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# EFFECT OF ROADS ON GROWTH OF WESTERN WHITE PINE PLANTATIONS IN NORTHERN IDAHO

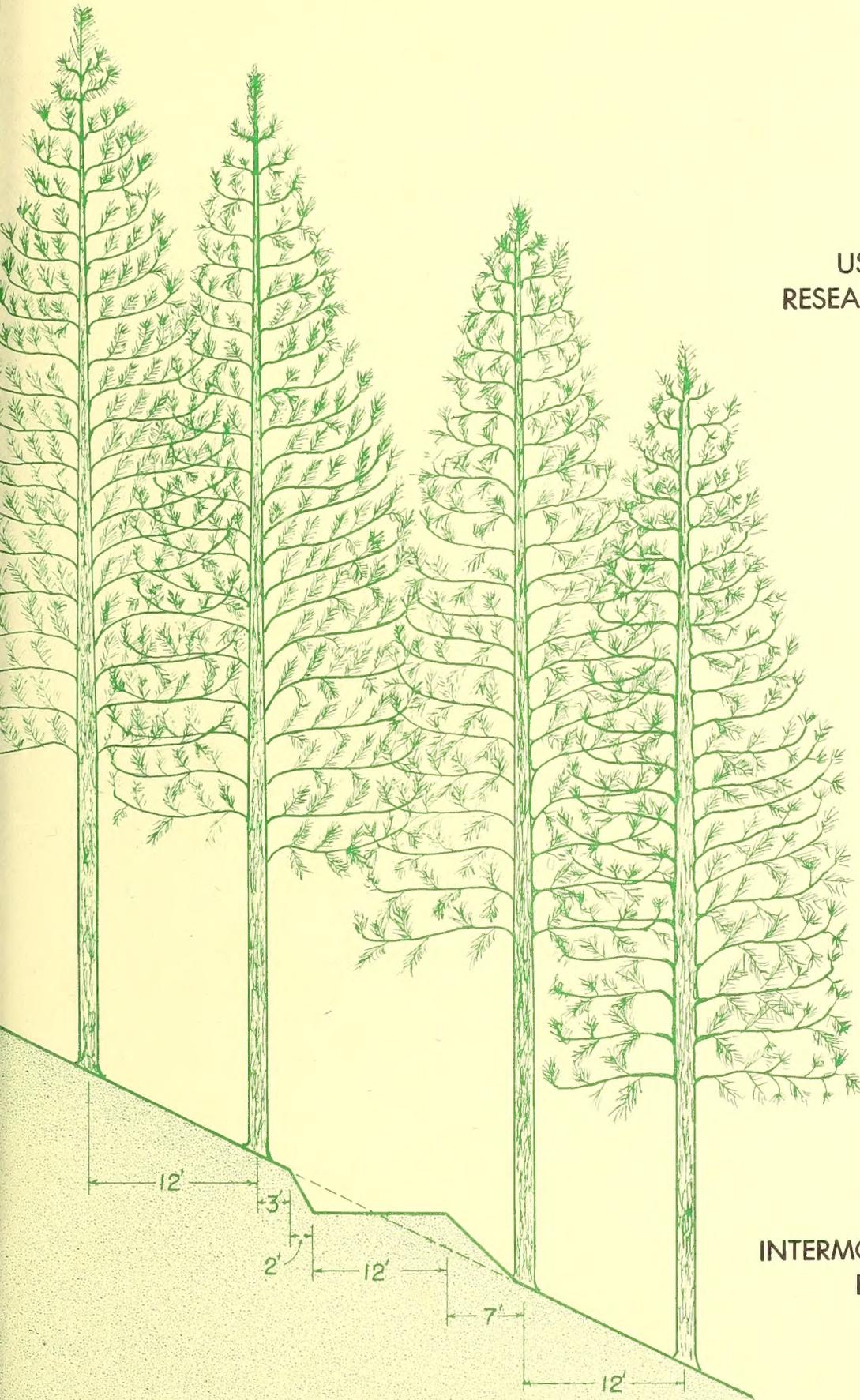
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EFFECT OF ROADS ON GROWTH OF  
WESTERN WHITE PINE PLANTATIONS  
IN NORTHERN IDAHO

