FIR Report

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

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

The FIR REPORT is one of the principal methods of reporting recent technological advances and research results pertinent to southwest Oregon, and alerts area natural resource managers to upcoming continuing education opportunities. Comments and suggestions concerning the content of the FIR REPORT are welcome and encouraged.

For the FIR Staff,

[redacted]

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Inside

Adaptive FIR

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Because of space limitations, articles appear as extended abstracts. Results and conclusions presented herein may be based on preliminary data or analyses. Readers who are interested in learning more about a study are encouraged to contact the principal investigator or wait for formal publication of more complete results.

Adaptive FIR

LAST FIR REPORT—FIR OFFICE TO CLOSE AS PROGRAM ENDS

This is the last issue of the FIR REPORT. On Sept. 30, 1991, the FIR Program officially ends. As most of you know, we've been winding down for some time — completing remaining studies, analyzing data, and preparing manuscripts for publication. The biggest project has been writing a book that will provide a synthesis of reforestation knowledge gained over the last 13 years. The book should be available in early 1992.

The FIR office in Medford will be closed about Jan. 1, 1992. I'll be moving to Corvallis shortly after that and will become a member of the Forest Resources Department. The plan is to have all FIR-related projects completed and manuscripts drafted before the team disbands in Medford, so that nurturing papers through the publication process will be my only FIR-related time commitment once I arrive in Corvallis. That is not to say, however, that the College of Forestry or the PNW Research Station will abandon southwest Oregon. Forestry Extension agents Allen Campbell (Medford), Ralph Duddles (Coos Bay), and Mike Cloughesy (Roseburg) have strong ties with on-campus departments in the College of Forestry and can provide important channels of communication, both for relaying questions or problems from you to faculty in Corvallis, or for the College to transmit new developments in science or education to you. In addition, some ongoing projects in southwest Oregon will be continued to provide longer-term information. Several existing study sites will be maintained and periodically remeasured to capture further information on young stand development. Some new projects will also be started focusing on different subjects as priorities for research and training shift. For example, a new effort is underway to modify the growth model ORGANON so that it can better project stand development in patchy, uneven-sized, diverse stands where maintenance or development of mature forest habitat over time is an important issue. It is perhaps true that OSU-based faculty will not be as convenient to work with as the Medford FIR team has been, but many will be actively working in the area, remaining aware of the local concerns and needs, and should be able to assist with training, research, or operational implementation.

The FIR REPORT has been a very successful means of transmitting current information to FIR clients and other readers. But perhaps equally important, this newsletter stimulated discussions between readers and the FIR staff that helped fine-tune research and training priorities. One of the original goals of the FIR Program was to ensure that local foresters had access to the best information on reforestation available in the world. This issue will be mailed to folks in 28 countries and 31 states, many of whom have reciprocated and shared their expertise with us to help meet that goal. Given the slow pace of the formal journal publication process, the FIR REPORT has enabled scientists to provide helpful preliminary and final information very quickly. However, since most studies are eventually documented in the scientific literature or in the upcoming FIR book, the collection of FIR REPORTS will not be preserved as a piece of the permanent scientific literature. These newsletters are not intended to be cited or referenced, nor are sets being sent to libraries. We do recognize that a great deal of practical information is found in the various issues, so we will continue to honor requests for back issues as long as our supplies last.

We've been proud of the FIR REPORT and hope you will miss receiving the information it contained. There are at least three other good ways to keep abreast of current research, recent publications, and training opportunities. I'd recommend you get on the mailing lists for the FORESTRY UP-

DATE (prepared by OSU Extension Forestry), the COPE REPORT (prepared by the OSU Adaptive COPE team), and recent publications from the OSU Forest Research Laboratory. Simply put your name and address on a note indicating to which lists you're interested in being added and send it to the Dean's Office, College of Forestry, OSU, Corvallis, OR, 97331-5704.

It has been a pleasure working with all of you over the last decade. Thanks for everything you have taught me!

Steve Tesch

FIR PROGRAM ENDS AS A SUCCESS

The FIR Program was started 13 years ago when community leaders in southwest Oregon asked the OSU College of Forestry and the USDA PNW Research Station to help solve local reforestation problems. The ensuing basic and applied research effort has greatly expanded knowledge of area ecosystems and the practices necessary to reforest them after timber harvest or wildfire. Scientists found few situations where the environment limited seedling survival when artificial reforestation practices were carefully applied.

Information on ecology and operational practices has been rapidly disseminated to field foresters and managers through the FIR REPORT, workshops, field trips, and personal contacts, as well as in over 400 publications. Results from the FIR Program have been applied on public and private lands throughout southwestern Oregon, northern California, and many other locations throughout the world. Perhaps the most graphic accomplishment resulting from the improvements in knowledge and training was the reclassification by the Medford District BLM of nearly 130,000 acres of land as suitable for reforestation and sustained timber production in the current planning cycle.

Finding ways to get conifer seedlings to survive on harsh sites in the region was the major challenge when FIR was started, particularly in conjunction with even-aged silvicultural systems. Carefully applied intensive reforestation practices have largely solved those problems. The information base is also very relevant, however, when alternative silvicultural systems are used to meet reforestation challenges associated with shifting resource objectives and social values. The basic ecological information is sound and much better analytical tools are also now available to assist in evaluating tradeoffs associated with various alternatives.

While foresters in the region obviously face many challenges, the FIR Program and associated efforts over the last decade provide the basis for optimism regarding our ability to sustain productive forests. The success of the Program is the result of a team effort — one that has been copied in other research and technology transfer programs world wide. We'd like to acknowledge the vision and leadership provided by members of the FIR Advisory Council, especially that of Martin Craine, S.V. McQueen, and Allyn Ford who served as chairmen. Financial resources for Adaptive FIR were always adequate thanks to efforts by the BLM, Forest Service, county governments, timber industry, and Oregon State University. Senator Hatfield and Representative AuCoin were stalwart supporters of funds for Fundamental FIR in the U.S. Congress. Finally, thanks very much to the many foresters, research assistants, and all others who helped with the installation and tending of research plots, collected data, and assisted with field trips and workshops. Without all of you this success would not have been possible!

