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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 Forest and Range Experiment 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. The report 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,

John W. Mann
Forest Engineering Specialist

Inside

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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.

Adaptive FIR

SECOND YEAR SURVIVAL AND PREDAWN MOISTURE STRESS OF DOUGLAS-FIR PLANTED UNDER HARDWOODS

Results from this experiment indicate that survival of Douglas-fir seedlings continues to be greatest under herbicide-treated hardwoods. The study was started in 1981 to explore the feasibility of converting low value hardwood stands to Douglas-fir by underplanting with and without herbicide injection of the overstory hardwoods. The last issue of the FIR Report ((6)3:5) compared first-year survival for two different planting years. Seedling survival appeared to depend on stocktype, herbicide treatment and precipitation received during the dry season.

This article describes preliminary survival and PMS (predawn moisture stress) trends observed in the second year after planting in 1983. Survival for the plantings done in 1983 decreased for seedlings planted under untreated hardwoods, but stayed the same for seedlings planted under herbicide-treated hardwoods (Table 1).

Table 1. First and second year survival (percent) for seedlings planted in 1983.

	Control		Injected	
Year	1-0 plugs	2-0 bareroots	1-0 plugs	2-0 bareroots
1983	100	89	100	95
1984	94	85	100	95

The lower survival of the 2-0 bareroots compared to the plug seedlings in this 1983 planting is consistent with the results for the 1982 plantings (FIR Report (6)3:5). During the second year, survival decreased for both stocktypes under the control stands, while remaining the same for the seedlings under the herbicide-injected stands.

Trends in PMS appeared to differ by herbicide treatment but not by stocktype. From May 15 to July 11, PMS values for both stocktypes under the control stands averaged about -0.7 MPa (-7 bars) compared to about -0.5 MPa for the stocktypes under the injected stands. The stocktypes under the control stands reached a PMS peak of -1.5 MPa on August 8. PMS for seedlings under the injected stands averaged around -0.6 MPa for this same date. Interestingly, seedling PMS continued to become more negative for the seedlings under the injected stands during the remainder of the growing season, reaching -1.0 MPa at the end of October. By this date, PMS values for the stocktypes under the control stands had declined to -0.9 MPa.

Given the well defined effects that moisture stress has on plant growth, photosynthesis and other physiological processes, it is likely that the drop in survival under the control stands is related to the increased levels of observed moisture stress. According to research by Stone, root elongation ceases at water potentials between -0.6 and -0.8 MPa.

Visual observation indicates that growth of understory vegetation (tanoak and madrone sprouts, poison oak, natural conifer germinants) is greater under the injected stands. Cover measurements have been made, but not yet analyzed. Look for these data and information on seedling growth in subsequent issues of the FIR Report.

O.H.

BRUSH SPROUTS OUTGROW DOUGLAS-FIR SEEDLINGS

Field data collection for the first phase of an Adaptive FIR study designed to explore non-chemical methods of controlling sprouting brush in the Siskiyou Mountains (FIR Reports 5(2):6, 6(2):2) has been completed. The objective of this phase was to describe changes in growth, phenology, and selected physiological characteristics (i.e., carbohydrate concentrations and moisture stress) of Douglas-fir seedlings and sprouts of tanoak and greenleaf manzanita. This information will now be used to select slashing treatments designed to minimize sprout growth. These treatments will be installed during 1985.

For the period July - September, significant differences in predawn moisture stress (PMS) were measured between Douglas-fir seedlings and brush sprouts. During July PMS in Douglas-fir seedlings increased dramatically to -1.7 MPa with a peak of -2.1 MPa in late August. This level was maintained through September, but decreased to -0.4 MPa by the end of October. On the other hand, moisture stress levels in greeleaf manzanita and tanoak sprouts never exceeded -0.7 MPa during the same period.

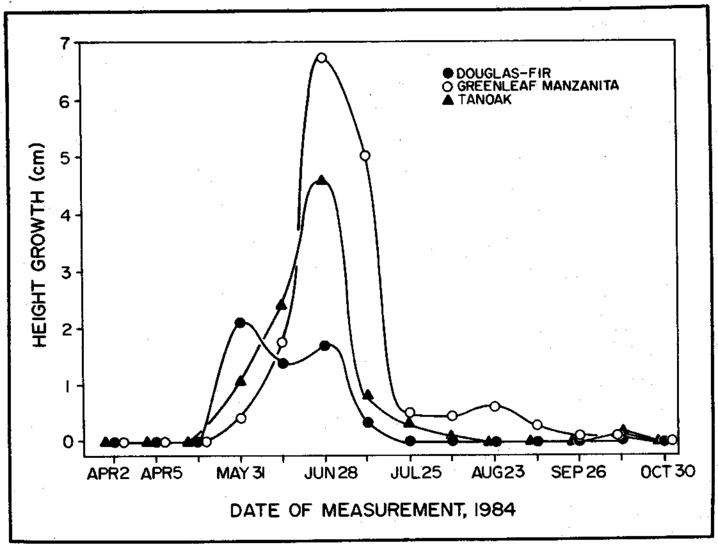

Figure 1. Height growth of four-year-old Douglas-fir seedlings and two-year-old sprouts of greenleaf manzanita and tanoak during 1984.

Height growth of all species did not start until mid-May (Figure 1), although visible root growth had been evident since the first week in April when selected plants were excavated. Initial elongation of Douglas-fir leaders exceeded that of sclerophyll species for two to three weeks. By mid-June, however, both tanoak and greenleaf manzanita sprouts were outgrowing Douglas-fir seedlings. Height growth declined rapidly for all species during July. The cessation of height growth in Douglas-fir may in part be linked to increasing moisture stress with increasing summer drought and evaporative demand. This does not necessarily explain height growth declines in the sclerophylls since their predawn moisture stress levels never exceeded -0.7 MPa. However, higher mid-day stresses may have induced other physiological responses that slowed height growth.

Laboratory analysis of plant tissues for total soluble sugars and starches have been completed, but only starch data for tanoak have been summarized. Starch levels increased slightly during April, with dramatic increases in May. Coinciding with the start of stem elongation, starch levels declined rapidly until the end of July at which time the trend was toward stabilization. This pattern of increasing and decreasing starch levels was the same for all plant parts (except new stems and foliage). The exact reason for the sudden decline in starch is unknown, although a plausible explanation is that increased carbohydrates derived from starch metabolism are necessary to supplement current photosynthate during rapid stem elongation.