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## INTRODUCTION

The system of "jammer" logging commonly used for harvesting timber on steep slopes in northern Idaho requires a network of roads spaced 300 to 500 feet apart. A well-designed and maintained road layout gives the land manager ready access for fire protection and application of cultural treatments. On the other hand, such a permanent road system requires preemption of timber-producing land for roadbeds, cuts, and fills. Estimates of land area used for roads have ranged from 5 to 21 percent of the total land area according to varying criteria and different sources (Moessner 1960; Olson 1952; Roffler<sup>1</sup>). Thus, some land managers assume a 10- to 15-percent loss of timber-production area when establishing and maintaining this type of road system. Furthermore, watershed managers have been concerned about a possible disruption of water movement through the soil mantle caused by roadcuts, with a consequent effect on adjacent and downslope stand development.<sup>2</sup>

A pertinent question facing the land manager is whether the open area actually occupied by the road is a legitimate estimate of the percentage loss in total area productivity. Is 10 to 15 percent an accurate estimate of timber-production area loss, or do roads affect production in the adjacent stands? In Germany, Kramer (1958) studied 108 temporary sample strips along roads that were 4 meters to greater than 20 meters in width in pure beech (*Fagus sylvatica* L.) and pure Norway spruce (*Picea abies* (L.) Karst.) stands from 30 to 150 years old. Roadside trees had greater growth in both height and diameter than those located farther within the stand. Volume effects were calculated by expanding the width of the 10-meter roadside strip to include half of the road width. For Norway spruce, the volume per hectare of these "expanded" roadside strips did not decrease until the unstocked area exceeded 5 meters (16.4 feet). For beech, the critical width of the unstocked area was 12 meters (39.4 feet). The capacity of beech to utilize larger openings than spruce was attributed to the large difference in crown expansion potential between the two species.

Landbeck (1965), conducting his studies in East Germany, followed the methods of Kramer (1958) and established 95 temporary plots along roads 3 to 6.5 meters (9.8 to 21.3 feet) wide in pure Scotch pine (*Pinus sylvestris* L.) stands aged 60 to 120 years. Here, too, the diameter of roadside trees was greater than that of interior trees, but height was slightly less and quality was lower. The volume per hectare of the "expanded" roadside strips (strip plus half of road width) was less than 2 percent lower than the volume per hectare within the stand. No critical width for the unstocked area could be established because the range of road widths was so narrow.

If roads seriously affect timber production in northern Idaho, land managers need a quantitative estimate of production losses to aid in management planning and evaluation of logging systems. The objective of this study was to estimate the potential timber production loss caused by a permanent road system. A projection of such loss was established by determining the magnitude of "edge effect" in managed stands in northern Idaho and comparing it with the width of road opening.

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<sup>1</sup>Roffler, H. C. Lost Block Road Study. USDA Forest Serv., Northern Region, Coeur d'Alene Forest, Unpub. Rep., 4 pp. 1950.

<sup>2</sup>Coile, T. S. Forest and range soil problem analysis for the Northern Rocky Mountain Region. USDA Forest Serv., Intermountain Forest and Range Exp. Sta., Unpub. Rep., 33 pp. 1950.

