PRELIMINARY GUIDELINES FOR FERTILIZING LESS THAN FULLY STOCKED STANDS AND MIXED SPECIES STANDS

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ABSTRACT

Foresters engaged in selecting areas for operational fertilization rarely encounter the fully stocked pure-species Douglas-fir stands that are studied by researchers. Most often the question is one of establishing minimal standards for choosing stands to fertilize. This paper offers preliminary guidelines for fertilizing less than fully stocked stands and mixed-species stands. Results are presented by age and site, and consist of a table showing minimal basal area stocking required to earn a given interest rate.

INTRODUCTION

Foresters engaged in selecting areas for operational fertilization rarely encounter the fully stocked pure-species Douglas-fir stands that are studied by researchers. Most often the question is one of establishing minimal standards for choosing stands to fertilize. This paper offers preliminary guidelines for fertilizing less than fully stocked stands and mixed-species stands.

The approach is to first determine volume of wood needed as response to fertilizer in order to earn a given rate of interest, and then to compare this volume with full-acre response estimates.

The model used compounds fertilizer cost at a given rate of interest (i) over the investment period (n) and then divides this sum of money by the estimated stumpage value when the trees are harvested, resulting in the volume of wood needed as fertilizer response to earn exactly "i" rate of interest (Figure 1).

When an interest rate to be earned and an investment period are set, fertilizer cost is known and stumpage value n years in the future is estimated; this formula can be solved for volume of response needed to earn i rate of interest. The necessary volume of response can be compared to estimates of response on a fully stocked acre (College of Forest Resources, University of Washington, 1979) to derive the percent of full-acre response needed to justify forest fertilization. The percent figure can then be applied to full stocking "normal" basal area tables to construct basal area stocking guidelines for choosing stands to fertilize.

RESPONSE CRITERIA

This procedure is demonstrated assuming that an 8% real rate of return must be earned on a 10-yr investment. Stumpage prices are assumed to be for 1979 as in Table 1, and 1989

Figure 1. Model used to determine volume of fertilizer response needed to earn i rate of interest:

$$\begin{bmatrix}\text{Response needed} \\ \text{(M Bd. Ft./acre)}\end{bmatrix} = \frac{\begin{bmatrix}\text{Fertilizer cost} \\ \text{(\$/acre)}\end{bmatrix} \quad \begin{bmatrix}(1+i)^n\end{bmatrix}}{\begin{bmatrix}\text{Estimated stumpage value} \\ \text{(\$/M Bd. Ft.)}\end{bmatrix}}$$

i = interest rate earned
n = investment period (yr)

Table 1. Assumed 1979 stumpage values; Douglas-fir.

1979 stand age	Unthinned 50-yr site class IV	III	II	I	Previously thinned 50-yr site class IV	III	II	I
	- - - - - - - - - - - - Mbm - - - - - - - - - - - -							
35	94	106	117	129	121	133	144	156
45	108	124	140	151	135	151	167	178
55	120	139	154	167	147	166	181	194
65	130	149	162	176	157	176	189	203

stumpage prices (in 1979 dollars) as in Table 2. A 3% real price increase is incorporated into Table 2. If a $55 per acre fertilizer cost is assumed in 1979, solution of the model for various sites and ages results in Table 3, which shows volume of fertilizer response actually needed in order to earn 8% real interest. Table 3 indicates that less response is needed with higher site stands and with older age stands, reflecting the increased value of larger trees.

Table 2. Assumed stumpage values in 1989 (1979 dollars); Douglas-fir.

1979 stand age	Unthinned 50-yr site class IV	III	II	I	Thinned 50-yr site class IV	III	II	I
	- - - - - - - - - - Mbm - - - - - - - - - -							
35	145	167	188	203	181	203	224	239
45	161	187	207	224	198	223	243	261
55	175	200	218	237	211	237	254	273

Note: This table incorporates a 3% "real" increase in value.

Table 3. Estimated volume of fertilizer response needed in 10 yr to earn 8% real interest.

1979 stand age	Thinned 50-yr site class IV	III	II	I	Thinned 50-yr site class IV	III	II	I
	- - - - - - - - - fbm/acre - - - - - - -							
35	819	711	632	585	656	585	530	497
45	738	635	574	530	600	532	489	455
55	679	594	545	501	563	501	467	435

Notes: (1) Assumed 1979 fertilization cost = $55/acre.
(2) fbm/acre, Scribner, 6 in. top.

Fully stocked acre response estimates are given in Table 4. When values of Table 3 (needed response) are expressed as a percent of Table 4 (full-acre response), Table 5 is created. As can be seen by the process in which it was constructed, Table 5 represents the percent of full-acre response that will just allow an 8% return. Thus it is an estimate of the minimal Douglas-fir stocking percent needed to justify forest fertilization. For example, an unthinned site III, 45-yr-old stand must be 54% (of normal) stocked with Douglas-fir in order to earn an 8% real rate of interest over a 10-yr period.

With the exception of sites III and IV, which are virtually the same, Table 5 reflects a trend that as site decreases, percent of full-acre response needed to justify fertilization also decreases. This results from the larger volume response expected on lower sites, which outweighs the size effect on value of higher sites. Simply stated: On lower sites you need more response to justify fertilization because the trees are smaller, but you also get more response. Older ages also require a smaller percent of full-acre stocking than younger ages because of the higher merchantable volume response due to tree size, coupled with the smaller volume response needed.