These data and other information collected during phase I of the study clearly show that sprouting tanoak and greenleaf manzanita plants can rapidly outgrow Douglas-fir seedlings. The problem to be addressed in phase II is how to minimize this obvious potential for extensive sprout growth from root crowns and burls that exist after site preparation of new conifer plantations.

S.H.

SEEDLINGS GROWING AMONG BRUSH SPROUTS GET FURTHER BEHIND AFTER TWO YEARS

Second-year results from the Negro Ben brush study show major effects that sprouting brush has on shoot and root growth of Douglas-fir seedlings. Comparisons between a complete vegetation control with herbicide treatment and a handslashing treatment show similar seedling survival rates, but handslashing results show a 3x reduction in seedling height growth, a 2.5x reduction in diameter growth, a 6.5x reduction in shoot biomass, and a 4x reduction in root biomass. The reductions in seedling growth were greater in the second year than in the first year.

As mentioned in previous FIR Reports, in March 1983, Douglas-fir seedlings were planted among four different levels of sprouting greenleaf manzanita and canyon live oak brush to study the effects of this competition on conifer survival and growth. The study area is at 1100 meters (3600 feet) elevation on a 66 percent west-facing slope. The soil is a skeletal Xerochrept with a surface mantle of ravel. Installation of the brush treatments was discussed in an earlier FIR REPORT (5(1):5), with a summary of treatments as follows:

1. Brush removed; first year sprouts sprayed with herbicide in late spring shortly after seedlings were planted.

2. Two-year-old brush sprouts sprayed one year prior to planting Douglas-fir seedlings.

3. First-year sprouts, slashed by hand 2/83.

4. Fourth-year sprouts, slashed by hand 4/80.

Survival rates for all treatments are still excellent after two growing seasons. Survival rates for treatments 3 and 4 declined by 6 percent each during 1984, but are still 94 and 90 percent, respectively. No mortality was observed in Treatment 2, the complete vegetation control treatment (94 percent survival), during 1984.

The effects of sprouting brush on conifer growth increased during 1984. For height growth, treatment 2 seedlings grew an average of 168 mm, treatment 3 seedlings averaged 54 mm, and treatment 4 seedlings averaged 28 mm. For diameter growth, treatment 2 seedlings grew an average of 4.0 mm, treatment 3 seedlings grew 1.6 mm, and treatment 4 seedlings grew 0.8 mm. See FIR Report 5(3):3 for first year's growth.

Root and shoot biomass was obtained by excavating 10 seedlings from each treatment in December 1984. Biomass increased very little for seedlings growing among any of the treatments with sprouts during 1984, but both root and shoot biomass increased substantially for seedlings growing in the complete vegetation control treatment area (Treatment 2). Average root and shoot weights (dry weight), respectively, for seedlings in treatment 2 were 12.4 and 24.6 grams, treatment 3 seedlings averaged 2.9 and 3.7 grams, and treatment 4 seedlings 1.7 and 2.2 grams. See FIR Report 6(1):4 for last year's biomass values.

Looking at the growth rates of seedlings growing among the sprouts, one can't help but wonder about their future. Seedlings growing among the original first-year sprouts (treatment 3) added 0.9 grams of root biomass, 1.7 grams of shoot biomass, and grew in height 54 mm (2.1 inches). Brush competition two years after handslashing was about 41 cm (16 inches) tall and occupied 33 percent of the site.

In contrast, seedlings growing where the vegetation was completely controlled by herbicide (treatment 2) have added 7.3 grams of root biomass, 20.5 grams of shoot biomass, and grew in height 168 mm (6.6 inches). An occasional sprout is beginning to show up on this treatment area, along with a few annual weeds, but basically competition for soil moisture is still minimal.

Seedlings growing among fourth-year resprouts during 1984 (treatment 4) added only 0.1 grams of root biomass, 0.5 grams of shoot biomass and grew 28.5 mm (1.1 inches) in height. These seedlings are competing with sprouts that now range from 0.5-1.0 meters in height and cover 50 percent of the site aboveground.

Conclusions are impossible after only two years; however, some interim interpretations can be made. Seedlings planted on harsh sites such as this get a more vigorous start when the site is free of above- and below-ground competition at the time of planting. The living root systems of competing brush that remain after handslashing can be related to severely reduced tree seedling root and shoot growth through the second year.

At this time, we have no evidence to conclude that handslashing leads to significantly greater mortality in comparison to the use of herbicides. However, at the current rate of growth, it will take approximately 25 years for seedlings in the handslashed treatment to reach breast height, while seedlings in the complete control units should reach that same height in less than 8 years. These kinds of growth differences necessitate considerable re-evaluation of management and economic strategies if intensive site preparation tools cannot be used in the future.

S.T.

SURVIVAL RESULTS FOR 12 SITES IN REGENERATION POTENTIAL STUDY

With the planting of ten more sites in 1984, survival results are now available for 12 test sites in a study that addresses the regeneration potential of lands withdrawn from the timber base of the Medford District BLM. The test sites that have been planted represent various levels of potential solar radiation and available water that are common to these withdrawn lands.

The data for these test sites illustrates that survival can be very high (Table 1).

These data indicate some interesting trends. Average survival of ponderosa pine is greater than Douglas-fir on all sites where these species are compared. Survival differences range from one percent at Tin Pan Peak to more than 20 percent at Stevens Creek. Survival of Douglas-fir seedlings can, however, be quite high, even on hot, dry south-facing sites, although the greatest first-year mortality was also recorded on this type of site.

Table 1. Percent seedling survival for sites in regeneration potential study. (Years of observation in parentheses).

Site	Aspect	Stocktype and Species				
		1-0 DF	2-0 DF	P+1 DF	1-0 PP	2-0 PP
Dutch Herman (1)	N	97	97			
Hog Remains (1)	N	76	96			
Julie Creek (1)	S	69	89			
Negro Ben (1)	S	88	95		100	
Oregon Belle (1)	S	87	80	68	90	
Peggler Butte (1)	S	81	75			
Rock Creek (1)	S	84	89		96	
Stevens Creek (1)	S	53	73	95	99	
Salt Creek (2)	S	74	95			95
Walker Return (1)	S	93	93			
Textor Gulch (1)	E	89	90		95	97
Tin Pan Peak (3)	E	88	99		92	97

For the sites planted in 1984, survival averaged 82 percent for 1-0 Douglas-fir plugs and 88 percent for 2-0 Douglas-fir bareroot stock. The greatest difference between these two stocktypes was at Stevens Creek, a site with extremely skeletal soils.