George Brown, Dean
Steve Tesch, FIR Coordinator
College of Forestry

HEIGHT GROWTH OF WHITE FIR AFTER RELEASE

In the last two issues of the FIR Report, 12(1):2-4 and 12(2):4-5, we have presented the results of a study on the height growth potential of released advance regeneration and compared advance regeneration height growth with that of planted Douglas-fir. Our initial comparison [12(1):2-4] assumed planted seedlings would grow at a trajectory equal to Hann-Scrivani site index curves, a liberal assumption for all planted trees. In the last issue [12(2):4-5] we compared the height growth of released Douglas-fir with that of planted Douglas-fir growing at rates determined by SYSTUM-1, a young stand growth simulator. In this issue we will compare the height growth of released white fir with that of planted Douglas-fir, again by utilizing SYSTUM-1 to project the height growth of planted Douglas-fir seedlings under two competition scenarios — one without competition and one with substantial competition from tanoak and madrone. SYSTUM-1 is a recently-completed tree growth simulator developed for use in northern California and southern Oregon for projecting height growth of young stands, with or without competition, up to an age where large tree simulators operate reliably.

Our stem analysis data for released white fir advance regeneration were subdivided by site class (site class III, IV or V) and regeneration height at the time of release (trees ≤4.5 ft, >4.5 and ≤12 ft, or >12 ft tall). Average height at the time of release was determined for the sample trees stratified into each of the nine respective treatment combinations. For example, the mean height of stem analysis trees in the medium (>4.5 and ≤12 ft) height class on site III was 7.6 ft (Table 1). The stem analysis data were further analyzed to compute average annual height growth over 5, 10, and 20 years for each treatment combination. Total height at the end of each period was calculated by multiplying the length of the time period (5, 10, or 20 years) times the average annual growth rate for that time period and adding that growth to the average initial height.

SYSTUM-1 was used to generate heights of planted Douglas-fir over a similar range of site qualities and time periods. We assumed that harvesting, site preparation, and planting took place within 1 year, so that the Douglas-fir were planted the same spring that the white fir were released. We used as SYSTUM-1 inputs: 200 trees per acre (present 3 years after planting), mean height=2 ft, s.d.=0.4 ft, and range=1-3 ft. Dunning and Reineke's 50-year site index values of 100, 80 and 60 were assumed to represent mid-points of McArdle site classes III, IV and V respectively. For the competition scenario, we assumed that tanoak and madrone sprouts in a 3-year-old plantation would average 4 ft tall with 90 percent cover.

As one might expect, projected heights of planted seedlings declined as site quality declined or competition increased, or both (Table 1). In general, the average total height of released trees also declined as site quality declined. Released trees on poorer sites were occasionally taller than those on better sites, however, depending on either the mean initial heights of the trees in the respective size classes at the time of release or the average growth rate of the sample trees for that particular time period, or both. For example, after 20 years

Table 1. Observed total heights of released white fir advance regeneration by initial height class (≤ 4.5 ft = small, >4.5 ft and ≤12 ft = medium, >12 ft = large) and projected heights of planted Douglas-fir seedlings grown at two competition levels for 5, 10, and 20 years after release.

		Total height (ft)				
		Released advance regeneration			New plantation	
Site class	Years since release	Small	Medium	Large	No competition	Tanoak/ Madrone
III	0	3.9	7.6	17.8	0	0
	5	6.9	11.8	22.6	5.4	4.9
	10	12.9	19.1	30.3	16.2	13.9
	20	28.9	39.3	48.9	38.7	34.7
IV	0	3.6	7.7	19.3	0	0
	5	5.9	11.0	24.6	4.8	3.8
	10	9.7	16.8	32.1	13.7	9.5
	20	25.8	33.2	53.6	32.1	22.4
V	0	3.3	7.7	15.7	0	0
	5	5.1	10.1	19.0	4.3	3.1
	10	8.4	14.2	25.1	11.2	6.3
	20	25.2	32.7	47.6	25.4	13.8

the average large white fir on site IV was taller than that on site III, as a result of greater growth by the site IV sample trees and initial starting height. This is an anomaly of our data set and probably reflects difficulties in correctly identifying site quality at the time of sampling. We also do not know what the effect of competition is on advance regeneration height growth because the competitive conditions at the time of release are unknown. Since apparently none of the released stands received any subsequent vegetation control treatments, we assume that competition between released trees and associated vegetation was at least moderate.

Medium and large white fir were consistently taller than planted Douglas-fir after 20 years, whether planted trees were grown