Table 5 can be used in two ways. For example, if you are faced with a site III unit that contains patches of well-stocked unthinned 45-yr-old Douglas-fir, the area can be fertilized profitably if the well-stocked areas cover 54% or more of the total land area in the unit. If the well-stocked areas have been

Table 5. Stocking percent needed to earn 8% real interest.

1979 stand age	Unthinned 50-yr site class IV	III	II	I	Previously thinned 50-yr site class IV	III	II	I
35	69	65	72	84	50	48	52	62
45	57	54	60	72	42	40	45	54
55	50	48	55	65	37	36	41	50

Table 4. Assumed 10-yr volume response from one fertilization for an acre fully stocked with Douglas-fir.

Stand age when treated	Unthinned, well stocked 50-yr site class IV	III	II	I	Previously thinned 50-yr site class IV	III	II	I
	- - - - - - - - - - - - bd ft/acre - - - - - - - - - - - -							
35	1,180	1,090	800	700	1,320	1,230	1,010	800
45	1,290	1,180	950	740	1,430	1,320	1,080	850
55	1,360	1,230	990	770	1,500	1,380	1,130	870

Notes: (1) Source: College of Forest Resources, University of Washington, Regional Forest Nutrition Research Project. 1979. Biennial Report 1976–1978, Table 11, page 18.
(2) 200 pound nitrogen per acre.
(3) Table volumes reflect a 20% "operational falldown."
(4) Bd ft/acre, Scribner, 6 in. top.

thinned, they need cover only 40% of total land area. In the more probable case of variable Douglas-fir stocking, with some trees in groups, but with others scattered, a fertilizer decision can be based on the question of whether or not Douglas-fir stocking amounts to 54% or more of full-acre stocking.

One approach to this latter situation is to apply the percents in Table 5 to a table of full stocking to determine the level of stocking necessary to be present in order to fertilize. This procedure is demonstrated in this paper by applying the percents of Table 5 to a table of normal unthinned basal area (Table 6), resulting in the figures shown in the left-hand (unthinned) side of Table 7. To use Table 7, an inventory of the unit is carried out (for example, using variable radius plots) and the mean basal area per acre in Douglas-fir is estimated. This is then compared to Table 7, and if enough Douglas-fir stocking is present, the area can be profitably fertilized.

Using the site III, 45-yr-old example, the unthinned area must contain a basal area of at least 92 ft^2 per acre in Douglas-fir trees 7 in. and larger. The balance of the stand can be unstocked, other conifers, hardwoods, skidtrails, or brush. All that matters is that at least 92 ft^2 per acre of Douglas-fir are present. As we acquire response data on the other conifer species, it will be possible to allow for some substitution of these species for Douglas-fir. At the present time it is safest to calculate solely on the basis of Douglas-fir stocking.

A special case occurs when red alder is present in the stand in appreciable quantities. Since alder contributes N which can be used by the Douglas-fir (Miller and Murray 1978, Tarrant 1961), it is probably best not to give high priority to fertilizing mixed stands of Douglas-fir and red alder if the alder is reasonably distributed throughout the fir stand.

Table 6. Basal area of well stocked unthinned stands, trees 7 in. dbh and larger.

Total age	50-yr site class IV	III	II	I
	- - - - ft^2/acre - - -			
35	94	129	157	181
45	137	170	197	219
55	170	202	227	249

Derived from: Chambers, C. J. and F. M. Wilson. 1972. Empirical yield tables for the Douglas-fir zone. DNR Report No. 20R. Department of Natural Resources, State of Washington.

GUIDELINES

Deriving guidelines for fertilizing thinned Douglas-fir stands requires that full-acre stocking be reduced, since response data of Table 4 are from stands thinned to approximately 60% of normal stocking. The right-hand (thinned) side of Table 7 is computed by applying the percents of Table 5 to 60% of Table 6 basal area stocking. If you are concerned with a site III area, you must have at least 41 ft^2 per acre in well-spaced 45-yr-old Douglas-fir crop trees in order to justify fertilization. Assuming these trees average 14 in. in diameter, this results in a need for 38 Douglas-fir crop trees per acre.

Guidelines such as those demonstrated in this paper are specific to the parameters used in the analysis. As values, costs, and investment periods change, the guidelines also will change. These are offered as examples of the form in which fertilizer research results should be presented in order to be most usable for the field forester faced with choosing areas to fertilize.

Table 7. Estimated of basal area stocking of Douglas-fir needed to earn 8% real interest.

Total age	Thinned 50-yr site class IV	III	II	I	Thinned 50-yr site class IV	III	II	I
	- - - - - - - - - - ft^2/acre - - - - - - - -							
35	65	84	113	152	28	37	49	68
45	78	92	118	158	34	41	53	71
55	85	97	125	162	38	44	56	75

LITERATURE CITED

College of Forest Resources, University of Washington, Regional Forest Nutrition Research Project.
1979. 46 p. Biennial Report 1976–1978.

Miller, R. E., and M. D. Murray.
1978. The effects of red alder on growth of Douglas-fir. *IN* Utilization and management of alder. 379 p. D. G. Briggs, D. S. DeBell, and W. A. Atkinson, eds. p. 283–306. USDA For. Ser. Gen. Tech. Rep. PNW–70.

Tarrant, R. F.
1961. Stand development and soil fertility in a Douglas-fir–red alder plantation. For. Sci. 7(3):238–246.