Forest Fertilization and Stand Management in Western Oregon and Washington: Status and Prospect

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This report is a publication of the Regional Forest Nutrition Research Project, a cooperative program initiated in 1969 to provide forest managers with accurate growth data for managed stands of Douglas-fir and western hemlock in western Oregon and western Washington. Over 30 Pacific Northwest forest industry companies, state and federal agencies, and fertilizer manufacturers provide support and direction for the Project. The RFNRP Report Series is intended to enhance communication of forest fertilization research results within the RFNRP community. Prepared to meet internal RFNRP needs, reports in the series may be descriptions of work in progress as well as final statements of research results.

SUMMARY

The Regional Forest Nutrition Research Project (RFNRP) surveyed member organizations in September 1983 regarding stand management and fertilization practices. Twenty-five organizations managing forest land in western Washington and Oregon responded, representing 18.5 million acres of public and industry-owned timberland.

As expected, the Douglas-fir forest type dominates PNW managed forests (56% of the timberland area). Douglas-fir was planted on 1.2 million acres of the 1.5 million acres of plantations established in the period 1978-1982. Silviculture planned for plantations established today includes precommercial thinning, commercial thinning, and fertilization (70%, 56%, and 36%, respectively, of total area planted). Survey data reveal several differences in management planned for public and private timberlands.

Prescriptions for forest fertilization call for 200 pounds of nitrogen per acre aerially applied as granular urea (46-0-0) to thinned and naturally well-spaced Douglas-fir stands. In general, fertilization priority decreased with increasing site class and fertilization of stands 7-20 years before final harvest was preferred. Most respondents do not link fertilization prescriptions to soil survey information, and most desired more information on soil and foliage tests as site-specific diagnostic tools.

Nearly 1.6 million acres of timberland in western Washington and Oregon was fertilized in the past 10 years (1973-1982). Prior to 1973, about 460,000 acres were fertilized. Projection of survey respondents' plans yields a cumulative total area fertilized of over 3 million acres in 1986. During the next 4-5 years timberland area fertilized is not expected to exceed 300,000 acres annually.

FOREST FERTILIZATION AND STAND MANAGEMENT IN WESTERN OREGON AND WASHINGTON: STATUS AND PROSPECT

H.N. Chappell and D. Opalach

Forest fertilization in the Pacific Northwest (PNW) has become a silvicultural practice of major significance over the past decade. Forest industry and federal and state agencies managing forest lands in western Oregon and Washington apply chemical fertilizers to extensive areas each year over a broad range of soil and stand types. Fertilization prescriptions generally are for nitrogen (N) applications, usually as urea, to Douglas-fir (Pseudotsuga menziesii) stands west of the Cascade crest. N fertilization has also been prescribed for stands of western hemlock (Tsuga heterophylla) and mixed Douglas-fir/hemlock, although the area fertilized in these stand types is not extensive.

Recent economic trends have necessitated close examination of the costs and benefits of silvicultural practices on lands managed for timber production. Forest fertilization has rightly come under scrutiny, resulting in heightened awareness of the need for site-specific fertilizer prescriptions. Fertilization is perceived as a cost-effective means to increase yields, and sharpening prescriptions for responsive sites and stands is seen as a means to increase return on investment. Current PNW prescriptions are largely based on results from the Regional Forest Nutrition Research Project (RFNRP), an industry-agency-university research cooperative established in 1969 at the University of Washington. In response to current concerns about targeting fertilizer applications, RFNRP planning efforts for the next 5-year phase of the project include consideration of site-specific response predictions. To provide data for planning purposes, RFNRP member organizations were polled on their practices and plans for forest fertilization and stand management.

The objectives of the survey on the status of forest fertilization in managed forests of the Pacific Northwest were:

1. To provide information on the nature, scope, and management of PNW forests of the future.
2. To compile data on forest area fertilized in western Oregon and Washington, and on plans for future fertilization.
3. To summarize current fertilization diagnostic criteria, prescriptions, practices, and costs.

Survey questionnaires were sent in September 1983 to the 27 RFNRP member organizations owning or managing forest land in western Oregon and Washington, including 1 member landowner in northwestern California (Appendix I). Respondents included 2 federal agencies (U.S. Forest Service, Bureau of Land Management), 2 state agencies (Washington Department of Natural Resources, Oregon Department of Forestry), the Quinalt Indian Nation, and 21 forest industry companies. In all, 29 questionnaires were returned; 2 companies returned a total of 5 completed questionnaires with data from different regions (n values reported reflect the total response of 29). The questionnaire, with data summarized from the 29 responses, is included as Appendix II.