Survival seems to have stabilized in the third year at Tin Pan Peak. No additional mortality occurred after the second year (FIR Report 5(4):4). This is probably because of the nearly total control of weeds on this site, which receives less than 30 inches of precipitation annually.

Shadecards continue to improve survival of 1-0 Douglas-fir plugs more than they do the 2-0 bareroot seedlings at the south-facing Salt Creek site. Survival of shaded 1-0 plugs was 89 percent (unshaded 74 percent). Survival of shaded bareroots was 98 percent (unshaded 95 percent). Survival for all Douglas-fir dropped from the first year, but survival of the pine remained essentially unchanged (FIR Report 5(4):4).

The results reported here are encouraging. The amount of additional mortality incurred in coming years will continue to be monitored for these sites. In addition, 12 more sites are scheduled for planting in 1985. Information from these sites should allow stronger inferences to be made about the relationships between seedling survival and site characteristics.

O.H.

SHADE STUDY SURVIVAL UPDATE

Survival results are now available for the 1984 growing season at the Lick Ridge and Julie Creek test sites (Table 1). This study was established in 1982 to determine if shading with styrofoam cups placed around the base of trees would increase survival of bareroot Douglas-fir seedlings. Another objective was to test whether east-placed shadecards, because of additional morning shade, would increase survival, despite greater afternoon heat. These treatments were compared to unshaded seedlings and seedlings with shadecards placed to the south. A third objective was to compare the effects of shade on bareroot Douglas-fir seedlings planted under different conditions on two different sites.

Table 1. First through third-year survival (percent) of 2-0 Douglas-fir seedlings at Lick Ridge and Julie Creek.

Site and Year	Control	East shadecard	South shadecard	Styrofoam coffee cup
Lick Ridge				
1982	94	99	100	99
1983	89	97	100	99
1984	89	87	99	98
Julie Creek				
1982	72	85	94	89
1983	69	82	89	85
1984	67	78	86	83

Seedling survival continues to be greater at the drier Lick Ridge site (30 inches annual precipitation) compared to the wetter Julie Creek site (80 inches annual precipitation).

Seedling mortality was greatest in the first and second years after planting. Survival changed very little from the second to the third year. Practically no mortality occurred at Lick Ridge. At Julie Creek, survival dropped an average of three percentage points for all treatments.

The relative effects of shading remain unchanged at both sites. This supports the conclusion previously reached that shading seedlings on south-facing slopes will be more cost-effective when the seedlings are planted late or are of lower vigor. Also, the lower cost of the styrofoam cups, despite their somewhat lower associated survival rates, may make this treatment more cost-effective than south-placed shadecards if the survival rate achieves the desired level of stocking.

Weeds were vigorously controlled on both sites. Thus, in the absence of significant weed competition, survival probably has stabilized at Lick Ridge and Julie Creek. Deer browsing at Julie Creek, however, may continue to cause additional mortality or growth losses. Subsequent analyses will tell whether seedling growth will continue to also be greater at Lick Ridge (FIR Report (6)3:4).

O.H.

SURVIVAL GOOD BUT GROWTH POOR FOLLOWING MACHINE SITE PREPARATION

Survival of 2-0 bareroot Douglas-fir seedlings after three summers remains high on a site used to evaluate a variety of machine site preparation techniques. The study site (Silvercat) is in the Siskiyou Mountains about 23 miles west-northwest of Grants Pass. Survival on machine prepared plots is high regardless of the method of treatment and is much better than the untreated control (Table 1). After the first summer, few seedlings died.

Table 1. Douglas-fir survival at Silvercat 1 and 3 summers following machine site preparation.

Treatment	Treatment description	Survival (%) 1982	Survival (%) 1984
Control	No site preparation	57.3a[1/]	50.7a
Scarify	Slash and shrubs removed with slashrake	95.3cd	91.3b
Scarify & rip	Soil scarified and ripped with rock rippers	94.0c	92.b
Soil removal	Slash, shrubs and 2 or more inches of top soil removed with a dirt blade	98.0d	97.3c
Soil removal & rip	Top soil removed and soil ripped	88.0b	86.0b

1/ Means in the same column followed by the same letter are not significantly different at the p=0.05 level.

First summer survival reflects the effectiveness of machine site preparation in controlling competing vegetation. In 1982, vegetation less than one meter tall covered 30 percent of the control plots while the area covered by brush on the treated plots was less than 3 percent. After 3 summers, vegetation less than one meter tall on all treated plots covered less than 16 percent, but cover on the control plots was 70 percent. The soil removal treatment appeared to be more effective than scarification at sustained control of vegetation. Most of the vegetative cover is brush sprouts. Few species germinate from seed on this site, although the surface is mostly mineral soil.

Growth of seedlings was poor in spite of the high survival (Table 2). Surprisingly, differences among treatments are generally insignificant. Only 1983 height growth of trees on scarified plots, and 1984 diameter growth on scarified and soil removal plots are significantly greater than the other treatments.

Measured growth on ripped plots is always less than on the similarly treated, non-ripped plots. This probably occurs because seedlings were planted in the bottom of the rip furrow. Over the three-year period, rip furrows filled with soil from overland flow or raindrop splash. Filling of the rip furrow increases the soil elevation around the seedlings which decreases the total seedling height or raises the point on the stem where the diameter was measured. The result is

Table 2. Height and diameter growth of Douglas-fir seedlings at Silvercat.

Treatment	Height Growth			Diameter Growth[1/]	
	1982	1983	1984	1983	1984
	- - - - cm - - - -			- - mm - -	
Control	3.46	1.05	1.48	0.74	0.50
Scarify	3.42	2.45	3.23	0.47	1.00
Scarify & rip	3.91	1.30	1.76	0.62	0.47
Soil removal	4.51	1.43	3.05	0.53	1.17
Soil removal & rip	3.52	1.51	2.16	0.56	0.63

1/ Initial seedling diameter was not measured in 1982.

an apparent reduction in the seedling growth rate due to the procedure used to measure seedlings.

