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RECOVERY OF FOREST SOILS FROM COMPACTION BY RUBBER-TIRED SKIDDERS

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Introduction

Mechanized thinning on 16-foot strips by full tree and tree length systems of a 90- to 100-year-old red pine stand on a sandy soil was conducted during the summer of 1969.[2/3/] Soil bulk density was significantly increased when measured immediately following skidding with rubber-tired skidders in both harvesting systems. A 5 percent increase in bulk density was determined for areas directly under the tracks of the skidders used in the tree length system.[4/] An 11 percent increase in bulk density was detected beneath the zones where the full trees were skidded by the full tree system.

This report is a follow up on initial results of this harvesting operation. It covers research designed to determine whether one year's regrowth of understory vegetation and the effects of soil freezing will rejuvenate these compacted soils to their original condition.

Methods

One hundred and sixty-eight bulk density samples were taken adjacent to points sampled in each harvesting system in 1969. Each randomly located sampling strip was broken into four areas designated as blocks 1, 2, 3, and 4 with block 1 representing the area most frequently traveled, while blocks 2, 3, and 4 were traveled with decreasing frequency.

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[2/]Acknowledgement - Cooperation was received from the U. S. Forest Service North Central Forest Experiment Station and Chippewa National Forest, who made a study area available and to the Wheeler Lumber Bridge and Supply Company, Cass Lake, Minnesota, who did the timber harvesting.

[3/]Zasada, Z. A. and J. W. Benzie. 1970. Mechanized Harvesting for Thinning Sawtimber Red Pine. Minn. Agr. Expt. Sta. Misc. Report 99, Forestry Series 9.

[4/]Mace, A. C. 1970. Soil Compaction Due to Tree Length and Full Tree Skidding with Rubber-Tired Skidders. Minn. Forestry Research Note No. 214.

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Two replications of bulk density were taken at depths of 0-2, 2-4, and 4-6 inches at seven points perpendicular to the thinned strip. Points A and G represented undisturbed areas (control), Points B and F were located on the tracks of the rubber-tired skidders, Points C and E were between the tracks of the skidders, while Point D represented the center of the strip where the trees or logs were skidded.

Bulk density was computed on an oven dry basis (110° C.) of a 134.9 cc undisturbed soil core.

Results and Discussion

Bulk density values for the 0-2 inch depth on both harvesting systems were significantly increased over control bulk densities after one overwintering period (Table 1). In contrast, the differences for the tree length system immediately after the harvesting operation were not significant (1969). In the tree-length system, bulk densities of control plots showed a reduction from those measured in 1969; whereas, reductions of bulk density were not detected for the full tree systems (Figures 1 and 2). A possible explanation for this unusual phenomenon may be increased growth of herbaceous vegetation on control plots which were located adjacent to the thinned strips. Residual slash on 40 percent of the strip thinned by the tree length system may reduce the competition for light and moisture of vegetation on the control plots. This may have increased root growth which would decrease bulk density. This effect did not occur on the full tree system due to an abundance of bracken fern which competes for light and moisture with vegetation on the control plots.

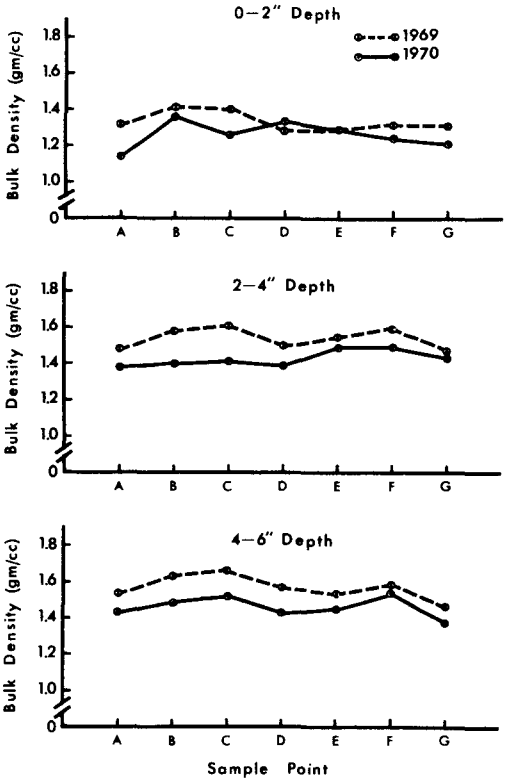

Figure 1. Bulk density values of the tree length system for 1969 and 1970 shown by depth and plot location. Each plotted point represents a mean of 16 measurements.