RESULTS

Scope of the Survey

Area of timberland[1] owned by respondents to the RFNRP survey corresponds closely to U.S. Forest Service statistics for industry and public landownership classes (Table 1). The U.S. Forest Service Renewable Resources Evaluation project estimates there are 23.9 million acres of timberland in western Oregon and Washington, including an estimated 4.7 million acres in private ownership not classed as forest industry lands. Non-industrial private ownership was not included in the RFNRP survey data; respondents to the RFNRP questionnaire reported ownership of 18.5 million acres of commercial forest land in western Oregon and Washington. The near equivalency of the USFS and RFNRP data (19.2 and 18.5 million acres, respectively) for public and industry-owned timberland indicates that responses to questions in the RNFRP survey represent virtually all the major forest land-managing organizations west of the Cascades in Oregon and Washington.

Timberland Characteristics

Survey recipients were asked to characterize their landownership in terms of forest type and site class. Responses to the question on forest type, weighted by area of ownership, yield the following proportions:

Douglas-fir	56%
Western hemlock	9
Douglas-fir/hemlock	9
True fir/hemlock	12
Other conifer	4
Hardwoods	8
Non-stocked	2

As expected, the Douglas-fir type dominates PNW forests; survey data are comparable to USFS data for Douglas-fir. For planning purposes, the relative position of the true fir/hemlock type in the list above is noteworthy, since there is not a strong base of knowledge on effects of fertilization or other management practices for this forest type. The importance of upper-slope forests of the Cascades, as well as the role of western hemlock in mixed-species stands, must be considered in any effort to improve productivity of PNW forests.

Responses to the question on generalized site classes reflect several means of quantifying site productivity, and should be interpreted cautiously. The intent of the question was to gain insight on the proportion of forest land in a generally accepted ranking (site class I-V), recognizing that the answer could be quantitative or subjective.

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[1] Timberland is defined by USFS Renewable Resources Evaluation as forest land capable of producing 20 ft^3/acre/year (1.4 m^3/ha/yr) of industrial wood. "Timberland" and "commercial forest land" are considered equivalent in this discussion.

Table 1. Comparison of timberland area by ownership classes for USFS and RFNRP data, western Oregon and Washington.

State	National forest	Other[1] public	Forest industry	Other private	All ownerships
	- - - - - - - - - - - acres x 1000 - - - - - - - - - - -				
OREGON					
USFS data[2]	4585	2860	3780	2442	13,667
RFNRP survey[3]	4586	2909	3475	--	10,970
WASHINGTON					
USFS data[2]	2454	1815	3709	2229	10,207
RFNRP survey[3]	2200	1609	3689	--	7,498
TOTAL					
USFS data	7039	4675	7489	4671	23,874
RFNRP survey	6786	4518	7164	--	18,468

[1]Includes Bureau of Land Management, Indian lands, and state lands in Oregon and Washington.

[2]Data are shown for inventory units in Oregon and Washington in Appendix III, Tables 1 and 2. Data from Bassett and Oswald 1981a, 1981b, 1982, and Gedney 1982.

[3]Data compiled from responses to RFNRP survey, Sept. 1983 (Appendix III, Table 3).

When weighted by area of ownership, the distribution of area over site class shows a high proportion in the most productive site classes:

Site Class	Area
I	21%
II	27
III	31
IV	16
V	5

When asked what portion of their land base has accurate soil mapping, responses from 22 respondents averaged 59%. Five respondents indicated 0%, six answered 100%, and several more placed a question mark on the form. Interestingly, respondents from Washington regarded DNR soil survey as both 0% and 100%. Results from this question probably reflect the respondents' perceptions of what is meant by "accurate soil mapping" as much as the availability of soils data for forest land.

The Future Forest and Its Management

All survey respondents are planting Douglas-fir seedlings, while only about half (n=15) indicated western hemlock was being planted. Seedlings of other conifer species, including noble fir (Abies procera) and other true fir species, Sitka spruce (Picea sitchensis), western redcedar (Thuja plicata), and ponderosa pine (Pinus ponderosa), are planted by 18 respondents. Only 2 organizations are planting hardwood species. Undoubtedly, natural regeneration methods are also commonly used by some organizations, particularly for western hemlock in pure or mixed stands. The median value of 60 acres for average regeneration unit size leads to speculation that very large (>100 acres) planted stands will not be common in future PNW forests.