Reduced seedling height growth during the second and third year is difficult to explain, but dry weather following planting and low soil fertility are considered the primary causes. Since snow covered the site until early May, it was not planted until May 18, 1982. Sufficient precipitation to recharge the soil profile in the seedling root zone, however, did not occur until June 27 and 29 - nearly seven weeks after planting. As a result, most seedlings did not break bud until after this event, and the growth generally was poor with short needles and small buds.

Soil fertility on this site is generally low, including nitrogen, phosphorus, and the exchangeable bases. This site had the lowest fertility when compared with other forest soils in Josephine County. This has contributed to the often chlorotic condition of the seedlings.

The high survival reflects the importance of good control of competing vegetation, but the study also shows that growth could still be limited by climatic conditions around the time of planting and other inherent site conditions.

I plan to further explore the effects of late planting on this site. More seedlings will be planted this spring on the soil removal treatment plots. This treatment currently has the least vegetative cover. Hopefully, these seedlings will be planted earlier in the spring and will receive more post-planting precipitation. Growth of the 1985 planting will be compared with the 1982 planting for about 3 years.

D.M.

Fundamental FIR

FEASIBILITY OF PROJECTING YOUNG STAND GROWTH

FIR research projects are underway that should provide southwest Oregon land managers with good information on the regeneration potential of lands in the region as well as the long-term growth and yield potential of such sites. However, one link in this chain of information is still missing. Results of current efforts will not necessarily allow us to reliably predict growth rates of young conifer stands from the time of plantation establishment up to about 20 years of age. During this period, many factors other than site quality can affect tree growth. For example, competing vegetation and animal damage may reduce growth rates substantially. These and other factors are complex and expensive to simulate, so most modelers have avoided this time period or simply admit that general models are inadequate for explaining growth differences during this phase of stand development.

Models specifically developed for this growth period become particularly important as shorter rotations are considered. The first 20 years of growth may now constitute 1/4 - 1/3 of the rotation. Young stand growth information will be useful when analyzing alternative cultural programs such as vegetation management. Coupling the young stand model with a merchantable stand model could provide estimates of long-term effects of treatments for yield forecasting purposes or investment analyses.

We have spent the last nine months conducting a feasibility study for development of a southwest Oregon young stand growth model. We did not encounter any existing models, either locally or elsewhere, that model the effects of competing vegetation and other early influences on growth rates of stands up to 20 years of age. Developing such a model for southwest Oregon will be a pioneering effort and, as such, will require extensive data collection and analysis. The balance of this article describes the approach we believe should be taken in order to provide a predictive model for early stand development.

Study proposal

We propose to develop a growth model within the following framework:

1. An individual-tree model capable of linking with Hann's ORGANON or Stage's PROGNOSIS models for merchantable stands.
2. Project growth of Douglas-fir dominated plantations from 3-20 years of age, located in the mixed-conifer and mixed-evergreen zones as defined by Franklin and Dyrness (1973). We will not measure stands less than 3 years of age to avoid additional variability caused by non-environmental factors such as stock quality, quality of planting job, etc.
3. Predict effects of competing vegetation on conifer growth rates. The model will be able to react to user-supplied information regarding changes in vegetation composition or competitive significance.
4. Stratify sampling to ensure that individual species models are available for madrone, tanoak, snowbrush ceanothus, and deerbrush ceanothus.
5. Basis for projections will be three-year remeasurement of short-term, permanent plots. Plots will be stratified to represent 4 age classes. The three-year remeasurement period was considered the minimum time necessary to provide sound information on interaction between conifers, competitors, and other environmental factors.

After careful consideration of the complexity of this modeling effort, and our desire to produce a model of broad utility to southwest Oregon users, the following table represents our best estimate of the minimum sample size necessary to achieve acceptable results.

Minimum Sample Size Estimation

	Age Class (Years)	Competing Vegetation density	Conifer density
1)	3-5	low	all*
2)	"	high	"
3)	6-8	low	all
4)	"	high	"
5)	9-11	low	all
6)	"	high	"
7)	12-17	all	low
8)	"	"	high w/o PCT**
9)	"	"	high w/PCT

* Indicates all densities encountered will be sampled.
** PCT = Pre-commercial Thinning

9 combinations of competing vegetation and conifer densities
x 3 site productivity classes (high, med, low)
x 5 replications

135 stands with a minimum of 10 plots per stand.

Minimum sample size = 1350 plots

Our sampling strategy will be to select stands that have been planted with Douglas-fir. However, as each plot is measured, all conifers encountered will be recorded by species. This will ensure adequate information about Douglas-fir, but may also provide adequate data to develop growth equations for other species as well.

If a stand has a brush or hardwood component, at least two-thirds of the total cover must be madrone, tanoak, snowbrush ceanothus, or deerbrush ceanothus, either individually or collectively, in order to qualify as a sampling unit. This will ensure adequate data to generate specific equations for these important species. However, all major competing vegetation will be recorded by species, which may result in additional individual species models. The remaining vegetation will be combined into collective equations.

How will the model work?

We anticipate that the model will operate on input from typical regeneration survey data. Measurements of height, diameter, and crown length will probably be required on the conifers and hardwood trees, and measurements of percent cover and height for all competing vegetation will be necessary. The model will then simulate growth of the competitors and trees over a user-specified time interval.

We hope to have a sufficient data set to simulate the response of stands to various vegetation management treatments. To do this, the model will present a summary of existing competition conditions and ask the user for input regarding the impact of the proposed treatment on the plant community. Through experience with treatment prescriptions, the user may reduce cover of various species or even replace one species with another. After this input, the model will then simulate growth of the stand for the desired time period.

Next steps

Future work on this project is contingent upon adequate financial and logistical support. Our preliminary work during the past 9 months indicates that modeling young stand growth is technically feasible and would be a worthwhile contribution to the management of southwest Oregon forests. Subsequent issues of the FIR Report will keep you informed of our progress.

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THE TANOAK SERIES OF THE SISKIYOU REGION OF SOUTHWEST OREGON

(Part 2 of a 2-Part Article; Part one appeared in the Fall 1984 issue of the FIR Report - 6(3):6-7)

Coastal Associations

The coastal associations have a high cover of salal, Pacific rhododendron, evergreen huckleberry, and swordfern. The average elevation of the group is 559 m (1835 ft), about 457 m (1500 ft) lower than the inland group. Although the aspects are not different from the inland group, the soil depth averages 107 cm (42 in), 15 cm (6 in) deeper than the inland group. These associations are productive with few regeneration problems. Vegetative competition can be severe, but because water is less limiting, the effects of competition may not be as detrimental to survival and growth as on inland sites.

