INCORPORATING FERTILIZATION IN LONG-RANGE PLANNING

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ABSTRACT

Fertilization should be considered and where appropriate incorporated in long-range timber management planning. Methods used by the Oregon State Forestry Department are described and illustrated. These methods include: incorporating projected fertilization responses in yield tables and simulation modeling; analyzing per-acre benefit/cost of fertilization; ranking the priority of fertilization compared with other intensive forest management practices; and simulating forestwide development and harvest schedules under intensive management including selected fertilization. It is important to analyze fertilization in the same terms and under the same assumptions used for other management practices.

INTRODUCTION

Planning can be simply defined as deciding what to do in time to get it approved, budgeted, organized, and under way. Planning that spans long time periods and goes beyond current decisions and budgets can be termed long range. Long-range timber management practices including all aspects of reforestation, rehabilitation of underproductive lands, precommercial thinning, commercial thinning, and clearcut harvesting. These items are of course interrelated (Figure 1).

Long-range plans also document the necessary support activities and project the harvest, revenues, and costs that will result. Enough is now known about N fertilization of Douglas-fir to mandate inclusion of fertilization in the list of potential intensive management practices. Forest managers must decide whether or not to incorporate fertilization in their plans at the same time other major management decisions are made.

Forest organizations usually have more cost-effective management opportunities than available funds, thus priorities must be set. Fertilization must be included in the priority-setting analysis along with all other potential management practices in order to determine the optimum acreage, relative priority, and timing of all beneficial practices including fertilization. For accurate analyses, fertilization must be examined in the same terms as other practices, including the same economic assumptions and constraints. Fertilization, as the other practices, must be analyzed under a forestwide system approach. Fertilization must be fully incorporated in the planning process, not handled "on the side."

NORTHWEST OREGON AREA STATE FORESTS

The Oregon State Forestry Department under the direction of the Oregon Board of Forestry manages 780,000 acres of forest land. 500,000 acres of these lands are located in Northwest Oregon. This forest is young (average age, 30 yr), principally Douglas-fir, high-site (mostly sites II and III), and is classified primarily for timber production. Management is self-funding.

About 36% of timber sale receipts are used for administration and management work; the balance is distributed to the counties. Oregon State Forest plans are made to maximize wood growth and sustained-yield harvest consistent with the financial resources available and the need to protect soils, streams, wildlife habitat, recreational opportunities, and other environmental values.

The Department has recently prepared for the timber management of the northwest area a new long-range plan incorporating fertilization. The remainder of this paper describes the

