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INCREMENT AND MORTALITY IN A VIRGIN DOUGLAS-FIR FOREST

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Is there any basis to the forester's rule of thumb that virgin forests eventually reach an equilibrium where increment and mortality approximately balance? Are we wasting potential timber volume by failing to salvage mortality in old-growth stands?

Six years' observation in a 350-year-old Douglas-fir stand in the Wind River Natural Area tends to answer these questions in the affirmative. The Wind River record may not be representative of all old-growth stands; however, it illustrates the problems of increment and mortality peculiar to the management of old-growth Douglas-fir.

The 1,140-acre natural area lies at an elevation of 1,100 feet in the Columbia River drainage in southern Skamania County, Washington. It was set aside in 1932 for studies in the virgin Douglas-fir forest type and is to remain indefinitely in a natural condition.

The natural area contains 95,000 board feet (Scribner rule) gross volume per acre, of which 67 percent is Douglas-fir and 24 percent western hemlock. Western redcedar, Pacific silver fir, and white pine account for the remaining 9 percent (figure 1). Through heavy mortality of Douglas-fir, the forest is in a process of change to a climax type of the more tolerant western hemlock and silver fir, which now grow in the understory and in small natural openings (figure 2). In addition to the increment and mortality data given in this report, records of lesser vegetation are being made at 12-year intervals. As time passes, these will help to complete the record of ecological change.

Figure 1. -- Wind River Natural Area showing part of the tract where the original Douglas-fir forest is still intact.

Figure 2. -- A stand in the Wind River Natural Area where over-mature Douglas-fir is being replaced by more tolerant western hemlock and Pacific silver fir.

Inventory Procedure

Inventory and increment data were gathered on concentric plots, one-twentieth acre and one-fifth acre in size. The plots are mechanically spaced at the rate of 2 per 40 acres, making a total of 50 plots of each size. All trees 2.5 to 9.5 inches d.b.h. inclusive on the 1/20-acre plots, and all trees 9.6 inches d.b.h. and larger on the 1/5-acre plots were tagged and tallied. A 10-percent estimate of mortality, covering 110 acres, was made by cruise strips 2 chains wide, running once through a forty. Inventory and increment plots are measured every 6 years; mortality strips are checked every 2 years.

Increment

Gross annual increment averaged 113 cubic feet per acre for the 6-year period from 1947 to 1953 (table 1). In terms of sawtimber, gross annual increment averaged 767 board feet, Scribner rule. Net annual increment, however, averaged -2 cubic feet, or +8 board feet for the 6-year period; and the difference is, of course, accounted for by mortality. The annual loss in Douglas-fir of 316 board feet per acre was barely offset by the 324 board feet net increment of hemlock and other species. Moreover, gross annual increment of Douglas-fir was only 161 board feet per acre; while hemlock, with 63 percent less volume, had a gross increment of 445 board feet.

Mortality

Mortality, which averaged 115 cubic feet, or 759 board feet per acre annually during the 6 years (table 2), practically wiped out gross increment. This large loss occurred primarily in Douglas-fir, 69 cubic feet or 477 board feet, with lesser amounts in other species. However, based on total volume of each species, annual board-foot loss (gross volume) was 0.76 percent for Douglas-fir, compared to 0.89 percent for hemlock, and 0.91 percent for other species.

Bark beetles and windthrow were the two principal causes of mortality. Highest wind damage occurred during the period 1949 to 1951, when unusually strong winter winds were common throughout the Pacific Northwest. Hemlock and silver fir were more subject to windthrow than other species.

Bark beetle losses were confined almost entirely to Douglas-fir. Period of greatest loss was 1951 to 1953, due primarily to rapid

Table 1.--Periodic annual increment and mortality, Wind River Natural Area, 1947 - 1953

Item	Douglas-fir	Hemlock	Miscellaneous	Total stand
	---- Board feet per acre, Scribner [1] ----			
Stand 1953	63,012	23,107	8,416	94,535
Gross increment	161	445	161	767 ± 66 [2]
Mortality	477	205	77	759 ± 107
Net increment	-316	240	84	8 ± 125
	------- Cubic feet per acre [3] -------			
Gross increment	25	64	24	113 ± 8
Mortality	69	33	13	115 ± 16
Net increment	-44	31	11	-2 ± 18

1/ Trees 11.6 inches d.b.h. and larger to an 8-inch merchantable top.
2/ Standard error.
3/ Trees 2.6 inches d.b.h. and larger for entire stem.