The TANOAK/EVERGREEN HUCKLEBERRY-SALAL Association is typical of the coastal associations. In addition to salal, the constancy of dwarf Oregongrape, swordfern, and beargrass is greater than 50 percent. Because the combined cover of the overstory and tree understory is greater than 170 percent, and shrub cover averages 70 percent, not many herbs are present. Beargrass cover averages 4 percent, but it can be an aggressive invader after disturbances.

The TANOAK/EVERGREEN HUCKLEBERRY Association is more moist than the Tanoak/Evergreen Huckleberry-Salal Association. Red alder and bigleaf maple are present but chinquapin and salal are absent. The former are indicators of either ample soil and/or atmospheric moisture; the latter are indicators of either drier conditions or more variable temperatures. This Association occurs on the deepest soils of the Tanoak Series. Reforestation is potentially less of a problem. Site preparation is essential.

The presence of California laurel, vine maple, and Pacific yew are characteristic of the three tanoak-California laurel associations described below which commonly occur in bottomland positions and along stream channels. These associations have the lowest average elevation of the Series. They often occur near the coast where high humidity and fog commonly occur and the evapotransporational demand is low. These associations are some of the most important terrestrial associations of the Series because of their proximity to riparian and aquatic systems. The integrity of these systems is directly dependent on careful management activities in the associations that lie above them.

The TANOAK-CALIFORNIA LAUREL/EVERGREEN HUCKLEBERRY Association is the typic, and the wettest, of these three associations. Evergreen huckelberry is conspicuous and often dense. Soils are deep and elevations low. This association is generally found close to the coast or in moderately moist upland coves with Pacific yew. Evergreen huckleberry can be both a physical barrier to planting and a competitor with crop trees.

The TANOAK-CALIFORNIA LAUREL/PACIFIC RHODODENDRON Association is similar to the previous association in species composition. The presence of Pacific rhododendron, which indicates relatively drier sites, sets it apart. Yet bigleaf maple, Pacific dogwood and red alder are still common, particularly on disturbed sites. We expect management responses to be similar to the previous association except for the increased competition by Pacific rhododendron.

The last of the California laurel group, the TANOAK-CALIFORNIA LAUREL/WHIPPLEVINE Association, is the driest of the trio. Soils are more coarse than those associated with the other two associations and slopes are steeper. It occurs further inland and at higher elevations. White-flowered hawkweed and small bedstraw are common here. Although it is vegetationally distinct, it is not widespread.

One of the more commonly occurring associations is the TANOAK-PACIFIC RHODODENDRON Association. It is relatively dry for a coastal association, as indicated by the presence of Pacific madrone, hairy honeysuckle, and Pacific rhododendron; evergreen huckleberry is codominant with Pacific rhododendron. Although both may be a barrier to planting, they are not serious competitors if adequate site preparation is done.

The TANOAK/PACIFIC RHODODENDRON-EVERGREEN HUCKLEBERRY Association is similar in composition to the previous coastal associations, but may occasionally support poison oak. Poison oak indicates coarse, hot, surface soil conditions. Where it occurs, seedling survival may be reduced, although it usually occurs in small pockets where attention to detail and microsite planting can avert seedling mortality.

The last of the coastal group is the TANOAK/PACIFIC RHODODENDRON-SALAL Association. It occurs at an average elevation of 856 m (2809 ft), and it has the shallowest soils of the group. Both Sadler oak and western white pine have a high constancy, but the elevation is too high for evergreen huckleberry. Soil surfaces are much cooler than in the previous associations as indicated by red columbine and starry Solomon-plume.

Transitional and Unusual Associations

The TANOAK/SALAL Association represents the transition between the coastal and inland groups. Evergreen huckleberry, a major coastal species, is absent and dwarf Oregongrape and Piper's Oregongrape, commonly found inland, are present. Some other transitional species include Smith fairy-bell, western yellow wood-sorrel, and deer-fern. Creeping snowberry, baldhip rose, and western prince's-pine also characterize this association. There are few management problems identified for this association, except for the occasional area with surface rock and/or skeletal soils.

The TANOAK-WESTERN REDCEDAR/EVERGREEN HUCKLEBERRY Association is an uncommon association sampled on toe slopes near permanent streams in the vicinity of Marial on the Rogue River. The deep soils are well watered and are derived from gravel-sized colluvium. Mature stands have an upper canopy of Douglas-fir dominants and co-dominants, and a lower canopy of pole-sized tanoak and western redcedar. Thickets of evergreen huckleberry characterize the understory. Because these stands are part of the riparian vegetation along second or third order streams, they should be carefully managed or left undisturbed to help maintain aquatic habitats. A well designated and executed uneven-aged system intended to produce large western redcedar may be possible.

The TANOAK-PORT-ORFORD-CEDAR Association is compositionally variable and generally occurs as stringers along stream channels. It supports coastal species such as evergreen huckleberry and Pacific rhododendron, and inland species associated with wet sites. Port-Orford-cedar averages about 42 percent cover and is a minor climax species. It is currently in jeopardy from the spread of *Phytophthora* rootrot. Because the spread of the rot is enhanced by streams, the "safest" sites for Port-Orford-cedar are in the driest associations.

The TANOAK/CALIFORNIA COFFEEBERRY Association, another unusual association, occurs on ultrabasic parent rock. It is low in productivity, with relatively shallow soils for the Series, 76 cm (30 in). Lodgepole pine, knobcone pine, huckleberry oak, and western white pine occur sporadically but are not uncommon on ultrabasics in general.

The TANOAK/BEARGRASS Association is an uncommon association representing relatively cool and dry sites along the east side of the coastal crest. The overstory is comprised of Douglas-fir and lesser amounts of sugar pine. Tanoak and golden chinquapin form a dense subcanopy, dominating the reproduction layer. Beargrass dominates the depauperate understory. Douglas-fir and sugar pine grow well, producing a basal area of 44 m^2/ha (192 ft^2/ac) with an average height of 50 m (164 ft) by age 200. The hardwoods and the beargrass may cause post-harvest regeneration difficulties.