Figure 1. Major management practices considered in long-range planning.
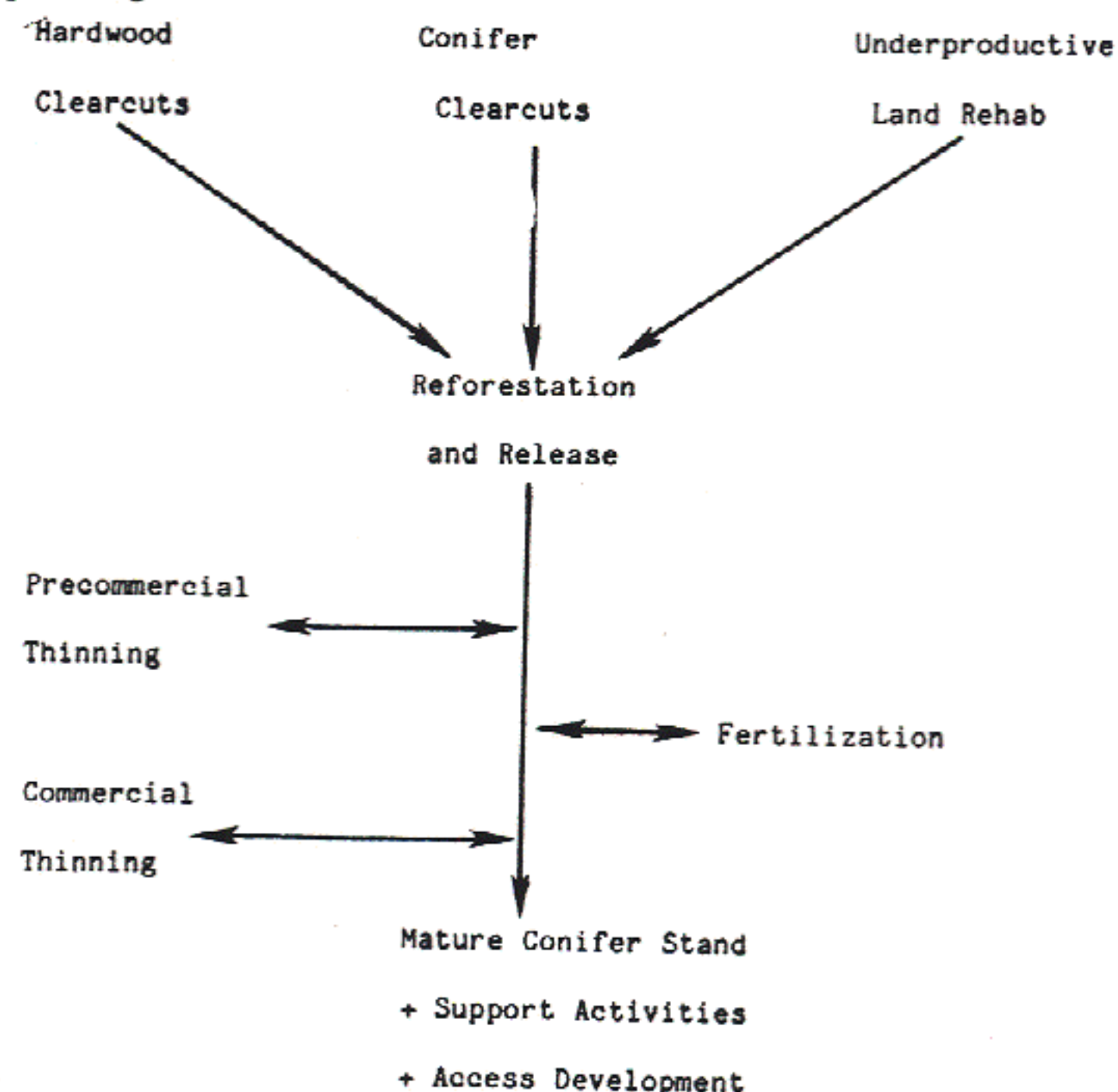
methods used for including fertilization in the decision-making process and the results. The methods illustrate several points of general interest; however, the results are examples only. Different forest inventories, financial situations, and objectives cause the actual results to differ among organizations.

ANALYSIS AND PLANNING

Analysis includes the following sequential steps: (1) projecting fertilization responses (per acre and forestwide); (2) analyzing fertilization economic opportunities on a per-acre basis; (3) priority ranking of fertilization compared with other management practices; and (4) simulating forest development, harvest, revenue, and costs under intensive management at various levels. Based on this analysis a management plan was formulated and is being implemented.

PROJECTING FERTILIZATION RESPONSES

Per-Acre Responses

Estimated per-acre fertilization responses (Table 1) were obtained from the University of Washington Regional Forest Nutrition Research Project (RFNRP). Several assumptions and adjustments were made to convert these data to merchantable cubic-feet-per-acre increment per fertilization application, assuming fertilization is done at 10-yr intervals and allowing for operational fall down.

Yields for unthinned stands represent 7 yr of response at the rates observed over 6 yr in the RFNRP for applications of 200 lb N/acre.[1] Response is a mean for all ages since age has not

1. K. J. Turnbull and C. E. Peterson. (Undated.) Regional growth analysis of thinned Douglas-fir, six years after fertilizer application/preliminary merchantable growth analysis of thinned Douglas-fir, four years after fertilizer application. 13 p. Paper prepared for Regional Forest Nutrition Research Project Liaison Committee, College of Forest Resources, University of Washington, Seattle.

Table 1. Projected increment in response to fertilization.[a]

	50-yr site 115	50-yr site 125
Unthinned stands	230	200
Thinned stands, thinning started at age 30 or 40	280	240
Thinned stands, thinning started at age 50	205	175

[a]Additional merchantable cubic-foot-per-acre increment per application of 200 lb N per acre. Values are relevant for single applications or multiple applications at 10-yr intervals. Metric conversion table in appendix.

been found to be significant in predicting response. Yields for 50-yr site 125 are those reported for site II; yields for site 115 are averages of those reported for sites II and III. Reported gross total stem volumes are reduced by 3.5% for stump and tip volume, by 20% for subsequent mortality, and by 20% for operational fall down.