Table 2.--Periodic annual mortality by cause, Wind River Natural Area, 1947 - 1953

Cause	Losses for 2-year period ending--				Percent of total
	1949	1951	1953	Average	
	-- Board feet per acre, Scribner [1] ---				
Bark beetles	0	24	637	221	29
Windthrow	37	364	218	207	27
Mistletoe	40	112	147	100	13
Unclassified	159	320	217	231	31
Total	236	820	1,219	759	100

1/ Trees 11.6 inches d.b.h. and larger to an 8-inch merchantable top.

increase of beetles in down timber following the heavy windstorms of 1949 to 1951. Extreme drought from April to August in 1951 and again in the late summer and fall of 1952 further aggravated the situation. Bark beetle activity has lessened with resumption of more normal weather.

Dwarfmistletoe is steadily increasing as an apparent cause of mortality. It is found throughout the entire area on scattered trees with hemlock and silver fir the most susceptible species. In a few instances large trees, heavily infected, have been killed. In many cases, mistletoe is a contributing cause of mortality rather than a primary agent. Trees weakened by the parasite become an easy prey for other diseases or for insects. Unclassified mortality from all other causes, including suppression and decay, accounted for 31 percent of the total volume lost.

The breakdown of mortality by 2-year periods (table 2) shows that volume of losses can be expected to vary tremendously from year to year. Average annual per-acre losses for the 2 years ending in 1953 were five times the loss for the 2-year period ending in 1949.

Sampling Errors

In addition to the large year-to-year variation, both mortality and net increment deviate widely from plot to plot. This variation led to the estimates of standard error shown in table 1. These standard errors indicate that the estimates of gross increment are 3 to 5 times more precise than the estimates of mortality and net increment. From these standard errors we may also infer that, unless a 1-in-20 chance has occurred in sampling, true annual gross growth for the 6-year period is between 97 and 129 cubic feet per acre, and net growth between -38 and +34 cubic feet. Corresponding ranges in board feet are 635 to 899 for gross increment and -242 to +258 for net increment. Obviously, the estimates of growth and mortality for the Wind River Natural Area are not precise. They are further based on a limited number of years. Nevertheless, they are believed to be the best estimates available for an old-growth Douglas-fir stand and should, if properly qualified, be useful.

Significance

These observations indicate that the Wind River Natural Area was in approximate equilibrium during the 6-year period ending 1953. However, there was considerable annual <u>gross</u> increment: 767 board feet, or 113 cubic feet, per acre. Hence, it is not for lack of increment but because of mortality that the stand is failing to increase in live-tree volume. The stand is obviously far past the age of maximum mean annual net increment, and, from a commercial viewpoint, should be harvested and a new crop started.

Unfortunately, not all of our Douglas-fir virgin timber areas can be harvested immediately, and for many practical reasons, should not be. Where final harvest cutting must be deferred, periodic salvage of mortality may be both beneficial and profitable. The Wind River records show that this annual loss is of above average in timber quality. Some 63 percent is Douglas-fir, capable of salvage if harvested within a 10-year period after death. Assuming that 600 board feet of the annual loss of 767 board feet would be salvable and that a stumpage value of $15 per M could be obtained, a gross return of $9 per acre would be available. Such an amount would justify the construction of a high standard road system, to be used not only for salvaging mortality but later for the harvest cut. For example, assume a road ratio of 1 mile to 150 acres, costing $15,000 per mile, $150 per mile maintenance, and a depreciation and obsolescence allowance based on a 35-year life:

Annual road construction and maintenance costs per acre	
Interest on construction cost, $15,000/150 acres x 4 percent	$4.00
Maintenance, $150/150 acres	1.00
Depreciation and obsolescence sinking fund to amortize $100 per acre road cost at 4 percent	1.43
Annual value of mortality salvage	
600 board feet Scribner at $15 per M (average 6-year mortality of 759 board feet reduced by 20 percent)	9.00
Net gain per acre	$2.57

Where reserve old-growth stands of Douglas-fir occur on ground adapted to salvage logging, the periodic harvest of mortality appears to be a practice that will increase total yields and pay its way.