The TANOAK-COAST REDWOOD Association is a special case. It occurs only in the southwestern corner of the area near Brookings and in scattered patches north to Wheeler Creek. It averages 344 m (1130 ft) in elevation, 107 cm (42 in) soil depth and 28 percent cover (50 percent constancy) along with tanoak, which averages 48 percent (100 percent constancy). Red alder, Pacific dogwood, and swordfern are common and abundant. This Association is highly productive, with few management problems.

The TANOAK-WESTERN HEMLOCK Association, like the TANOAK-COAST REDWOOD Association, is confined to a narrow coastal strip in the same general area of the southwestern coast. Although absent between Brookings and Gold Beach, it is a prominent ecosystem component in the Elk and Sixes River Drainages near Powers. Local climatic patterns seem to exclude it from the Brookings-Gold Beach section of the coast. Normally, regeneration is not a problem with adequate site preparation measures. Management of competing vegetation may be necessary, particularly where blue blossom ceanothus is present.

Inland Associations

The inland group can be broken into two subgroups. The first group of six associations are the most productive, the highest in elevation [1130 m (3708 ft)], and have the deepest soils. The second group of five occur at lower elevations [764 m (2505 ft)], have shallower soils, are less productive, and may have reforestation problems. The inland moist subgroup is as follows:

The TANOAK/SALAL-PACIFIC RHODODENDRON Association occurs on the drier coastal sites and the wetter inland sites. Sugar pine and chinquapin are common trees; dwarf Oregongrape, salal, Pacific rhododendron, and red huckleberry are common in the shrub layer. Twinflower and vanillaleaf are the most abundant and constant herbs. This Association is highly productive. Stocking levels can be maintained at higher than "normal" densities while maintaining impressive radial growth.

The TANOAK/SALAL-DWARF OREGONGRAPE Association generally occurs east of the coastal crest. It is occasionally found coastward, but only on the driest sites. Along with sugar pine and chinquapin, incense-cedar and an occasional ponderosa pine can be found. Most species which are dependent on the coastal climate are absent. Dwarf Oregongrape quite often indicates deep soils and does so here. One of the major differences between the Tanoak/Salal-Pacific Rhododendron and the Tanoak/Salal-Dwarf Oregongrape associations are the soil depth and operability. The former averages soils 91 cm (36 in) deep, the latter 103 cm (41 in). Both are productive sites with few silvicultural problems.

The TANOAK-VINE MAPLE Association occurs on bottomland stream channels; concave, protected positions; and upper third of the slope positions. Moss cover is high, averaging 43 percent. Pacific yew, vanillaleaf, and swordfern are present and sometimes abundant, an indication of the cool, moist character of the Association. Similarly, this is the only tanoak association in which cascara, a species with known ties to moist sites, was sampled. This is not a common association, but the vine maple can be a serious competitor.

At the upper elevation limit for the Tanoak Series, white fir becomes an important component of the overstory and reproduction layers. Three associations are recognized which reflect a moisture gradient. The TANOAK-WHITE FIR-MAPLE Association is found on the relatively wet end of this gradient. Soils are the deepest of the Series; they average 119 cm (47 in) and are usually loams to clay-loams. Basal area has been sampled as high as 129 m^2/ha (560 ft^2/ac.) Sugar pine is common and performs very well. Canyon live oak cover is greater than 20 percent. It indicates a pocket of shallow soil or a high volume of coarse fragments in the surface horizons. Vine maple grows very well and can be extremely competitive for site resources.

The TANOAK-WHITE FIR/DWARF OREGONGRAPE Association is very common in the Illinois Valley/Cave Junction area. It is the "middle of the road" association without notable distinction. Douglas-fir, white fir, chinquapin, and sugar pine are quite common in the tree overstory. Dwarf Oregongrape, baldhip rose, creeping snowberry, and western prince's-pine are characteristic of this Association, but they are also ubiquitous in southwestern Oregon. Vanillaleaf and swordfern are the most common herbs. There are no particularly outstanding silvicultural problems, but there could be a combination of circumstances that make reforestation difficult. However, almost any of the conifers of southwestern Oregon should perform well here.

The dry end of the gradient is represented by the TANOAK- WHITE FIR/CALIFORNIA HAZEL Association. These sites are generally gravelly, well drained, and are on southerly exposures. Mature stands are characterized by a mixed canopy of Douglas-fir and white fir with scattered Douglas-fir emergents. California hazel dominates the tall shrub layer and abundant dwarf Oregongrape, whipplevine and vanillaleaf characterize the low shrub and herb layer. Douglas-fir and white fir grow well, although some problems with competition from shrubby tanoak, California hazel, and golden chinquapin may occur following harvest.

Soils derived from granodiorite outcrops in the Peavine/Hungry-Picket area south of Galice support many unusual plant associations, including the TANOAK-SADLER OAK/SALAL Association. These stands are found near 966 m (3150 ft) elevation. The soils are generally sandy, contain few course fragments, and may be relatively shallow. The vegetation is dense and multi-layered. Douglas-fir dominates the upper canopy, tanoak and golden chinquapin the lower canopy, Sadler oak the tall shrub layer and salal the ground layer. The low basal area values give an indication that these stands are not very productive. Planning should consider the sandy soils and possible dense competing vegetation following harvest.

The TANOAK-DWARF OREGONGRAPE is another indistinct Association. It is vegetationally similar to the Tanoak-White Fir Dwarf Oregongrape Association. The soils are deeper [102 cm (40 inches)] than the Tanoak-White Fir Dwarf Oregongrape Association but the climate is significantly warmer. Consequently, reforestation could be difficult on the hottest, driest sites. Another consideration for these mid-elevation sites is the potential for snowbrush ceanothus invasion. Snowbrush ceanothus can quickly occupy a site to the exclusion of other species after harvest activities and site preparation. If snowbrush ceanothus is present in adjacent harvested areas or road cut and fill slopes, the potential for invasion is high. In such areas disturbance must be held to a minimum, planting delays avoided, and large stock used. Any vegetation management technique, whether pulling, cutting, or herbicide application, should be applied early.

The inland dry subgroup. The following five associations have a combination of relatively shallow soils, surface rock up to 20 percent, and a high coarse fragment content in the surface soil horizons. Dry site indicators such as poison oak, hairy honeysuckle, and canyon live oak are common and sometimes abundant. Competition for moisture, the most limiting factor, will be severe in most years, and hardwoods which can sprout will have an advantage over newly planted conifers.