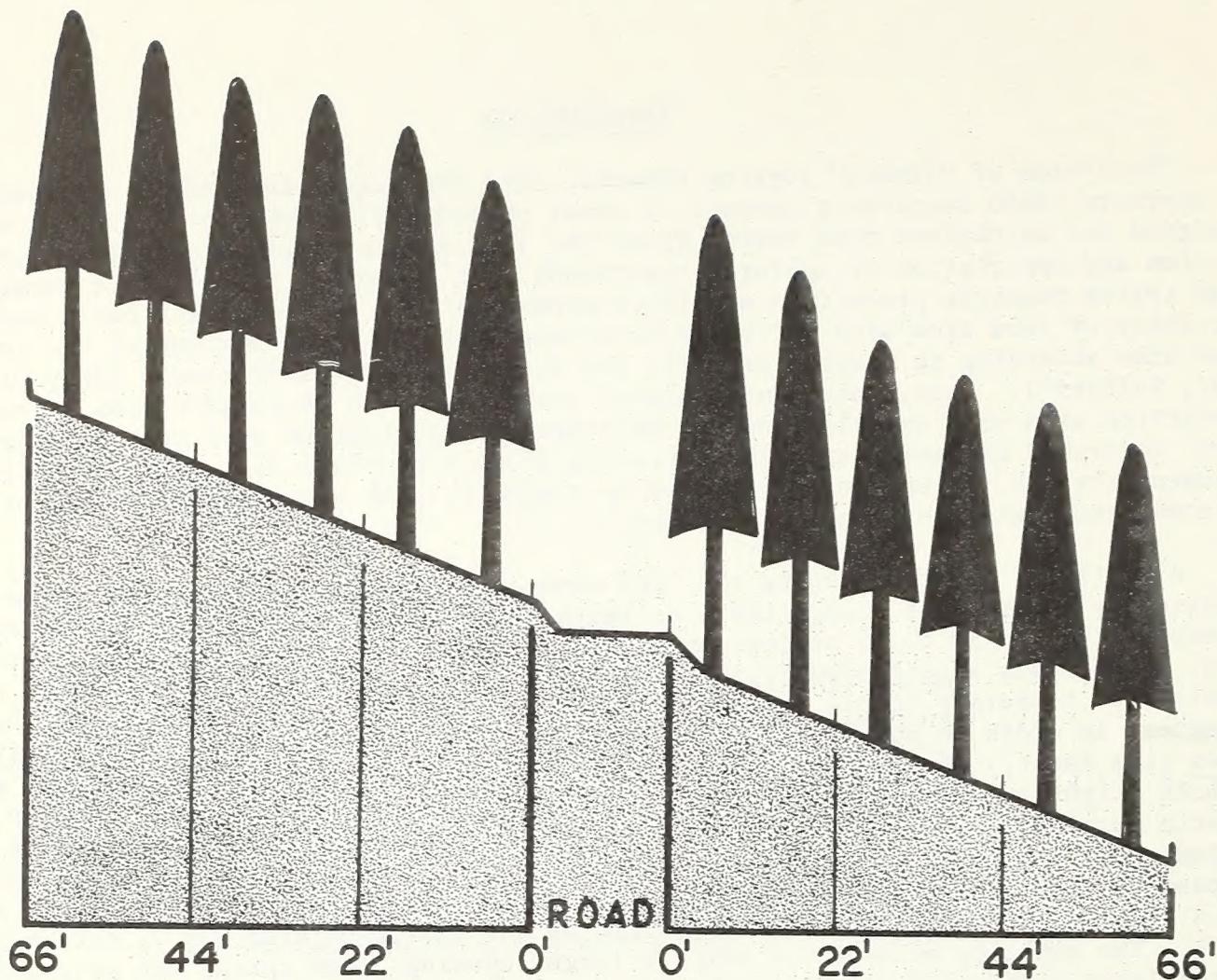


Figure 1.--Diagrammatic layout of plantation plots in relation to road.

#### METHODS

Since the long-range need is for information on managed stands, study areas were in western white pine plantations between 25 and 50 years old containing permanent roads constructed about the time of stand establishment. Plantations with obvious stocking irregularity or low survival were not selected. (Some irregularities were not obvious until data had been collected.) At each selected location, paired 1/20-acre plots were established above and below the roads. Plots were 33 feet wide and extended 66 feet into the stand from the top of the cut bank or from the top edge of the road shoulder (figure 1). The 24 plots were measured and grouped for subsequent analysis as shown in table 1. Soils in the Coeur d'Alene National Forest study areas were Brown Podzolics developed from volcanic ash overlying and intermixed with argillites and quartzites of the "Belt" formation; the Kaniksu National Forest study area soils were developed mainly from coarse-textured glacial outwash.

Roads were predominantly single-lane and outsloped at the time of measurement. Judging by location and present condition, it is reasonable to assume that they were maintained in an outsloped condition during most of the stand history. Road width, as well as cut-and-fill dimensions were measured at each plot location.

Table 1.--Distribution and description of sample plots

Number of plots	Location	Age of stands (yr.)	Slope		Aspects
			Average %	(Range) %	
12	Cathedral Peak (Coeur d'Alene N.F.)	40	44	(20-80)	NW,N,NE,E
6	Brett Creek (Coeur d'Alene N.F.)	29	42	(25-55)	N, NE
3	Miscellaneous (Coeur d'Alene N.F.)	23-46	12	(7-25)	NE, SW
3	Miscellaneous (Kaniksu N.F.)	30-33	20	(16-26)	NE

Height, diameter, crown class, and distance from the road edge were recorded for all trees larger than 2.5 inches d.b.h. Height increment (for the first 5 years above breast height) was measured on all dominant and codominant trees to assess road effects on height during early stand development.