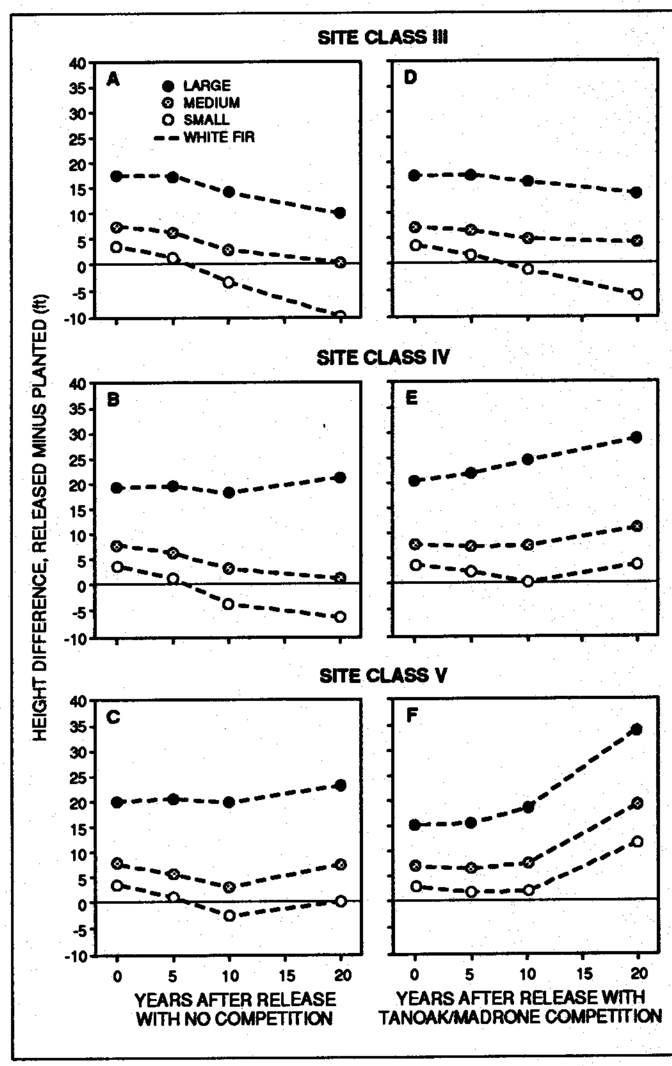

Figure 1. Trends in the difference in height between released white fir and planted Douglas-fir seedlings, based upon site class, initial size of advance regeneration, and the presence or absence of tanoak/madrone competition in the Douglas-fir plantations. Label designations are as follows: zlarge, medium and small represent the following initial tree height classes: small trees ≤4.5 ft tall (small); medium trees between >4.5 ft and ≤12 ft tall (medium); and large trees >12 ft tall (large).

with or without competition. The 20-year heights of small white fir advance regeneration, however, were less than those of planted Douglas-fir grown without competition across site classes. When planted Douglas-fir were grown with competition, small white fir were taller than planted trees after 20 years, except on site class III ground (Table 1). The usually greater height of advance regeneration resulted from the initial size at the time of release and the growth rate over the 20-year period or both (Figure 1). With or without competition on site class III ground (Figures 1A and 1D), planted seedlings tended to grow more rapidly (trend of lines are downward) over 20 years than released trees. In fact, planted trees had surpassed the total height of small white fir within 10 years after release, with or without competition, on site class III ground. For the site class IV no competition scenario, small and medium released white fir grew more slowly than planted seedlings (Figure 1B), while large white fir grew at about the same rate as planted seedlings (Figure 1B). With competition, trends were level to upward, indicating that released white fir were growing as fast or faster than planted Douglas-fir (Figure 1E). On site class V ground, without competition, height growth of released white fir was about the same as or a little slower than that of free-growing planted Douglas-fir for 10 years (Figure 1C). For the 10- to 20-year period, released white fir grew somewhat faster than planted Douglas-fir. With competition, trends are fairly level for 10 years and then released white fir grew substantially faster than planted Douglas-fir (Figure 1F).

In summary, these projections support our earlier conclusion that managing advance regeneration may be a viable reforestation option in southwest Oregon and northern California. As site quality declines or competing vegetation increases, opportunities to manage established advance regeneration may become more attractive. The decision to use or reject advance regeneration as the next crop requires site-specific evaluations of product and land management goals, feasibility and cost of protecting an adequate amount and distribution of advance regeneration during overstory removal, and the cost and difficulty of establishing a new plantation. Studies of advance regeneration response after release provide information that, in combination with SYSTUM-1, enables more comprehensive and reliable evaluations of reforestation alternatives.

EJK
SDT

SEEDLING HEIGHT AND MORTALITY AMONG SITES IN THE REGENERATION POTENTIAL STUDY

Thirty-nine sites were planted between 1982 and 1987 in order to test the regeneration potential of land within the BLM Medford District considered difficult to reforest. Species and stocktypes included Douglas-fir 1+0 plug (DF1), Douglas-fir 2+0 bareroot (DF2), Douglas-fir plug+1, ponderosa pine 1+0 plug (PP1), ponderosa pine 2+0 bareroot (PP2), and sugar pine 1+0 plug. Sites were either clearcut and broadcast burned or they were brush fields that had been cleared and broadcast burned. Competing vegetation was aggressively controlled using herbicides, paper mulch, and hand-grubbing. Plastic mesh tubes protected the Douglas-fir seedlings from deer browsing. Seedling survival, height, and diameter were measured each year for 5 years. Fifth-year survival for all sites was reported in FIR Report 12(2).

On average, DF2 maintained a height advantage over DF1 throughout the 5-year measurement period (Figure 1A). PP1 and DF1, however, had virtually the same average heights over 5 years (Figure 1B). The average height for DF2 was greater than PP2 until the fifth year when PP2 caught up with DF2 (Figure 1C). Fifth-year Douglas-fir heights varied more between sites than ponderosa pine. This was partly because Douglas-fir seedlings were browsed by deer, in spite of efforts to keep the protective plastic net tubes in place, while ponderosa pine seedlings were not browsed. With a couple of exceptions, the best growing Douglas-fir tended to be on the same sites as the best growing ponderosa pine (Table 1). This suggests that certain site characteristics have influenced height growth over the 5 years.

Tin Pan Peak (TPP) and Texter Gulch (TG) were the only sites where DF1, DF2, PP1, and PP2 were planted together and performance between both stocktypes of each species could be compared. The pattern of annual growth was similar between species and stocktypes at both TPP and TG. Overall growth was quite different between sites, however, with greater fifth-year heights at TPP (Figure 2A). The amount of mortality that occurred each year at TPP and TG also varied drastically between species and stocktypes (Figure 2B). Overall, most mortality occurred in the first year and annual mortality generally decreased throughout the five-year period. To illustrate how seedling age and seasonal rainfall can impact seedling performance, annual (Oct.1-Sept.30), spring (Feb.-April), and dry season (May 1-Sept.30) rainfall estimates were calculated for TPP and TG (Table 2). TPP (elevation 411 m) was planted February, 1982, and TG (elevation 884 m) was planted February, 1984. Normal rainfall amounts for TPP and TG are from the OSU Extension Service annual and dry season precipitation maps for southwest Oregon and are based on the average rainfall between 1960-1980. Normal annual, spring, and dry season rainfall values for Medford, Oregon (elevation 422 m) were obtained from the National Weather Service for the same period. To estimate the first- through fifth-year rainfall at TPP and TG, an adjustment factor was calculated by dividing actual seasonal rainfall values for 1982-1988 by normal rainfall for Medford. Rainfall for TPP and TG was then calculated by multiplying the map-based normal rainfall for