The TANOAK/DWARF OREGONGRAPE-POISON OAK is the most productive of the dry tanoak group because it has the best soil surface features of the group. Litter averages 88 percent, moss cover averages 20 percent, and bareground and rock are 4 percent and 2 percent, respectively. Pacific madrone and sugar pine are common. Poison oak occurs on all sites but is not very abundant. Poison oak is an indicator of hot, dry soil surface conditions. Therefore, the choice of species and seedling placement is critical to survival.

The TANOAK-CANYON LIVE OAK Association is species poor. Pacific madrone and golden chinquapin account for most of the vegetative cover, with an occasional occurrence of sugar pine (on the better sites). The high surface rock content and steep slopes, about 60 percent average, indicate that ravel may be prevalent and could cause regeneration problems. Soils are skeletal as coarse fragment content averages about 84 percent. Planting will be physically difficult, and successful regeneration will require careful coordination of all phases of planning and operations. The most important reforestation effort will be the original stand prescription.

The TANOAK-CANYON LIVE OAK/POISON OAK Association is dominated by Douglas-fir and sugar pine in the overstory. Tanoak, of course, dominates the lower canopy with about 28 percent cover, but canyon live oak is a close associate averaging 23 percent. Poison oak was present on all the plots sampled and again is an indication of dry conditions. Canyon live oak may be present because of recent disturbance or as an indication of a site's relatively poor potential. In either case, it is found on the hotter, drier sites of Southwestern Oregon. In this Association its presence is an indication of the site's potential. Reforestation can be extremely difficult in stands where it occurs with cover greater than 20 percent.

The TANOAK-CANYON LIVE OAK/DWARF OREGONGRAPE is similar to the previous association in terms of vegetational composition, with the addition of abundant dwarf Oregongrape which indicates a more amenable site. Both soil surface characteristics and coarse fragment content are more favorable and reforestation is less difficult than in the Tanoak Canyon Line Oak/Poison Oak Association.

The last of the five dry tanoak associations is the TANOAK/POISON OAK-HAIRY HONEYSUCKLE Association. The vegetation is similar to the two previous associations, but the cover of poison oak and hairy honeysuckle are unusually high. Poison oak is a hot, dry site indicator, as is hairy honeysuckle. It is the hottest, driest, most difficult to reforest, and one of the least productive of the tanoak associations. However, it should be noted at this point that we are speaking of productivity in relative terms. Generally, the Tanoak Series is one of the most productive in Southwestern Oregon.

Summary

Tanoak is not universal in the southwestern Oregon FIR area. It occurs mainly in the western portion: the Illinois Valley drainage and the Hungry-Pickett area of the Rogue River drainage. Although it is known as an invader of harvested areas, it is indicative of productive forest sites. It plays a major role in supporting big game by providing hiding cover, thermal cover, and a dependable crop of acorns. It is an aggressive sprouting species, and the regeneration reduces erosion, reduces mass failures and increases water quality. Its utility in the nutrient cycling process and its contribution of energy to the soil system are just beginning to be understood.

The Tanoak Series is one of the most diverse and complex in southwestern Oregon. In fact, more associations than presented here could be identified based on floristics. Although continuing work will better resolve this complexity, effort will also be concentrated on defining management groups which contain associations that are similar in response to management activities and productivity.

If there are any questions or comments, please contact us at the Siskiyou National Forest, Grants Pass, OR 97526 (503)479-5301, or at the Forestry Sciences Lab, 3200 Jefferson Way, Corvallis, OR 97331 (503)757-4361.

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Of Interest

WESTERN JOURNAL OF APPLIED FORESTRY

Professionals responsible for the management of North American forests have long wished for better access to applicable new research results and technology improvements to help them make sound decisions. This acutely-felt need for rapid and effective technology transfer led forestry leaders in the Southern and Northeastern regions to launch two highly successful publication ventures, the Southern and Northern Journals of Applied Forestry. The western United States and Canada is certainly no less in need of such information than these other regions, and the time has come to launch a similar publication in the West.

Actually, the ground work for this project was laid during the 1980 SAF Convention in Spokane, Washington when the Society Council first endorsed the concept of a Western Journal of Applied Forestry. The deteriorating economic situation in the forestry community during the ensuing several years dictated deferral of action on WJAF until now. Significant start-up funds raised by contributions within the region are required for such a venture and, while recent economic improvement in our industry is certainly less than ideal, the steering committee for the new applied journal has resolved to move ahead with its implementation.

The three person steering committee consists of George Bengtson (Oregon State University), Jay Hughes (Colorado State University) and Dick Fisher (Utah State University). They are currently leading efforts on two principal tasks: 1) organization of a Promotion and Support Committee which will direct a campaign to secure sufficient funds to underwrite publication of the Western Journal through its first year, and 2) selection and activation of an editorial staff. Work on these tasks is underway, with the goal of completing both by late March 1985 and having the first issue ready for distribution by January 1986.

The objective of a regional journal of applied forestry is to provide field foresters, technicians, administrators, landowners, and others active in practicing forestry with current and useful information that can be directly applied in managing forestland for goods and services (Journal of Forestry, June 1983, page 410). Typical content of the WJAF will span all phases of applied forestry and will include:

1. Articles concerned with applications in each of the major subject areas, e.g. resource administration, economics, management, protection, timber harvesting, forest engineering, utilization, measurement, silviculture, tree improvement, hydrology, wildlife, recreation, etc. Each of these areas, which remain to be precisely defined for WJAF, will be under the charge of a subject matter Associate Editor.

2. Articles interpreting research results with emphasis on how the practitioner can put the information to use.

3. Short communications, comments, letters on past articles, announcements of meetings and workshops, book reviews and other important publications of regional interest.

Such a regional journal does not compete with Forest Science, the Journal of Forestry, or the Western Forester, since it will not discuss society affairs, or carry editorials. It will focus on applied regional problems. The Journal of Forestry will retain its position as the main voice of the forestry profession in the United States while the Western, Southern and Northern Journals will provide the kind of practical information that the J of F can't supply in sufficient quantity.

You will be hearing more about the fund raising drive soon through your local SAF chapter or employer. The Weyerhaeuser Company has already come forward with a challenge grant of $5,000 to help launch this drive. The total amount we need is estimated at $25,000. Forest products companies, western forestry schools, and federal and state natural resource management agencies are seen as the principal and logical donors in this campaign, but contributions from local SAF chapters and from individuals will be most welcome. All contributions will be acknowledged in the first issue of the journal.