Yields for stands thinned at age 30 to 50 represent 6 yr of response at the rates observed over 4 yr in the RFNRP for applications of 200 lb N/acre.[2] Yield is the mean for the average installation age 37. Site 115 yields are those reported for the average installation site 115. Yields for site 125 are adjusted from site 115 yields using the relation observed for unthinned stands. Reported gross total stand volumes are reduced by 3.5% for stump and tip, 5% for subsequent mortality, and 20% for operational fall down.

Yields for stands first thinned at age 50 and older represent 6 yr of response at the rates ofserved over 4 yr in the RFNRP for applications of 200 lb N/acre (University of Washington College of Forest Resources 1977). Yield is that reported for fertilization at age 57. Yields for site 115 and 125 are adjusted from reported site III yields using the relation observed for unthinned stands. Reported gross total stem volumes are reduced by 3.5% for stump and tip volume, by 5% for subsequent mortality, and by 20% for operational fall down.

The responses shown in Table 1 are conservative. Selecting either lower-than-average sites or better-than-average stands would increase response. Shumway and Atkinson (1978) have found that average response would be increased by one-third on sites II and III if fertilization could be confined to stands in the upper 75% of response.

Timing of Yield

Where stands will not be commercially thinned after fertilization all increment due to fertilization will be harvested at the time of clearcutting. Where commercial thinning will be done some of the increment due to fertilization will be harvested in thinning and the remainder at the time of clearcutting. We have assumed that one-third of the accumulated increment due to fertilization will be harvested at each thinning. This approximates the proportion of basal area removed in commercial thinning.

Forestwide Responses

Projecting forestwide response requires multiplying the per-acre responses by the acres fertilized and taking credit for additional harvest at the time of commercial thinning and clearcutting. The Department has incorporated these calculations in its

2. K. J. Turnbull and C. E. Peterson. 1979. Regional growth analysis of thinned Douglas-fir, four years after fertilizer application/preliminary merchantable growth analysis of unthinned Douglas-fir, six years after fertilizer application. 11 p. Paper prepared for Regional Forest Nutrition Research Project Liaison Committee, College of Forest Resources, University of Washington, Seattle.

forest simulation model, SFDSFD (a FORTRAN simulation program, conceptually similar to SIMAC, SORAC, TREES, and the like). This model simulates fertilization as an optional treatment in each conifer management regime. Acreage already fertilized is entered as input data. Specifications for fertilization are made as the percentage of acres to be fertilized in each regime-age-class-terrain-district combination.

ANALYZING FERTILIZATION OPPORTUNITIES

The economic efficiency of fertilization at various ages, in several stand conditions, and on two average sites was examined through benefit/cost analysis, using the same economic assumptions developed for analysis of other management practices. These assumptions are critical and any significant change in the assumptions will change the results. Key assumptions made by the Oregon State Forestry Department were:

1. 1978 stumpage prices of $0.19 to $0.39/ft³ commercial thinnings and $1.16/ft³ in clearcut sales. Real stumpage price appreciation of 2.5% yr projected over the next 30 yr followed by constant real prices.
2. 1978 fertilization cost of $46/acre projected to remain constant in real terms.
3. Variable rotations based on management regimes (age 60–70 for unthinned stands, 55–75 for stands thinned early and 70–80 for stands thinned late).
4. Real discount rate of 4.5%.

Benefit/cost ratios are shown in Table 2. Benefit/cost ratios

Table 2. Benefit/cost of fertilization.

Situation	Stand age	50-yr site 115	50-yr site 125
Current/unthinned stand	20	1.3	1.1
	30	2.0	1.7
	40	2.9	2.6
	50	4.0	3.5
	60	4.3	3.8
Current/thinned early stand	30	1.6	1.3
	40	2.2	1.9
	50	3.5	3.0
	60	5.2	4.5
Current/thinned late stand	50	2.7	2.3
	60	3.4	3.3
	70	3.9	2.7
Future/unthinned stand	20	1.3	1.1
	30	2.0	1.7
	40	3.1	2.7
	50	5.0	4.4
	60	6.3	5.5
Future/thinned early stand	30	2.2	1.9
	40	3.3	2.8
	50	6.2	5.2
	60	7.7	6.6

are positive for all situations examined, but vary significantly with situation, stand age, and site. Ratios are significantly better for older stands than younger (a reflection of the shorter time to hold the investment); somewhat better for the lower site (a reflection of greater response), and somewhat better for unthinned stands than thinned stands (despite better response in thinned stands and earlier harvest, lower thinning stumpage price reduces benefit/cost ratios).