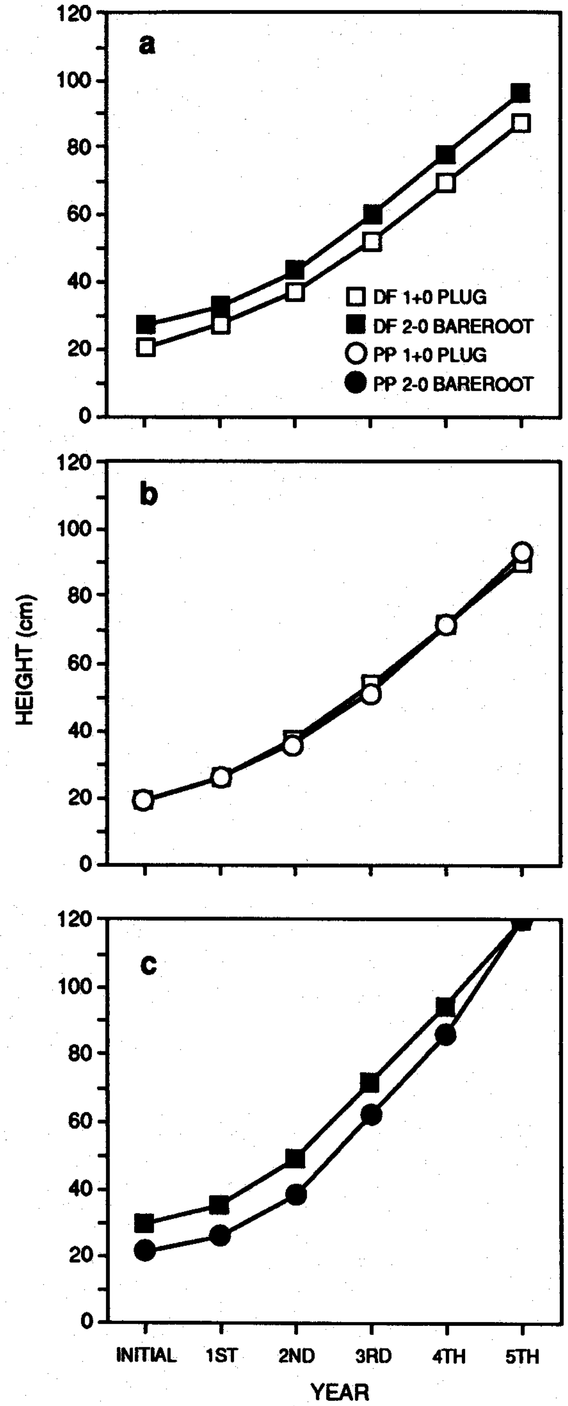

Figure 1. Average height over 5 years for Douglas-fir 1+0 plug (DF1) and Douglas-fir 2+0 bareroot (DF2) seedlings planted together at 34 sites (A), DF1 and ponderosa pine 1+0 plug (PP1) seedlings planted together at 14 sites (B), and DF2 and ponderosa pine 2+0 bareroot (PP2) seedlings planted together at five sites (C) in the Regeneration Potential Study.

Table 1. Average fifth-year height (cm) for Douglas-fir (DF) and ponderosa pine (PP) ranked by the average DF height (1+0 plug and 2+0 bareroot) for sites in the Regeneration Potential Study.

Site	DF	PP	
Tin Pan Peak	155	121	*
China Ridge	119	123	**
Old Ben	116	144	***
Stevens Creek	114	90	**
Low Crow	103	107	***
Salt Creek	102	121	***
Left Fielder South	100	103	**
Texter Gulch	98	88	*
Millcat	97	96	**
Negro Ben	92	89	**
Brandt Crossing	88	110	**
Buckhorn 1	85	83	**
Limp Hog	84	76	**
Pickett Again	82	87	**
Rock Creek	78	80	**
Left Fielder West	76	68	**
Burton Butte	61	76	**
Average	97	98	

Average of PP: * 1+0 plug and 2+0 bareroot; ** 1+0 only; *** 2+0 only.

Table 2. First- through fifth-year rainfall esitmates for the Tin Pan Peak (TPP) and Texter Gulch (TG) Regeneration Potential Study sites.

Season	Map-based normal rainfall (cm) (1960-1980)	Site	Calculated rainfall estimates (cm) 1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
Annual (Oct.1-Sept.30)	76.2	TPP	99.8	103.6	82.3	65.5	70.9
	88.9	TG	96.0	76.4	82.7	64.0	57.8
February-April	no map-based value available	TPP	(136)*	(201)	(114)	(60)	(147)
		TG	(114)	(60)	(147)	(81)	(37)
Dry (May 1-Sept.30)	11.4	TPP	7.0	22.7	8.1	10.5	15.8
	11.4	TG	8.1	10.5	15.8	8.7	10.0

* Numbers in parentheses are the percent of normal rainfall for Medford, Oregon.