Scatter diagrams were prepared for each plot relating tree diameter and height to distance from the road. The diagrams were used to evaluate stocking uniformity and to estimate how far the road effects extended into the stand. Analysis of variance, with individual degree-of-freedom tests, was used to test the hypothesis that roads had no effect on growth of adjacent trees.

### RESULTS

The Cathedral Peak plantation plots were selected for detailed analyses of road effects because they had uniform stocking, were all of the same age, and there was a well-located road through an area large enough for several replications on varying aspects and topography. Applicability of data from Brett Creek and elsewhere was diminished by variation in stocking due to heavy blister rust mortality, nonutilization of roadside space, inadequate area to obtain suitable replications within each plantation, and different ages of the plantations. The results reported below are therefore based primarily on these 12 Cathedral Peak plots; the information from the other 12 plots is used only to supplement the Cathedral Peak analysis.

For the Cathedral Peak plots, scatter diagrams revealed an obvious roadside effect on height and diameter of trees in the plots below the road; this effect appeared to extend an average of 24 feet into the stand. No roadside effects were observed in the plots above the road.

Heights and diameters of dominant and codominant trees were adjusted to remove between-plot site variation and were pooled within six 11-foot zones as shown in figure 2. The average height of border trees in the plots below the road was 113 percent of that within the stand, or approximately 7 feet greater. The average diameter of border trees in plots below the road was 131 percent of that within the stand, or approximately 2.5 inches greater. In neither case were effects evident above the road. (Distance from road edge did not appear to influence early height increment for the 5 years above breast height on any of the 12 plots.)