PRIORITY RANKING OF FERTILIZATION

Similar response projections and benefit/cost analyses were made for other intensive management practices. All practices were then compared and ranked in priority by a planning team composed of responsible forest managers. Priority ranking criteria included silvicultural opportunity, benefit/cost ratios, relative ability to postpone, and logistics.

The resulting forest management priorities for Northwest Oregon Area State Forests are, first, clearcut harvesting of all eligible stands and commercial thinning of all silviculturally suitable and marketable stands, subject to sustained-yield constraint; and second, intensive management practices and road development in the following priority order: (1) good reforestation of timber sales, completion of main management and protection road net, accessible precommercial thinning; (2) fertilization of 40-yr and older stands; (3) remaining precommercial thinning and completion of roads to access future sales; (4) fertilization of younger stands in Tillamook Burn and rehabilitation of high-site, underproductive land; (5) fertilization of younger stands outside the Tillamook Burn; (6) completion of access roads in the Tillamook Burn and rehabilitation of underproductive land in the Tillamook Burn; and (7) fertilization of youngest stands and remaining rehabilitation of underproductive land.

SIMULATION MODELING

The forest inventory and planning decisions and prescriptions were entered in the SFDSFD simulation model. Fertilization prescriptions included the percentage of acreage of various regimes, terrains, and districts to fertilize and the age range over which to fertilize. Since SFDSFD does not by itself optimize, the analysis and decision-making discussed earlier was essential for the prescription entries. Also, since SFDSFD does not optimize, several simulation runs were necessary to find the "best" solution.

The first simulation run included all possible intensive management practices. This run was not feasible financially. First-decade costs exceeded the Department share of timber sale revenues. By trial-and-error simulation runs, the highest possible management level at which revenue and cost were balanced was identified. The final run included harvesting and intensive

management priorities (1) through (3) in the previous section for the 1980–1990 decade and all intensive management priorities for 1990 and beyond.

The final simulation run is the basis for the new timber management plan. Under this plan about 74,000 acres will be fertilized over the next decade—about 15% of the ownership. After 1990 fertilization should increase to between 175,000 and 190,000 acres per decade—about 37% of the ownership.

Figure 2 illustrates the additional projected harvest attributable to fertilization. The figure is constructed from SFDSFD runs wit and without fertilization at the prescribed levels. Since this young forest has no allowable cut effect, all increases attributable to fertilization occur in the future.