Foresters employ a range of desired planting densities and stocking levels for stands 10 years old (Table 2). Responses here indicate there is not consensus on a "best" stocking prescription, and reflect a host of factors influencing these prescriptions, including soil and climatic characteristics of the landownership and management objectives. Mean planting density was 468 TPA (n=26) and age 10 stocking desired was 298 TPA (n=29) for Douglas-fir, and 472 TPA (n=6) and 343 TPA (n=6), respectively, for western hemlock. The few responses specifying planting or age 10 density for other species were similar to the Douglas-fir or western hemlock specifications cited.

An effort to describe the resource base of stands with early management, i.e. artificial regeneration by planting or precommercial thinning (PCT) before age 20 (question 8), resulted in a response inconsistent with data on area planted in the past 5 years (question 8a). Total area for all species 0-10 years old in planted or PCT stands is about 1.3 million acres, while the sum of area planted in 1978-1982 for all species is about 1.5 million acres. The lack of 100% response to both questions is a major factor in the discrepancy, although there are a number of other interrelated possibilities that cannot be examined with the survey data. Perhaps the best conclusion from data compiled on planted and PCT stands (question 8) is that young stand management

appears to have become a significant activity in the PNW only in the last 3 decades. Survey data show few organizations were planting or spacing stands prior to 1950; respondents reported a total of less than 150,000 acres in stands with early management that are now over 30 years total age (Table 3).

More organizations responded to the query about 5-year planting history, and it may be that more accurate data is available for recent regeneration efforts than for earlier planting or PCT. For 1978 through 1982, responding organizations planted over 1.5 million acres, with 79% of the area planted with Douglas-fir seedlings (Table 4).

Survey recipients were asked what portion of stands planted today would be precommercially thinned, commercially thinned, or fertilized in the management regime planned for the new stand. This question yielded a diverse response, with some distinction apparent between forest industry and agency answers when weighted by their data on 5-year planting history (question 8a). Forest industry respondents plan to precommercially thin relatively more and commercially thin relatively less of the area planted than their agency counterparts, and to fertilize more than twice the percentage of recently planted stands (Table 5). Several survey respondents indicated uncertainty on the role of fertilization in their planned regimes; only 2 respondents felt that more than 80% of stands planted today would be fertilized (Appendix Table III-4).

Status and Plans for Forest Fertilization

Current PNW fertilizer application prescriptions call for 200 lbs N/acre, aerially applied as granular urea (46-0-0) to Douglas-fir stands, for all survey respondents (n=25). Three respondents indicated some hand application of urea in certain situations, but the area treated in this way is not extensive. With one exception, organizations contract application work to firms specializing in chemical applications by helicopter, and purchase urea from one of two manufacturers; 1983 costs for fertilizer and application averaged $52/acre. No operational fertilization programs were reported for other than N applications.

While most prescriptions did not include species, Douglas-fir may be assumed where not stated (only 1 response was for other than Douglas-fir; hemlock and hemlock-silver fir were specified). In brief statements on sites and stands slated for fertilization, most respondents indicated priority for preharvest fertilization (7-20 years before final harvest) over commercially or precommercially thinned stands. Only one response specified stand density level, and stocking criteria was only generally expressed. In general, fertilization priority decreases with increasing site class. (Specific responses are listed in Appendix II).

Ten respondents indicated that fertilization prescriptions are linked to soil survey information, while 14 responded negatively. When asked to classify a set of selection criteria in relation to current fertilization programs, the following compilation of responses resulted (no response was considered as "don't know"):

Table 2. Desired planting density and desired stocking at age 10 for Douglas-fir and western hemlock.

Trees per acre	Number of Responses Douglas-fir	Western hemlock
AT PLANTING:		
301-400	6	
401-500	15	6
501-600	4	
more than 600	1	
AT AGE 10:		
less than 200	1	
201-250	6	
251-300	16	3
301-350	2	
more than 350	4	3

Table 3. Area in planted stands or stands that have been or will have been precommercially thinned before age 20.[1]

Total age	Douglas-fir	Western hemlock	Other	Total
Years	- - - - - - - - - - acres x 1000 - - - - - - - - - -			
0-10	1067.0	253.1	22.1	1342.2
11-20	489.8	164.4	4.2	658.3
21-30	99.3	198.1	1.0	298.4
31-40	66.7	31.5	-	98.2
41-50	40.8	1.2	-	42.0
over 50	8.0	0.7	-	8.7

[1]Totals may be off due to rounding.