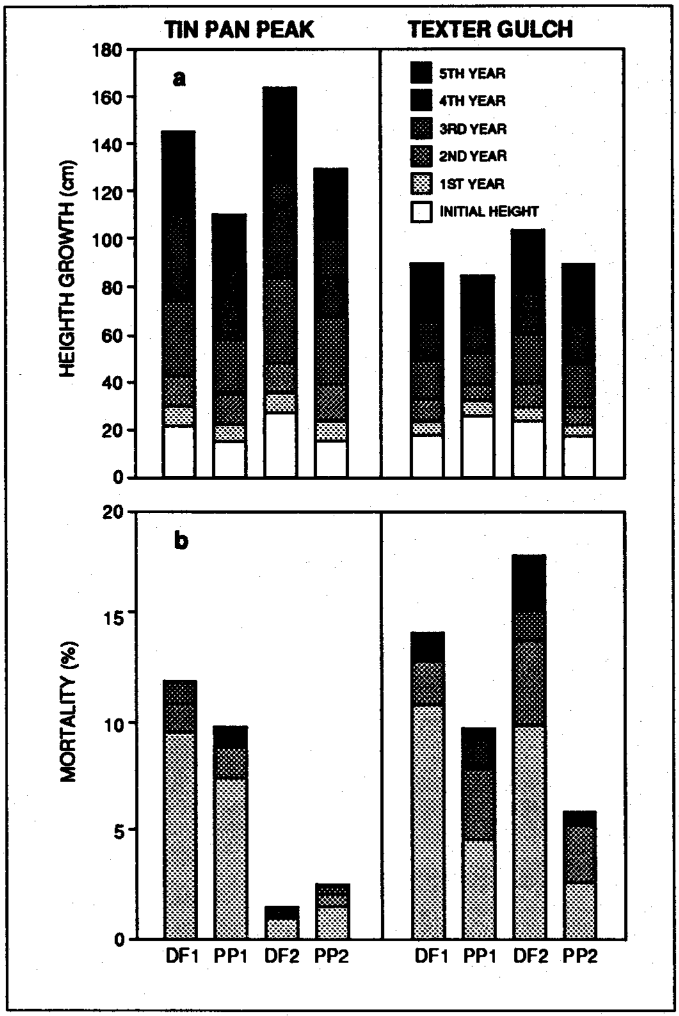

Figure 2. Cumulative height (A) and percent mortality (B) by year for Douglas-fir 1+0 plug (DF1), ponderosa pine 1+0 plug (PP1), Douglas-fir 2+0 bareroot (DF2), and ponderosa pine 2+0 bareroot (PP2) seedlings planted together at Tin Pan Peak and Texter Gulch in the Regeneration Potential Study.

each site by the adjustment factor. Although the maps did not provide normal Feb.-April rainfall values for TPP and TG, the calculated percent of normal rainfall for Medford gives an indication of the relative amount available during the critical period of root growth in early spring. The difference in mortality between TPP and at TG stands out in the second- and fifth-years (Figure 2B). All estimates show that TPP had substantially more rainfall in its second and fifth year (1983 and 1986) than the second and fifth year at TG (1985 and 1988) and that rainfall amounts may have reached a critical minimum for survival in those 2 years at TG.

Apart from inherent species differences, it is apparent that site factors influenced seedling survival and growth at TPP and TG. Elevation, aspect, slope, solar radiation, plant association, rock content of soil, soil bulk density, and rainfall are being analyzed to determine what combination and to what extent these factors influenced seedling performance over a 5-year period at 37 sites. These analyses will provide a means for predicting reforestation success on similar sites in southwest Oregon. For background material on this study, see FIR Reports 3(4):4, 4(1):1, 4(4):4, 5(2):6-7, 5(4):4, 6(4):4, 8(4):2-3, 9(2):2, 10(1):3-4, 10(4):6-7, 11(1):2-3 and 5-7, 11(2):2-4, 12(1):7-9, and 12(2):5-8.

KBK

Continuing Education

FIRE IN PACIFIC NORTHWEST ECOSYSTEMS: EXPLORING EMERGING ISSUES

January 21-23, 1992. Portland, Oregon. This symposium will address issues surrounding the use of fire in Pacific Northwest forests, rangelands, and wetlands and is designed to build on information compiled in two recently published books (*Natural and Prescribed Fire in Pacific Northwest Forests*, 1990. Oregon State Univ. Press, Corvallis and *The Burning Decision: Regional Perspectives on Slash*, 1989. College of Forest Resources, Univ. Washington, Seattle). Over 40 regional and national experts on wildland fire will present information on:

- the historical and ecological aspects of fire
- effects of fire on long-term site productivity
- effects of fire on the atmosphere
- fire and biological diversity
- using fire to achieve management objectives
- implications of fire policies
- future use of prescribed fire
- current positions and philosophies about fire.

There will be an evening session featuring volunteered posters, slide-tapes, videos, computer models, and other displays highlighting the latest developments in fire management and science. Call the Conference Assistant **before** November 1st about volunteering a display at the poster session (please no commercial exhibits). CONTACT: Conference Assistant, College of Forestry, Peavy Hall, Room 202, Oregon State University, Corvallis, OR 97331-5707 or phone (503) 737-2329.

Of Interest

COMPETITION LIMITS DOUGLAS-FIR MORPHOLOGY AND PHYSIOLOGY: A CASE OF DOUBLE TROUBLE

A synthesis of results from several Fundamental FIR studies has revealed that hardwood competition causes simultaneous limitations in morphology and physiology of five- to nine-year-old Douglas-fir which combine antagonistically to reduce conifer growth and delay their dominance of the site. At high densities, tanoak and Pacific madrone exert a strong influence on the microclimate of young stands, creating conditions that severely limit both leaf area production and unit-leaf-area rates of photosynthesis (Ps) for associated Douglas-fir.

In a previous FIR Report, 11(2):6-7, a technique was described for predicting future growth of Douglas-fir from measurements of the size and number of buds on the terminal shoot. Such information can be used to quantify conifer vigor and growth potential, e.g., current level of competitive stress or response to a recent release treatment. Other features of Douglas-fir morphology that are limited by competition include the number, length, thickness, and dry weight of needles per shoot. Douglas-fir competing with hardwoods for water but not for light (trees growing in openings within a hardwood stand) will have moderate reductions in their morphological development compared to that for trees growing free of competition (Figure 1a). A Douglas-fir growing in the shade of hardwoods, however, may have a terminal shoot with only a single bud — a minuscule terminal bud — and only a few, short, and closely-spaced needles (Figure 1a).

The following discussion describes the effect of hardwood competition on the seasonal pattern of net Ps for Douglas-fir. It is based on about 1000 field measurements of Ps at monthly intervals between May 1986 and December 1988 at three sites in southwest Oregon, two of which were dominated by tanoak and the other dominated by madrone (Figure 1b). Three competitive regimes for five- to nine-year-old Douglas-fir were studied: (1) removal of hardwoods and other competing vegetation, (2) full exposure to sunlight in openings within a hardwood stand, and (3) shaded conditions under a hardwood stand. Ps rates are expressed on a unit-leaf-area basis, i.e., mass of carbon assimilated for a fixed amount of leaf area.