Figure 2. Projected harvest schedule with and without planned fertilization program, Northwest Oregon Area State Forests.
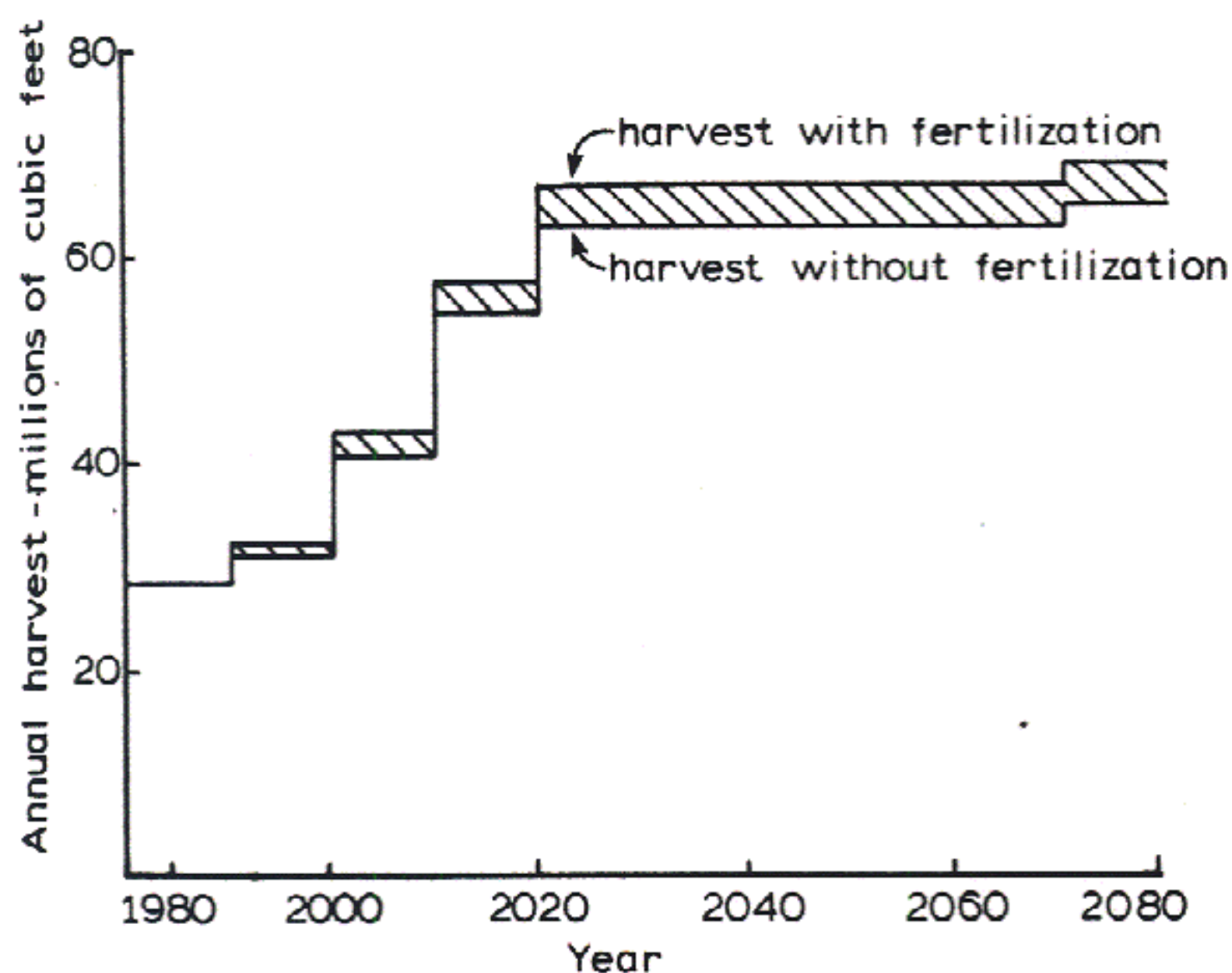
Fertilization does not increase the first decade harvest. Harvest levels increase by about 1.5% in the second decade, 4% in the third decade, 5% in the fourth decade and about 6% thereafter. These increases are not large, are based on conservative response data, reflect the fact that not all acres will be fertilized, and will be brought about by a program that is relatively easy to administer and that will require only a small part of projected management costs—5%–6% in the Department's case.

SHORT-RANGE PLANS

Short-range plans should follow long-range plans but must be kept flexible because of fluctuation of funds available for management work. Some practices can be accelerated in years of above-average funds and postponed in years of below-average funds. Fertilization has two attributes that lend itself to such flexibility. First, in contrast to timber sales, reforestation, and release, the precise timing of fertilization in a decade is not critical. The entire decade's worth of fertilization could be done in any 1, 2, or 3 yr of the decade. Second, in contrast to most other forestry work, the administrative cost of locating, contracting, and supervising fertilization work is low in relation to the management investment. Relatively little lead time or staff work is required.

The obvious danger in this flexibility is that fertilization could be continually postponed until it is never done. This danger can be avoided only by a realistic job of long-range planning and a commitment to the long-range plan itself.

CONCLUSIONS

A method for incorporating fertilization in long-range plans involves: (1) assembly of projected fertilization response in the same units used for other management practices; (2) analysis of opportunity through benefit/cost analysis using the same financial assumptions used for other practices; (3) comparative ranking of all intensive management practices using consistent criteria; and (4) simulation of forest development and harvest scheduling incorporating fertilization in the model used.

Fertilization should be analyzed in the same way other practices are analyzed. Wherever appropriate, fertilization should be incorporated in long-range plans.

LITERATURE CITED

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