Table 4. Area planted, 1978-1982[1]

Year	Douglas-fir	Western hemlock	Other	Total
	- - - - - - - - - - - acres x 1000 - - - - - - - - - - -			
1978	237.2	17.8	53.8	308.8
1979	235.6	19.1	51.2	305.9
1980	242.8	18.5	49.7	311.0
1981	244.5	12.2	53.2	309.9
1982	220.8	9.5	37.2	267.5
5-year total	1180.9	77.1	245.0	1503.0

[1]Totals may be off due to rounding.

Table 5. Silvicultural activities planned for recently planted stands.

	Area planted 1978-1982	Planned Silviculture		
		Precommercial thinning	Commercial thinning	Fertilization
	acres x 1000	- - - - - - acres x 1000 (%) - - - - - -		
Forest industry	670.1	491.0 (73)	281.2 (42)	399.2 (52)
State and federal agency	833.0	561.8 (67)	562.1 (67)	195.0 (23)
Total[1]	1503.1	1052.8 (70)	843.3 (56)	544.2 (36)

[1]Totals may be off due to rounding.

1 - currently used

not currently used

2 - would like to use (lack information)
3 - don't consider to be useful
4 - don't know

	Number of Responses			
	1	2	3	4
basal area or stocking	25			2
stand age	26			1
species composition	26			1
stand area	21			6
accessibility	18	1	4	4
site class	23	1		3
elevation	9	1	9	8
annual precipitation	4	1	9	13
slope	5	1	10	11
aspect	4	2	11	10
soil series	5	15	2	5
mineralizable soil N	5	15	1	6
other soil tests		7	1	19
foliar N		14	1	12
other foliar tests		7	2	18
foliage color	6	7	4	10

Interest in site-specific prescriptions is reflected in respondents' desire for more information on soil and foliage tests and soil series data. This gap in knowledge provides a clear direction for future evaluations of fertilization response.

Over the past 10 years, 18 forest industry companies and 4 federal and state agencies have used the prescriptions noted above to fertilize nearly 1.6 million acres of timberland in western Oregon and Washington. Prior to 1973, a total of about 460,000 acres was fertilized, and respondents' plans project a cumulative total area fertilized of about 3 million acres in 1986 (Figure 1 and Appendix Table III-5). Accurate projections beyond 1986 from survey data are questionable since plans for major PNW projects were not stated or are uncertain for several organizations. In recent years some of the area fertilized in a few projects was reapplication to previously treated stands, and a third fertilization of some areas will occur in the near future. The area in these categories is relatively minor, although the extent of refertilization cannot be evaluated with the survey data.

Data for cumulative area fertilized from this survey slightly exceed previously published figures (Bengtson 1979), mainly due to more complete response to this survey by PNW organizations with forest fertilization programs. Bengtson's 1979 prediction that "no more than 500 thousand acres (i.e., double the 1977-78 rate) will be fertilized annually during the decade just ahead" is borne out by survey data. For the period 1979-1983, the first half of the decade mentioned above, an average of