In spring, when both light and soil water conditions are at peak levels and are most favorable for Douglas-fir Ps, shaded trees receive less than 25 percent of full sunlight. Under these conditions, Douglas-fir Ps rate is limited directly by reduced light availability. Shaded foliage is thinner than sun foliage because it has an interior morphology composed of only one

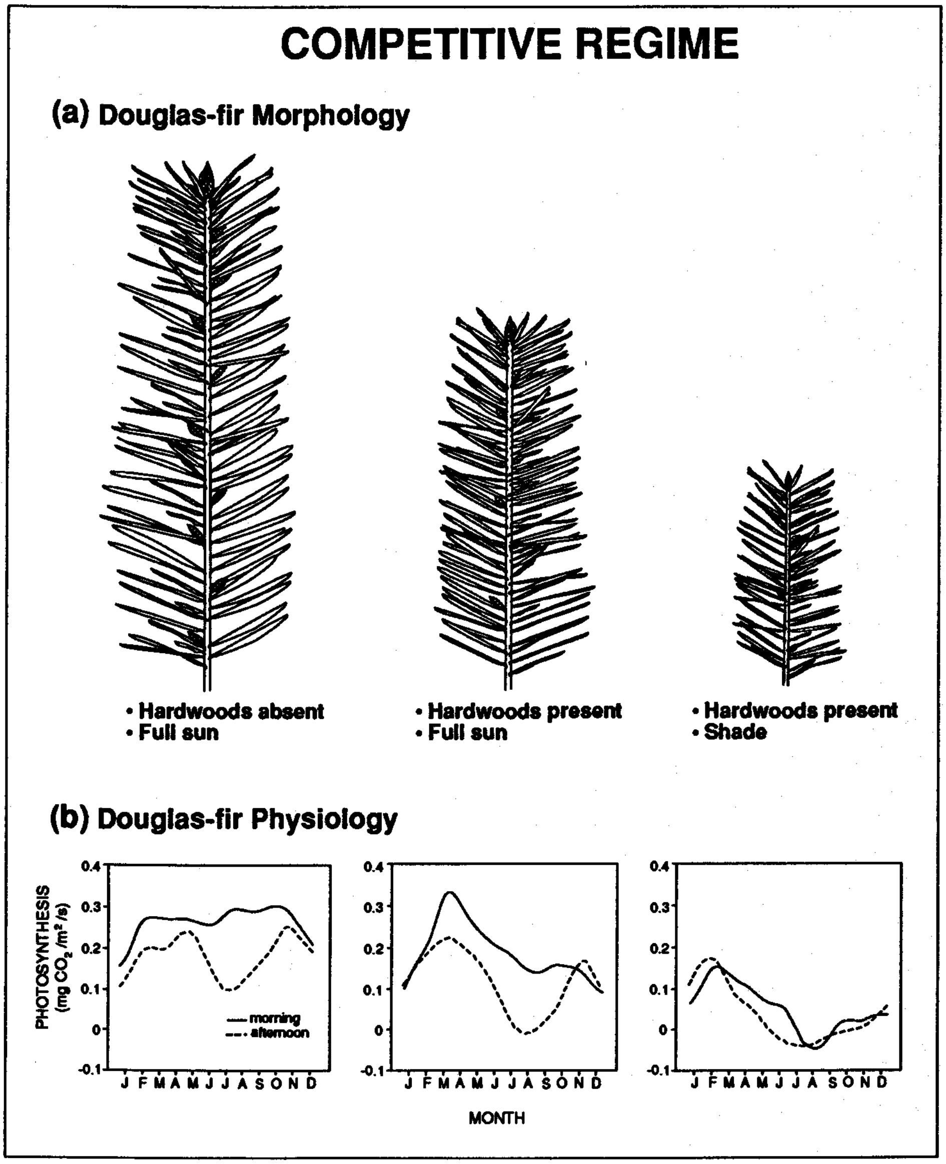

Figure 1. Generalized responses of Douglas-fir (a) morphology and (b) physiology as affected by three regimes of hardwood competition in southwest Oregon.

to two layers of short cells. Thus for a given amount of leaf area, shade foliage will have a lower volume of chlorophyll and less interior surface area for CO_2 absorption than sun foliage, i.e., a lower **Ps** capacity. Specific leaf area (leaf area/ leaf weight) therefore is greater for shade foliage than sun foliage (Table 1.).

Table 1. Parameters used to calculate average annual rates of whole-tree photosynthesis (Ps) for the three competitive regimes in young Douglas-fir/hardwood stands.

Parameter	Competitive regime for Douglas-fir		
	Hardwoods absent (full sun)	Hardwoods present (shade)	Hardwoods present
Specific leaf area (m^2/kg)	6.30	6.68	9.17
Annual leaf area increment per tree (m^2)	5.41	1.00	0.23
Average unit-leaf-area Ps rate (mg $CO_2/m^2/s$)	0.219	0.146	0.029
Average Ps rate per tree (mg CO_2/s)	0.586	0.076	0.003

An added limitation to **Ps** begins in early summer when leaf temperatures become elevated for trees within the hardwood canopy, especially for shaded trees. Presumably this occurs when air becomes trapped and heated within the dense hardwood canopy. Respiration rates then begin to equal or exceed **Ps** rates resulting in a net loss of carbon (note "negative" **Ps** in Figure 1b). In addition, Douglas-fir reduce their stomatal aperture in response to temperature increases and corresponding decreases in relative humidity which further limits the tree's ability to absorb and assimilate CO_2. By late summer, hardwoods have consumed most of the available soil water and pre-dawn water stress values for Douglas-fir become increasingly negative (-12 to -18 bars). Douglas-fir competing with hardwoods will often by mid-morning reach values of water stress that cause stomatal closure (-20 bars). This is especially true for the shaded trees which have poorer stomatal control. For the remainder of the day, fixed carbon is lost through respiration. In contrast, the major factor limiting the growing-season **Ps** rates for Douglas-fir growing without competition is the low relative humidity typical of mid- to late-summer afternoons (Figure 1b).

By autumn, as microclimatic conditions become similar to those of spring, a second peak in **Ps** rates occurs for Douglas-fir. The shaded Douglas-fir, however, do not demonstrate a fall peak, presumably because of limitations in light availability and a residual effect from the summer drought. During the winter, **Ps** rates of the Douglas-fir in each of the three competitive regimes become limited because of reduced levels of light and air temperature. Rates comparable to those observed in the growing season, however, are possible during periods of mild weather. Shaded Douglas-fir continue to be at a disadvantage because of severe light limitations. Low soil temperatures during the winter reduce the ability of tree roots to absorb water for transpiration and have a limiting influence on **Ps** of Douglas-fir in each competitive regime.