J.M.

Continuing Education

IMPROVING MOUNTAIN LOGGING PLANNING, TECHNIQUES, AND HARDWARE

May 8-11, 1985. Vancouver, British Columbia. A joint meeting of the Pacific Northwest Skyline Symposium and the International Union of Forestry Research Organizations (IUFRO). Objectives are to exchange new ideas in mountain logging, and to allow the logging industry to get together with regional and international harvesting research workers to discuss applicable practical research. Meetings will be held on the University of British Columbia campus. Field trips will follow the technical sessions. Registration fee is $100 Canadian per person. The cost of field trips is extra. For more information, contact: E.A. Sauder, FERIC, 201-2112 West Broadway, Vancouver, B.C., Canada V6K 2C8. Telephone: (604) 732-3711.

SHELTERWOOD MANAGEMENT SYSTEM WORKSHOP

May 13-14, 1985. Riverside Motel Conference Center, Grants Pass, Oregon. Sponsored by the southwest Oregon FIR Program and the Society of American Foresters G-1 Forest Production and Utilization Working Group. This program will address some of the important biological, economic, and operational aspects of using shelterwood management. Topics will include soils and microclimatic conditions, brush competition and seedling development, logging feasibility and planning, harvest project administration, site preparation, seedling damage and recovery, and frost problems. The workshop is approved for 10.5 credits in the SAF's Continuing Forestry Education (CFE) program. Attendance will be limited to 150. Contact: John Mann or Steve Tesch, workshop directors, or Tracy LeBarron, secretary, Adaptive FIR, (503) 776-7116.

STAND DENSITY MANAGEMENT WORKSHOPS

June 10-11, 1985 Medford, Oregon	June 12-13, 1985 Corvallis, Oregon

Two workshops will be offered by Oregon State University in June, 1985 on Stand Density Management - one in Corvallis and a similar one as part of the SW Oregon FIR program. Both sessions will focus on western Cascade conditions, but will emphasize local conditions. The content is designed to bring the forest manager up-to-date on the principles of density management and the several systems currently in use. About half of the program will be spent in the field evaluating a variety of forest stands for pre-commercial and commercial thinning opportunities. The Medford workshop will concentrate on Growth Basal Area and Reineke's Stand Density Index. The Corvallis session will focus on the Relative Density and Growth Basal Area systems. Both courses will make comparisons with other systems such as Curtis' relative density and Wilson's percent of height. The workshops are intended for foresters with responsibility in pre-commercial or commercial thinning. For further information, contact: Medford session, Tracy LeBarron or Steve Tesch, (503) 776-7116; Corvallis session, Conference Assistant, (503) 754-2004.

SOUTHWEST OREGON FOREST PEST CONTROL

August 19-20, 1985. Grants Pass, OR. This program will address various aspects of forest pest management in southwest Oregon. Topics will include theoretical and managerial aspects of insect, mammal, disease and weed control. Attendance limited to 120. CONTACT: Ole T. Helgerson, Workshop Director, or Tracy LeBarron, Secretary, Adaptive FIR, (503) 776-7116.

IDENTIFYING AND USING PLANT ASSOCIATIONS FOR FOREST MANAGEMENT IN SOUTHWEST OREGON

A two-day workshop is scheduled for May 29-30, 1985, at Nendel's Inn in Medford, Oregon. The first day of the session will be spent in the classroom and the second day in the field. For further details, contact: OSU Conference Assistant, (503) 754-2004.

Recent Publications

MECHANIZED FORESTRY, WORLD WAR II TO THE PRESENT, by C. R. Silversides. 1984. The Forestry Chronicle 60(4). As the Pacific NW moves toward the harvesting of smaller stems from second growth stands, logging systems must change in order to handle the increased piece count per unit volume. For other regions that have undergone this transition, the trend is to more mechanization and it seems reasonable to assume that this trend will apply to our region. In order to fully appreciate the evolutionary process that we must experience in this changeover, it is useful to learn the history of harvest mechanization in other regions as well as within the Pacific N.W. In this article, Ross Silversides relates first-hand knowledge of Canadian forest mechanization developments over the first 40 years of his career in forestry. It is an interesting and informative story that should help us understand what to expect in this region's move toward smaller wood and more mechanization.

Source: C.R. Silversides Forestry Consultants, Ltd.
R.R. #1
Prescott, Ontario
CANADA K0E 1T0

DEVELOPMENT OF TANOAK UNDERSTORIES IN CONIFER STANDS, by J.C. Tappeiner, II, and P.M. McDonald. 1984. Canadian Journal of Forest Research 14:271-277. The stocking, age, and growth rates of tanoak were studied in the understory of 13 Douglas-fir and mixed conifer stands, 53-240 years old, on a range of sites in Oregon and California. Findings show tanoak grows slowly in the conifer understory and at 50 years of age is only 80 to 160 cm tall. Sprouting potential also develops slowly, with perhaps 100 years required for a new understory to develop the capacity for vigorous resprouting. Three years after burning, 41-50-year-old tanoak averaged five sprouts only 30 to 70 cm tall. Authors conclude tanoak control may be less costly and less frequently needed if accomplished in 30- to 75-year-old conifer stands.

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

MINIMIZING SOIL COMPACTION IN PACIFIC NORTHWEST FORESTS by H. A. Froehlich and D. H. McNabb. 1984. IN: E. L. Stone (ed.). "Forest Soils and Treatment Impacts," p. 159-192. Proc. Sixth North Amer. For. Soils Conf., University of Tenessee, Knoxville. This paper is a review of the soil compaction literature as it relates to forests and soils in the Pacific Northwest. Soils in the region generally have a combination of properties that make them susceptible to compaction. As a result, tree growth is generally reduced in compacted soil. Because natural processes to loosen compacted soil are mostly ineffective, several methods of controlling heavy equipment operation have been used to reduce compaction. The effectiveness of these methods are discussed.

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

FIR PROGRAM: REFORESTATION RESEARCH IN SOUTHWEST OREGON, by Jack Walstad and Steve Hobbs, October, 1984. This eight page information flier tells the story of the Forestry Intensified Research Program from inception in 1978. Problem statement, approach, organizational structure, list of cooperators and research results to date are discussed in short, synopsis form with several color photographs of studies in progress. A useful bulletin in helping to understand the "why's" and "how's" of FIR.

Source: J. D. Walstad
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