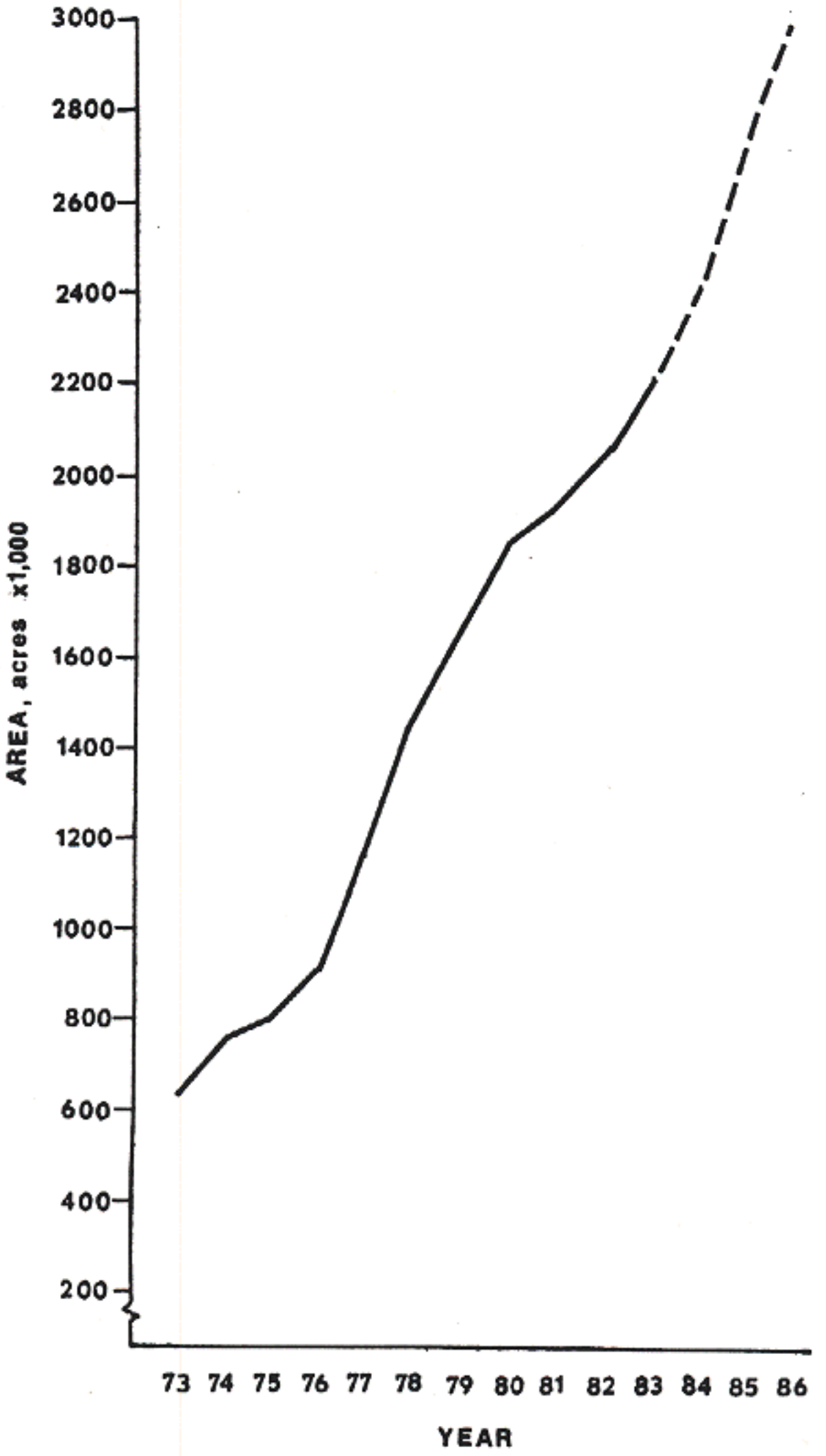

Figure 1. Cumulative area fertilized through 1982 in western Oregon and Washington. Planned fertilization indicated by broken line.

155,000 acres per year was fertilized, ranging from 41,900 acres in 1975 to 281,300 acres in 1977. Survey respondents' projections for the next few years are significantly less than the half-million acre annual maximum forecast by Bengtson. It may be that as old-growth harvests decline and reliance increases on younger, smaller trees for volume production, fertilizer use may increase to boost yields. Without extrapolation from the commitment to precommercial and commercial thinning and concomitant fertilization expressed by respondents to this survey, current information indicates PNW fertilization projects will not exceed about 300,000 acres annually in the next several years. Again quoting Bengtson: "The uncertain technology of prescription and the capital demands of massive programs will likely restrict any dramatic expansion..." Clearly, the extent of future use of fertilization as a silvicultural tool in the PNW depends on the development of improved diagnostic techniques for targeting fertilizer applications.

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APPENDIX I.

RFNRP Member Organizations Owning or Managing Forest Land in Western Oregon and Washington

Barringer and Associates, Inc.
Boise Cascade Corporation
Bureau of Land Management
Champion International Corporation
Crown Zellerbach Corporation
Fruit Growers' Supply Company
Georgia Pacific Corporation
Giustina Bros. Lumber & Plywood Company
Hampton Tree Farms, Inc.
International Paper Company
ITT Rayonier, Inc.
Longview Fibre Company
Menasha Corporation
Murray Pacific Corporation
Plum Creek Timber Company
Publishers Paper Company
Quinault Indian Nation
Rex Timber Company
St. Regis Paper Company
Scott Paper Company
Simpson Timber Company
State of Oregon Forestry Department
State of Washington Department of Natural Resources
U.S. Forest Service
Weyerhaueser Company
Willamette Industries, Inc.

APPENDIX II:

Response Summary: Status of Forest Fertilization and Stand Management In the Pacific Northwest

Data compiled from a survey conducted in Fall 1983 by the Regional Forest Nutrition Reseach Project. The questionnaire was sent to the 27 RFNRP member organizations owning or managing forest land in western Oregon and Washington (1 member landowner is located in NW California). There were 25 respondents: 2 federal agencies (U.S. Forest Service, Bureau of Land Management), 2 state agencies (Washington Department of Natural Resources, Oregon Department of Forestry), the Quinalt Indian Nation, and 20 forest industry companies. In all, 28 questionnaires were returned: 2 companies returned a total of 5 completed questionnaires with data from different regions (n values reported reflect the total response of 28).