In summary, year-round limitations in Douglas-fir **Ps** were associated with microclimatic conditions of the hardwood shade. While limitations mainly occurred during the growing season for trees growing in hardwood stand openings, their **Ps** rates did peak in early spring. When expanded to a whole-tree level, values of **Ps** rates for Douglas-fir in the three competitive regimes span a huge range (Table 1). Whole-tree values for annual increment in leaf area were estimated by multiplying annual increment in foliage biomass by specific leaf area for a given tree. Unit-leaf-area **Ps** rates for a given tree were averaged across the series of seasonal measurements and the average was multiplied by the tree's annual increment in leaf area to provide a rough estimate of its average annual rate of **Ps**. A combination of restricted leaf area development and reduced average unit-leaf-area **Ps** rate limited whole-tree **Ps** rates of Douglas-fir growing in the shade of hardwoods to about 1/200th of that for trees growing competition-free (Table 1). Douglas-fir growing within openings in the hardwood canopy have average annual **Ps** rates that are about 1/8 of those for trees growing in the competition-free regime. As discussed earlier, the leaf area development of a given Douglas-fir depends greatly on its bud production (bud size and number) and needle morphology (number, length, and mass).

These results demonstrate that hardwood competition causes limitations in both the morphology and physiology of Douglas-fir, which combine antagonistically to severely limit annual carbon assimilation of individual trees. The slow growth rates and reduced vigor of the shaded Douglas-fir is evidence of their extremely low assimilation rates and appear to account for their frailty. Similar factors appear to account for the moderate growth reductions observed for trees that occur in openings within the hardwood canopy. Additional details concerning this research are found in the author's Ph.D. thesis.

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THE NEW INTEGRATED FOREST PROTECTION PROGRAM AT OSU

The Integrated Forest Protection (IFP) program in the Department of Forest Science has been in place for 3 years. Development of the program gained momentum with the recent addition of Dr. Greg Filip and Dr. Darrell Ross (introduced in the last edition of the FIR Report) to the Forest Science faculty. This program includes research, teaching, and extension components designed to link the concepts of integrated pest management with the broader aspects of forest resource management.

As the importance of forests continues to grow in the Northwest, the complexity of management—including pest management—is also increasing. With the shift from mature forests already in place at the time of settlement to second-growth forests and plantations that must be nurtured and protected over time, opportunities for pest problems abound. Simplistic direct solutions to such problems are no longer feasible in many instances, and integrated, preventative approaches designed to accommodate multiple resource values and ecological functions are becoming more important. The IFP program emphasizes incorporating pest management considerations into comprehensive forest management plans to minimize significant pest-caused losses of forest resources.

The research component includes both basic studies of pest ecology and applied studies designed to compare the response of pest populations to alternative silivcultural treatments. The research will stress an interdisciplinary approach to understanding and solving pest problems. Proposals for specific research projects are currently being developed.

The educational component of the program provides opportunities to earn M.F., M.S., or Ph.D. degrees in Integrated Forest Protection. Students have the flexibility to develop an individual curriculum which bridges the traditional forestry and pest management disciplines. Questions or comments about the program should be addressed to:

Greg Filip - (503) 737-6078
Darrell Ross - 737-6566
Department of Forest Science
OSU

A SYNTHESIS OF SOUTHWESTERN OREGON AND NORTHERN CALIFORNIA REFORESTATION RESEARCH

One of the capstone accomplishments of the FIR Program will be the completion of Reforestation Practices in Southwestern Oregon and Northern California, a book that makes silvicultural recommendations for achieving reforestation success based on biological and ecological principles that apply on a wide variety of site conditions found in southwestern Oregon and northern California. This book will represent the culmination of research and development of practices over the past 13 years that address different phases of stand management directly impacting plantation establishment — from timber harvest through release treatment. It is being written primarily for silviculturists, forest technicians, forest planners, and resource specialists, but will also be of reference value to forest resource managers, forest scientists, small woodland owners, forestry extension agents and specialists, forestry students, instructors, and public interest groups concerned about forest resource management.

The book, edited by S.D. Hobbs, S.D. Tesch, P.W. Owston, R.E. Stewart, and J.C. Tappeiner with 38 contributing authors, is tentatively scheduled for publication in early 1992. A history of the development, use, and management of resources in the region along with a chapter on planning for reforestation success provide an overview of the subjects addressed:

Ecology - (Geology and Soils, Climate, Vegetation, Seedling/Site Interactions, Ecology of Hardwoods, Shrubs, and Herbaceous Vegetation and Their Effects on Conifer Regeneration);

Regeneration Operations - (Regeneration Methods, Harvesting Timber to Achieve Reforestation Objectives in Southwest Oregon and Northern California, Site Preparation, Natural Regeneration, Genetic Considerations, Selection and Use of Planting Stock, Mycorrhizal Fungi, and Direct Seeding, Seedling Handing and Planting);

Post-Planting Operations - (Regeneration Surveys and Evaluation, Protecting Seedlings After Planting, Reforestation Knowledge: Perspectives and Synthesis for Land Managers).

A brochure with details about the book, where to buy it, and the price will be mailed to FIR Report subscribers this fall.

EXTRA! EXTRA! GET 'EM WHILE THEY LAST

Reprints of the 1986 publication by W.I. Stein, REGENERATION OUTLOOK ON BLM LANDS IN THE SISKIYOU MOUNTAINS (USDA Forest Service Research Paper PNW-349, 104 p.) are still available. On timberland cut over from 1956 to 1971 in the Applegate, Evans, and Galice-Glendale areas of southwest Oregon, both partial cuts and clearcuts were well stocked with a combination of pre-harvest and post-harvest regeneration. Stocking differed by forest type, soil series, soil origin, soil depth, and stream drainage and correlated with an array of environmental variables. Equations predict future stocking based on variables observed or specified before harvest. To get a reprint, CONTACT: Forestry Sciences Laboratory, Atten: Marian Ely, 3200 SW Jefferson Way, Corvallis, OR 97331 or phone (503) 750-7261.