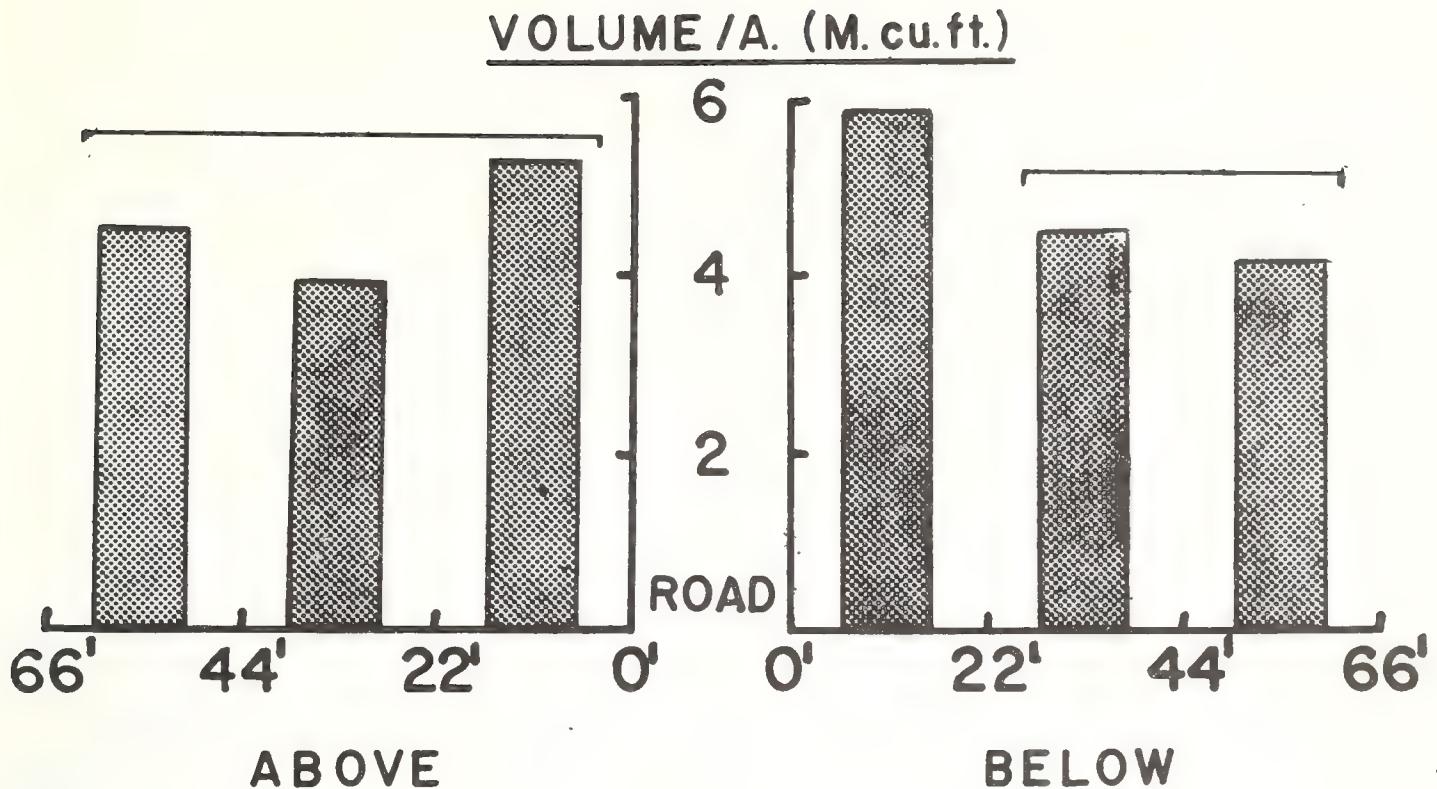


Figure 3.--Total stand volume by zones in relation to distance from the road. (Zones connected by brackets are not significantly different,  $P < 0.05$ .)

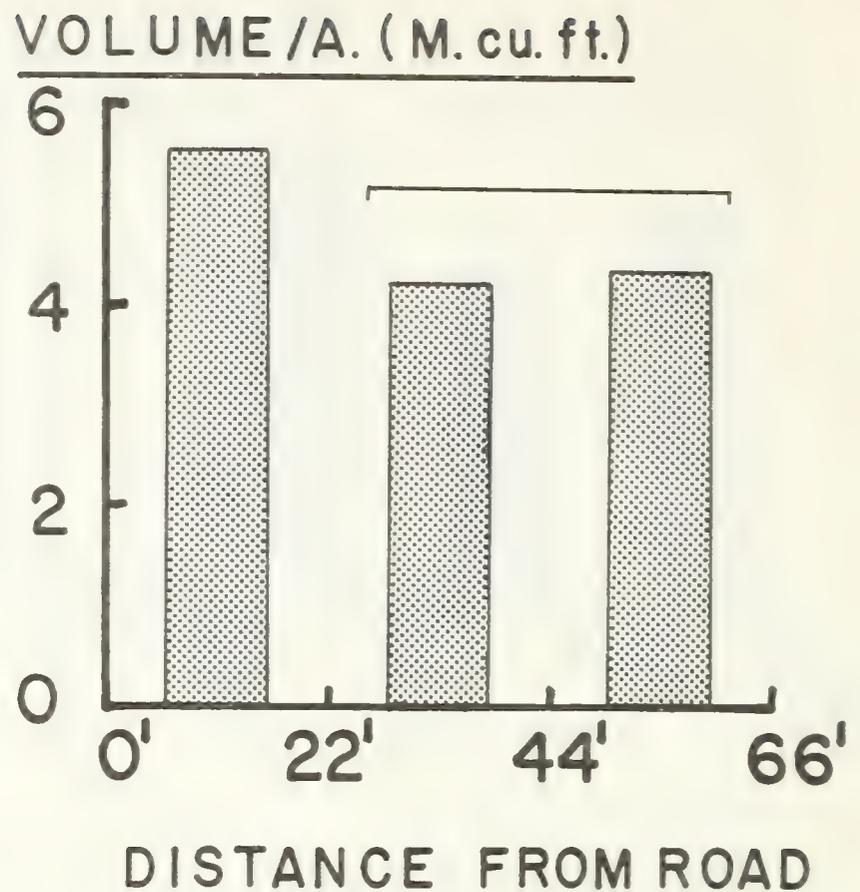
Because the "edge effect" appeared negligible beyond 22 feet from the road, the plots were divided into three equal 22-foot zones for analysis of volume. Above- and below-road plots were analyzed separately using 6 plots and 3 zones for each test. An orthogonal individual degree-of-freedom test was employed to test for significant differences between zones.

Volume in the roadside zone of below-road plots was significantly greater than in the two zones within the stand (figure 3). Roadside volume appeared greater in above-road plots, but was not significant. By pooling the data for above- and below-the-road plots, the total effect on utilization of road area can be determined and the significant additional volume growth (130 percent of that within the stand) is apparent (figure 4).

The average distance (road width plus cut width) was 18.5 feet. The increased volume in roadside zones was sufficient to compensate for 13.1 feet of this distance, leaving 5.4 feet of unproductive road area. With an average space of 400 feet between roads, the unproductive road area would convert to only about 1.4 percent of the total area.