OWNERSHIP

1. Ownership of commercial forest land west of the Cascade crest:

California	305,000 acres	
Oregon	10,970,329 acres	
Washington	7,497,951 acres	
Total	18,773,280	n = 29

2. How would you characterize the ownership in terms of forest type?

	$\bar{X}$	RANGE
Douglas-fir	53	0-100%
Western hemlock	15	0-60
Douglas-fir/W. hemlock	10	0-98
True fir/Mtn. hemlock	4	0-25
Other conifer	5	0-55
Hardwoods	10	0-30
Non-stocked	3	0-15

n = 29

3. How would you characterize the ownership by generalized site classes?

		$\bar{X}$	RANGE
Site Class	I	7%	0 -43%
	II	32	5 -65
	III	44	10-83
	IV	12	0 -26
	V	2	0 -15

n = 27

4. What portion of the land base has accurate soil mapping?

$\overline{X}$ = 59%
Range = 0-100%
n = 22

STAND MANAGEMENT

		n
5. What species are being planted:	Douglas-fir	29
	W. hemlock	16
	Other conifers	18
	Hardwoods	2

6. What is the desired planting density and/or desired stocking level at age 10

Planting Density:

TPA	Douglas-fir	W. hemlock
less than 300		
301-400	6	
401-500	15	6
501-600	4	
more than 600	1	

Age 10 Stocking:

TPA	Douglas-fir	W. hemlock
less than 200	1	
201-250	6	
251-300	16	3
301-350	2	
more than 350	4	3

7. What is the average size of a regeneration unit?

$\overline{X}$ = 70 acres
Range = 28-175 acres
n = 28

8. What is the total area in stands that have been planted or have/will have received density control (i.e. precommercial thinning) before age 20?

Total Age	Douglas-fir		W. hemlock		Other	
	Acres	n	Acres	n	Acres	n
0-10 yrs	1,066,971	20	253,131	9	22,118	6
11-20	489,756	25	164,370	11	4,184	3
21-30	99,267	14	198,115	8	1,040	2
31-40	66,680	6	31,520	4		
41-50	40,800	2	1,200	1		
over 50	8,000	1	700	1		

8a. How many acres were planted in the past 5 years?

	Douglas-fir	W. Hemlock	Other	Total
1982	220,830	9,488	37,184	267,502
1981	244,513	12,208	53,191	309,912
1980	242,750	18,541	49,723	311,014
1979	235,626	19,050	51,179	305,855
1978	237,221	17,841	53,751	308,813
5-yr total	1,180,940	77,128	245,028	1,503,096
	n = 28	n = 12	n = 13	

8b. What portion of the stands planted today (8a) will be

		$\bar{X}$	RANGE	n
	precommercially thinned	55%	5-100%	27
	commercially thinned	46%	0-100%	26
or	fertilized	53%	0-100%	22

in the management regime planned for the stand?

FERTILIZATION

9. Total area fertilized west of the Cascade crest in the last 10 years

		n
1982	128,502 acres	9
1981	72,380	11
1980	181,784	16
1979	231,590	21
1978	279,634	19
1977	255,476	18
1976	109,579	18
1975	41,873	11
1974	120,465	12
1973	177,034	13
10 year total	1,598,317	

9a. Acres fertilized before 1973 459,446

cumulative total 2,057,763

10. What are current fertilization plans or projections?

		n
1983	166,913 acres	11
1984	202,322	15
1985	311,619	17
1986	286,714	16
1987	86,652	15
1988	77,550	12
1989	76,400	11
1990	79,900	11

11. What is/are the fertilizer application prescription(s)?

200 lbs.N/acre, applied as granular urea (n = 25)

- suppliers: Cominco American and Union Chemical

- 1 prescription for Melamine at 200 lbs N/acre

12. Briefly stated, what sites or stands are slated for fertilization?

SUMMARY
Most respondents indicated priority for preharvest fertilization (7-20 yrs. before final harvest) over commercially or precommercially thinned stands; only one response specified stand density level. Only 1 response was for other than Douglas-fir (most responses did not include species), and stocking criteria was only generally expressed. In general, fertilization priority decreases with increasing site class. Prescriptions reflected landowners' age class distributions and frequently resulted in directly opposing rankings of fertilization priorities.

SPECIFIC RESPONSES

- Site III, 80% Douglas-fir, > 40 acres, 40 years total age or 10 years before scheduled harvest.