EFFECTS OF PRESCRIBED CATTLE GRAZING ON REFORESTATION IN OREGON'S SOUTHERN CASCADES

Reforesting harvested lands in southwestern Oregon has been difficult because of low rainfall, high evaporative demand, and competitive understory vegetation. Herbicides were the preferred method of controlling competing vegetation until their use on federal lands was curtailed in 1984. As a result of an increased interest in using livestock grazing as a vegetation control method, a study was conducted using survival and growth of Douglas-fir and ponderosa pine seedlings to assess the effects of prescribed cattle grazing from 1986-1990 on reforestation of a low-elevation (670 m) site. Treatments included seeding of palatable forage species (SU), seeding with grazing (SG), no seeding with grazing (NG), and no seeding or grazing with paper mulch applied on Douglas-fir only (PM/C).

Fifth-year mortality among treatments ranged from 57 to 87 percent for Douglas-fir and 11 to 25 percent for ponderosa pine. Porcupine girdling of ponderosa pine and late-spring frost damage to Douglas-fir were the major sources of mortality. Competition from understory vegetation, browsing, and trampling were only minor sources of seedling mortality. Cumulative growth of both species was best in NG. Severe browsing by cattle in the second year on SG resulted in reduced third-year relative growth for ponderosa pine. Second-year browsing, however, did not reduce long-term relative growth. By the fifth year, relative growth for ponderosa pine was greatest in SG and lowest in SU.

During the first through third year, soil moisture availability was not enhanced on the grazed *vs* ungrazed treatments. By the fourth year, however, xylem potentials and soil moisture indicated seedlings in SG were less water-stressed than those in SU. Reduced water stress probably resulted from reductions in roots of orchard grass because of defoliation. Sampling with a root periscope indicated roots were reduced for defoliated (SG) plants compared with undefoliated (SU) plants. Leaf area and root growth reductions were apparent mechanisms permitting increased soil moisture availability. These results suggest that prescribed cattle grazing can facilitate reforestation.

This research was done for the senior author's 1991 Ph.D. thesis in Rangeland Resources at OSU.

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Recent Publications

Copies of the following publications are available from the source noted in parentheses at the end of each abstract. The addresses for the sources are:

(OSU) - Forestry Publications Office
Oregon State University
Forest Research Laboratory 225
Corvallis, OR 97331-5708

(PNW) - Pacific Northwest Research Station
Atten: Publications Division
P.O. Box 3890
Portland, OR 97208-3890

(PSW) - Pacific Southwest Research Station
P.O. Box 245
Berkeley, CA 94701

<u>DIAMETER GROWTH EQUATIONS FOR FOURTEEN TREE SPECIES IN SOUTHWEST OREGON</u> by D.W. Hann and D.R. Larsen. 1991. Forest Research Laboratory Research Bulletin 69, Oregon State University, Corvallis. 3 p. Equations predict individual-tree 5-year diameter growth for 14 southwest Oregon tree species expressed as a function of diameter at breast height, crown ratio, site index, total stand basal area, and stand basal area. (OSU)

<u>ROOT DEVELOPMENT IN PLANTED DOUGLAS-FIR UNDER VARYING COMPETITIVE STRESS</u> by M. Newton and E.C. Cole. 1991. Canadian Journal of Forest Research 21:25-31. Five-year-old Douglas-fir roots from three Oregon sites were excavated and analyzed for the effects of competition on root biomass and of planting-induced root deformities. The ratio of standing aboveground to belowground biomass was the same for each competitor type. Neither shoot:root ratio nor tree size was affected by planting-induced root deformities. After 5 years, all root systems apparently compensated fully for planting deformities. (OSU)

MULCHES AID IN REGENERATING CALIFORNIA AND OREGON FORESTS: PAST, PRESENT, AND FUTURE by P.M. McDonald and O.T. Helgerson. 1990. USDA For. Serv. Gen Tech. Rep. PSW-123, Pacific Southwest Research Station, Berkeley, CA. 19 p. Large, long-lived mulches made of reinforced paper, polyester, or polypropylene sheet material enhance tree growth and survival and control vegetation with stiff stems. (PSW)

COMPETITION AFFECTS MORPHOLOGY, GROWTH DURATION, AND RELATIVE GROWTH RATES OF DOUGLAS-FIR SAPLINGS by T.B. Harrington and J.C. Tappeiner II. 1991. Canadian Journal of Forest Research 21:474-481. Douglas-fir saplings were grown with and without tanoak competition at two forest sites in southwest Oregon. Competition reduced the number and size of buds, length of shoots, internodes and needles, the number of internodes, biomass, the rate and duration of basal area growth, and height growth of Douglas-fir. (OSU)

PLANNING WITH PSME: A GROWTH MODEL FOR YOUNG DOUGLAS-FIR AND HARDWOOD STANDS IN SOUTHWESTERN OREGON by T.B. Harrington, J.C. Tappeiner II, T.F. Hughes, and A.S. Hester. 1991. Forest Research Laboratory Special Publication 21, Oregon State University, Corvallis. 14 p. PSME (Plantation Simulator—Mixed Evergreen) is a computerized growth model for predicting Douglas-fir plantation development under specific initial competition levels of tanoak, Pacific madrone, golden chinkapin, and herb+shrub vegetation in southwest Oregon using values tions of Douglas-fir height and stem diameter at 10 years. (OSU)

HERBACEOUS VEGETATION IN FORESTS OF THE WESTERN UNITED STATES: AN ANNOTATED BIBLIOGRAPHY by D.M. Loucks and T.B. Harrington. 1991. Forest Research Laboratory, Oregon State University, Corvallis. 104 p. Citations and abstracts for 325 articles on herbaceous vegetation in western U.S. forests and reviews of articles published since 1970 pertaining mostly to conifer stand management in the Rocky Mountains and Pacific Northwest, especially ponderosa pine and Douglas-fir, are included. (OSU)

ASSESSMENT AND MANAGEMENT OF ANIMAL DAMAGE IN PACIFIC NORTHWEST FORESTS: AN ANNOTATED BIBLIOGRAPHY by D.M. Loucks, H.C. Black, M.L. Roush, and S.R. Radosevich. 1990. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-262, Pacific Northwest Research Station, Portland, OR. 371 p. This is a comprehensive source of information on animal damage assessment and management in the Pacific Northwest with citations and abstracts from more than 900 papers indexed by subject and author. (PNW)

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