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YES, INCREASED YIELDS CAN REDUCE HARVESTS!

by

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ABSTRACT

Increases in stand yields resulting from growth-stimulating or inventory-protecting silvicultural investments may actually reduce the allowable cut calculated by Timber RAM as presently used on National Forests. The case study presented here indicates that the timing of the silvicultural investment and the lack of flexibility with respect to the rotation and timing of thinnings affect the occurrence and severity of this unusual result.

KEYWORDS: Allowable cut, yield regulation, timber management planning, Timber RAM.

INTRODUCTION

The allowable cut effect (ACE) (Bell et al. 1975, Lundgren 1973, Schweitzer et al. 1972, and Teeguarden 1973) represents the change in present forest harvest level attributable to any action which changes timber yields at some time in the future. The effect is a direct result of harvest flow constraints on a forest and thus is also affected by changes in the severity of these constraints.

Traditionally the ACE for a silvicultural treatment has been measured in terms of the increase in mean annual increment that can be attributed to that treatment distributed equally over the rotation. This procedure often produces reasonable results for many of the harvest scheduling techniques used in the past, but the advent of Timber Resource Allocation Method (RAM) (Navon 1971) and other computer harvest scheduling models has made this procedure suspect. In actuality, the ACE in these models may range from a negative quantity to an increase as large as the increase in yields at the end of the rotation depending upon when the increase occurs.

To illustrate and explain this wide range in ACE, two alternatives for fertilization on a western National Forest were analyzed with the 1972 version of Timber RAM using the present Forest Service nondeclining even-flow policy. For the first alternative, a fertilizer application in conjunction with precommercial thinning on 28,480 acres (11,526 ha) of medium site Douglas-fir increased the final harvest after nine decades by 10 percent to 6,900 ft^3 per acre (483 m^3/ha). For the second alternative, the same treatment applied to 10,460 acres (4,233 ha) of high site Douglas-fir also increased the final harvest by 10 percent to 8,250 ft^3 per acre (577 m^3/ha) following an eight decade period.

The results of these treatments on the allowable cut are shown in table 1. If one uses the traditional measure of increased mean annual increment, both alternatives appear attractive, since mean annual increment increases in both cases. When using RAM, however, the results are quite different. In the case of the medium site Douglas-fir, the harvest in the first decade actually declines rather than increasing as one might expect. Furthermore, the results for the high site Douglas-fir, while positive, are not as large as might be expected from use of the traditional analysis.

Why do these results occur? Intuitively it is clear that when volume is constrained to be a certain level in a given decade, any increase in volume above that level will not be permitted. Because of increased volume per acre in the example above, fewer acres can be harvested before the constraint is reached. This means fewer acres will be available for harvest at a future date because only a few harvest and thinning schedules are allowed in RAM for regenerated timber. This reduction in acres harvested can become extremely significant and actually result in reduced future harvest. What is less obvious is how these changes relate to the first decade harvest when the critical period is in some later decade.

Timber RAM for National Forests generally maximizes harvest in the first decade subject to some flow constraints. The Pacific Northwest Region of the Forest Service constrains the harvest level in each decade to be not less than 99.9 percent of the harvest in the preceding decade during the conversion

Table 1--*Change in first decade harvest for two alternative fertilization levels measured by two methods*

Investment alternatives	Method of calculation	
	Mean annual increment	Timber RAM[1/]
	Cubic feet/acre (m^3/hectare)	Cubic feet/acre (m^3/hectare)
1. On medium site Douglas-fir[2/]	+37 (+2.6)	-7 (-0.5)
2. On high site Douglas-fir[3/]	+94 (+6.6)	+60 (+4.2)

[1/] Daniel Navon, 1971. Timber RAM...a long range planning method for commercial timberlands under multiple use management, USDA For. Serv. Res. Pap. PSW-70. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

[2/] Fertilize 28,480 acres (11,526 ha) of medium site Douglas-fir to increase final harvest in nine decades by 10 percent.

[3/] Fertilize 10,460 acres (4,233 ha) of high site Douglas-fir to increase final harvest in eight decades by 10 percent.

period. Private industry may consider other less restrictive flow constraints. In any case, linking the decades together by constraints means that what happens in future decades affects the previous decades in proportion to the severity of the flow constraints.

In more technical terms, the nonbasis of the final linear programing tableau provides other clues to the results. Table 2 shows the shadow prices for the volume variable in Timber RAM for the example presented above. When the objective is to maximize first decade harvest, the shadow price for a given decade indicates the increase (or decrease) in first decade harvest that would result from a unit increase (or decrease) in volume during that decade. Because of the way the model is set up, negative signs should be interpreted as reflecting direct relationships whereas positive signs indicate inverse relationships. For example, the positive sign for the decade nine shadow price indicates that increases in volume in decade nine will result in decreases in harvest during the first decade--a situation described in table 1. Unfortunately, the large number of constraints and activities in the model often restrict the range over which the shadow prices are relevant. That is, large changes in volume will likely change the linear programing basis and thus, the shadow prices.

The unusual allowable cut effect shown in table 1 is not unique to this case study. Analysis of eight western National Forests under alternative flow restrictions, ranging from nondeclining even flow to 5-percent declining flow and 10-percent fluctuating flow around an average, indicate that these

Table 2--*Final nonbasis linear programing results for case study volume variables by period*

Period	RAM volume variable name	Shadow price
1	VOLU1	-0.071
2	VOLU2	- .072
3	VOLU3	- .073
4	VOLU4	- .086
5	VOLU5	- .090
6	VOLU6	- .086
7	VOLU7	- .084
8	VOLU8	- .081
9	VOLU9	+ .034
10	VOLUA	+ .007
11	VOLUB	- .001
12	VOLUC	- .001

unexpected results should be expected. Five out of the eight Forests under all types of flow constraints had some decades where increased volume would reduce the even flow harvest level. The other Forests had these decades only under certain flow constraints. Unfortunately no pattern appears to exist which might allow prediction of these situations.

In addition, since Timber RAM has received such widespread use among both public and private sectors, the implications of these results must be considered significant. Some of these include:

1. Practices which increase growth may not increase harvest and in some cases may even decrease it; e.g., precommercial thinning may reduce the even flow harvest level.

2. Factors which reduce growth or inventory such as insects, diseases, or fires may make increased even flow harvest levels possible; e.g., bugs and fires should be allowed to progress in some cases.

3. Rescheduling of thinnings, although not changing growth, may increase or decrease the harvest level. Changes in rotation age may also have the same effect, even though these changes are away from culmination of mean annual increment.

In conclusion, the allowable cut effect in Timber RAM depends upon the period in which the action producing the ACE occurs. No longer can investments in silvicultural and other forest practices on forests where harvests are scheduled subject to flow constraints be evaluated without considering the time of their implementation. Just as there is an optimal timber harvest schedule, there is also an optimal investment schedule, and the timing of the investment is critical in determining the amount of the allowable cut effect. The problem of scheduling investments is further complicated by the limited rotation and thinning alternatives for regenerated timber available in RAM. Because of this limitation, increased yields can actually reduce harvests in some cases.

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