- 1) Site III-IV, 2) stands commercially thinned (CT) 3) stands precommercially thinned (PCT).

- Stands that are principally Douglas-fir without significant amounts of intermixed hemlock or alder and avoiding Site I. First priority are stands 10 yrs. or more from rotation; priority decreases with age due to economics.

- CT -a) Site III, b) Site II
  2) PCT a) Site III, b) Site II, c) Site I

- Fully stocked, Site II-III: 1) 40-50 years old
  2) 30-40 years old

- 1) 30-40 years old CT or naturally well-spaced
  2) 20-30 years old PCT or naturally well-spaced

- 1) 35-45 years old, 2) CT or PCT, 3) Site 130-170 4) normality $\geq$ 35%

- Site III-IV, PCT, hemlock and hemlock-silver fir types

- 1) CT, 2) ages 80-40, 3) ages 30-10

- Site IV-II, 80% Douglas-fir stands up to age 70, SDI 180-395 on soils with moderate to low mineralizable and total N.

- All relatively pure Douglas-fir stands within 20 years of harvest.

- Site II-III 7-10 years from harvest; site II and III 2 years after partial cut.
- Site II, III, IV+, fully stocked with predominantly Douglas-fir, age $\geq$ 25.
- 45-55 year-old CT Douglas-fir stands on sites greater than 115.
- 1) Age 20-80, SI < 130
  2) Age 15-20, SI < 115
  3) Age 30-80, SI > 130
- Douglas-fir: 1) 40-50 years, site II-III
  2) 35-40 years, site I-IV
  3) 30-35 years, site I-IV
  4) 25-30 years, site I-IV
- Site III-IV, Age 40-60 years.
- Medium- and well-stocked Douglas-fir: 1) 20-35 years, site III-IV
  2) 40-50 years, site III-II
  3) 20-50 years, site II
- 1) Age 20-40, site III, PCT
  2) Age 41-50, site III, PCT

12a. Are fertilization prescriptions tied to soil survey information?

Yes 10
No 14

12b. Classify each of the following selection criteria in relation to your organization's fertilization program:

1 - currently used

not currently used

2 - would like to use (lack information)
3 - don't consider to be useful
4 - don't know

	Number of Responses			
	1	2	3	4
basal area or stocking	25			2
stand age	26			1
species composition	26			1
stand area	21			6
accessibility	18	1	4	4
site class	23	1		3
elevation	9	1	9	8
annual precipitation	4	1	9	13
slope	5	1	10	11
aspect	4	2	11	10
soil series	5	15	2	5
mineralizable soil N	5	15	1	6
other soil tests		7	1	19
foliar N		14	1	12
other foliar tests		7	2	18
foliage color	6	7	4	10

13. Is all fertilizer aerially applied?

Yes	24
No	3

Other methods:

- hand cyclone spreaders; some hand application around drip line in orchard situations
- by hand
- tractor mount spreader; 5 gallon bucket with coffee can

14. Who is/are the current or most recent contractor(s)?

Bertia Aviation
Evergreen Helicopters
Hi Life Helicopters
Helijet
Reforestation Services
Spokane Helicopter
Western Helicopter Services

14a. If fertilizer is applied by landowner's aircraft, what portion of fertilization program is accomplished in-house?

	n
0%	25
100%	1

15. Current or most recent cost information:

Year	Total Cost/acre*	n
1977	$44	1
1978	$42-50	2
1979	$33-60	7
1980	$49-56	2
1981	$51	1
1982	$48-60	5
1983	$45-58	6

*aerial application

16. Are there other data that you feel should be included in this survey?

- Frequency of application (i.e. repeated applications planned? at what interval(s)?)
- Any operational monitoring of distribution and/or tree growth?
- Repeat application with regards to a) stand density, and b) different rotation ages.
- Standard procedures in a) monitoring application of fertilizer, b) establishment of growth plots, and c) methods used by pilots in fertilizer application.

17. Other comments:

- Some of these questions we felt were too sensitive to answer.
- A major concern is fertilization as it relates to tree improvement and progeny response.
- What are the future plans for the established plots?
- Will a good herbicide program (assume rotation ages of 50-60 years) which allows trees to be "free to grow" reduce the need for repeat fertilization programs?
- Not all questions were answered. Either the answer contained proprietary data or the data was not available.

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Table III-2. Area of timberland by ownership class, western Washington[1] (from Bassett and Oswald 1981a, 1981b, 1982).