The miscellaneous plots on the Coeur d'Alene and Kaniksu National Forests showed the same trend of increased growth adjacent to the road with a magnitude of response very comparable to Cathedral Peak. Data from the Brett Creek plots were highly variable because of heavy blister rust mortality. Volume above the road appeared unaffected, but in contrast to the other plots, growth of below-road border trees was slightly diminished. However, this stand was established after the road was built and the trees were not planted to fully utilize the road opening in much of the area. On 2 of the 3 below-road plots the closest border tree was 10 feet from the edge of the road. This 10-foot space was occupied by dense shrubbery evidently negating a potential growth response of border trees.

Figure 4.--The net effect of roads on total stand volume production by pooling data from above and below the road. (Zones connected by the bracket are not significantly different,  $P < 0.05$ .)



#### DISCUSSION

The obvious additional growth of below-road trees indicates improved site productivity due to additional water availability. Precipitation falling on an outsloped road is redistributed below the road and the unvegetated fill should provide a reservoir of available water for adjacent trees during part of the summer drought period.

A normal growth increase in border trees in response to additional growing space is apparently masked by water distribution effects. Below-road trees would have this effect included as part of the total response. Conversely, ~~a significant~~ growth response in above-the-road trees may indicate that the expected additional growth due to space is reduced by the loss of moisture from the cut bank. These roadside effects indicate that disruption of water movement through the soil mantle because of roads (see footnote 2) is not a serious consideration for soils similar to those in this study.

The common method of multiplying clearing width times road length to obtain estimates of area in roads does not take into account the capacity of trees to utilize at least part of the opening. Silen and Gratkowski (1953) presented an enlightened view on use of road measurements in their analysis of a staggered-setting system of clear-cutting on the H. J. Andrews Experimental Forest in Oregon. The total area disturbed by roads and landings amounted to 9.8 percent, but the estimated loss in productive area was only 4.1 percent when reasonable assumptions on crown expansion and productivity were included in the calculations.

A similar approach can be demonstrated for our conditions by a simple exercise. On an average slope of 50 percent, a 12-foot road would require an additional 9 feet for cut and fill. Planting at the toe of the fill and 3 feet above the cut bank would result in a nonstocked width of 24 feet. Assuming 400 feet between roads and a 12-by-12 spacing we would lose only one row out of 33 for each road, or only 3 percent. Additional growth below the road would further reduce the loss of productive area. Thus, the loss becomes insignificant in relation to the improved accessibility for protection and management.

The small loss in total stand production (1.4 percent) shown by this study is comparable with that found in Germany for roads of similar width. Kramer (1958) reported no volume reduction in Norway spruce roadside strips for roads less than 16.4 feet wide and only about 7 percent reduction in volume of roadside strips for roads from 16.4 to 29.5 feet wide. Assuming a road spacing of 400 feet, this 7 percent would convert to a net loss of production area over the entire stand of about 1.6 percent. Applying the same assumptions and calculations to Landbeck's (1965) data, the Scotch pine stands sustained an overall production loss of only 0.4 percent. Kramer's report (1958) also demonstrated that edge effect was much greater in stands 50 to 80 years old than in younger stands. Therefore, as the stands approach maturity we may expect a greater edge effect and less production loss than the 1.4 percent estimated in this study.

This study was based on western white pine stands, but this close agreement with the above noted studies indicates that a similar response could be expected with other species. In fact, those species with a greater crown expansion potential than western white pine should utilize road openings more fully.

### CONCLUSIONS

On soils comparable to those studied (relatively stable with good drainage characteristics) near maximum production can be maintained concurrently with continued maintenance of a permanent road system. To do so, it is necessary to keep roads reasonably narrow (less than 14 feet). Furthermore, trees must occupy the site up to the toe of the fill and near the top of the cut for maximum utilization of space.

The potential loss of timber-producing land is minor and can be reduced to practically zero if road widths are kept to the minimum actually needed. With large, modern equipment one of our perennial problems in road building is keeping width to the minimum needed for access and safety. The arguments for narrow roads (except for main roads) need to be reemphasized and enforced in current practices. Narrow roads are cheaper to build, less maintenance is required, they are more stable from a watershed protection standpoint, and they are less offensive from a recreational (esthetic) view, especially if the new stand is established to make maximum utilization of the space.

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