Restricted or bent seedling terminals and protector loss occurred with certain protectors on some sites; however, these problems could be decreased by proper or modified installation with stakes or stapling, respectively. Only No Nibbles® caused abortion of terminal bud flushes. The study demonstrates that alternatives to Vexar® tubes are available that cost less and exhibit comparable effectiveness.

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