Inventory unit[2]	National forest	Bureau of Land Management	Other public	Forest industry	Other private	All ownerships
	- - - - - - - - - - - - acres x 1000 - - - - - - - - - - - -					
Olympic Peninsula	538	161	598	1,215	580	3,092
Puget Sound	835	18	611	998	1,001	3,462
Southwest	1,081	--	427	1,496	648	3,652
Total	2,454	179	1,636	3,709	2,229	10,207

Estimates are subject to sampling error.

[1]Totals may be off because of rounding.

[2]Inventory units include the following western Washington counties:

Olympic Peninsula = Clallam, Grays Harbor, Jefferson, Mason, Thurston.

Puget Sound Area = Island, King, Kitsap, Pierce, San Juan, Skagit, Snohomish, Whatcom.

Southwest = Clark, Cowlitz, Lewis, Pacific, Skamania, Wahkiakum.

APPENDIX III.

Table III-1. Area of timberland by ownership class, western Oregon[1] (from Gedney 1982).

Inventory[2] unit	National forest	Bureau of Land Management	Other public	Forest industry	Other private	All owner-ships
	- - - - - - - - - - - - acres x 1000 - - - - - - - - - - - -					
Northwest	936	227	575	1,042	766	3,546
West-central	1,630	442	109	1,097	701	3,979
Southwest	2,019	1,329	180	1,641	974	6,143
Total	4,585	1,997	863	3,780	2,442	13,667

Estimates are subject to sampling error.

[1]Totals may be off because of rounding.

[2]Inventory units include the following western Oregon counties:

Northwest = Clackamas, Clatsop, Columbia, Hood River, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill

West-Central = Benton, Lane, Lincoln, Linn

Southwest = Coos, Curry, Douglas, Jackson, Josephine.

Table III-3. Area of timberland west of the Cascade crest owned by respondents to the 1983 RFNRP survey.

State	National forest	Bureau of Land Management	Other public[1]	Forest industry	All ownerships
	- - - - - - - - - - - - acres x 1000 - - - - - - - - - - - -				
Oregon	4,586	2,179	730	3,475	10,970
Washington	2,200	38	1,571	3,689	7,498
Total	6,786	2,217	2,301	7,164	18,468

[1] Comprises forest lands managed by the State of Oregon, State of Washington, and Quinalt Indian Nation.

Table III-4. Total area of recently planted stands (1978-1982) for which precommercial thinning, commercial thinning, or fertilization is planned.[1]

	Portion of Stands Planted Today 0-20%	21-40%	41-60%	61-80%	81-100%	Total
PRECOMMERCIAL THINNING						
Industry	6,389	28,562	29,800	21,302	404,959	491,012
n=	6	5	3	2	8	24
Agency			58,200	503,631		561,831
n=			1	2		3
Total	6,389	28,562	88,000	524,933	404,959	1,052,843
	Number of respondents indicating 0% = 0, 100% = 5					
COMMERCIAL THINNING						
Industry	12,598	36,259	192,260	30,336	9,751	281,204
n=	7	3	7	4	2	23
Agency		29,100		532,970		562,070
n=		1		2		3
Total	12,598	65,359	192,260	563,306	9,751	843,274
	Number of respondents indicating 0% = 2, 100% = 1					
FERTILIZATION						
Industry	762	21,520	42,891	243,885	40,156	349,214
n=	3	2	6	5	2	18
Agency	41,074		61,000	92,888		194,962
n=	1		2	1		4
Total	41,836	21,520	103,891	336,773	40,156	544,176
	Number of respondents indicating 0% = 1, 100% = 1					

[1] Area data was compiled for each responding organization by summing the total area planted in 1978-1982 (question 8a) and multiplying the sum by the percentage specified for PCT, CT, or fertilization (question 8b). Area was summed for all organizations by classes.

Table III-5. Forest area fertilized in western Oregon and Washington through 1982 and planned fertilization through 1986.

Year	Forest industry	Federal and state agency	Total
	- - - - - - - - - - - acres - - - - - - - - - - -		
Prior to 1973	411,913	47,533	459,446
1973	161,381	15,653	177,034
1974	114,611	5,854	120,465
1975	32,349	9,524	41,873
1976	83,881	25,698	109,579
1977	206,542	48,934	255,476
1978	248,149	31,485	279,634
1979	194,100	37,490	231,590
1980	172,814	8,970	181,784
1981	64,880	7,500	72,380
1982	88,755	39,747	128,502
Total	1,779,375	278,388	2,057,763
Planned Fertilization:			
1983	139,867	27,046	166,913
1984	195,332	7,000	202,332
1985	282,619	29,000	311,619
1986	257,714	29,000	286,714