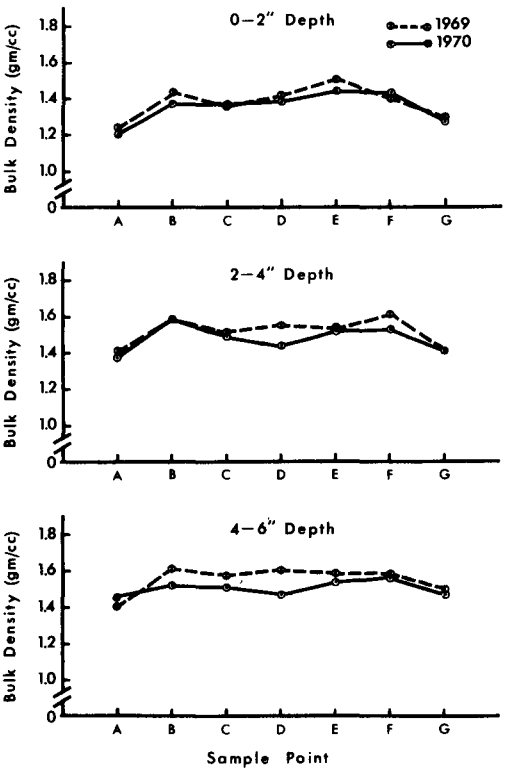

Figure 2. Bulk density values of the full tree system for 1969 and 1970 shown by depth and plot location. Each plotted point represents a mean of 16 measurements.

Table 1. Analysis of variance, treatment and block means of bulk density (gm/cc) by mechanical thinning (July 1970)

Depth	Treatment		Block		Treatment[1]							Block[2]			
(Inches)	d.f.	F	d.f.	F	A	B	C	D	E	F	G	1	2	3	4
Full Tree System															
0 - 2	6	4.05**	7	0.77	1.20	1.37	1.37	1.38	1.44	1.43	1.27	1.34	1.36	1.38	1.34
2 - 4	6	4.59**	7	1.16	1.37	1.58	1.49	1.44	1.52	1.53	1.41	1.52	1.43	1.49	1.47
4 - 6	6	1.54NS	7	2.06	1.46	1.52	1.51	1.47	1.54	1.56	1.47	1.53	1.45	1.54	1.52
Mean					1.34	1.49	1.46	1.43	1.50	1.51	1.38	1.46	1.41	1.47	1.44
Tree Length System															
0 - 2	6	2.78*	7	0.70	1.14	1.36	1.26	1.33	1.29	1.24	1.21	1.25	1.30	1.26	1.25
2 - 4	6	1.23NS	7	0.88	1.38	1.40	1.42	1.39	1.49	1.49	1.43	1.43	1.45	1.46	1.40
4 - 6	6	1.67NS	7	1.59	1.43	1.48	1.52	1.43	1.45	1.54	1.47	1.49	1.48	1.50	1.43
Mean					1.32	1.41	1.40	1.38	1.41	1.42	1.37	1.39	1.41	1.41	1.36

[1] Mean of eight samples

[2] Mean of fourteen samples

* Significant at 0.05 level

** Significant at 0.01 level

NS - Non-significant

Compaction of soils at the 0-2 inch depth was significant on both systems after one overwintering period. These results are unexpected, because alternate freezing and thawing and a greater degree of freezing should be greater at this depth which would reduce bulk density. In addition, approximately 12 inches of snow had accumulated by mid-November which prevented concrete soil frost. Soil frost present in mid-February was 4-6 inches in depth and of the granular type. However, because the fall of 1969 was extremely dry, there would be a reduction in the effect of soil freezing, particularly at the soil surface. This could explain a decrease in bulk density at the lower depths where moisture is greater and an absence of reductions at the drier soil surface.

Bulk density values taken during the second year at the 2-4 inch depth showed a non-significant difference in the tree length system and a significant difference in the full tree system. These data indicate recovery from soil compaction in the tree length system after one overwintering period; whereas, recovery in the full tree system occurs at a slower rate. One reason for a quicker recovery in the tree length system would be a greater degree and intensity of soil freezing as a result of increased soil moisture. Soil moisture content would be higher in this system due to residual slash retarding moisture evaporation and understory vegetation growth. A second reason could be related to the smaller amount of compaction in this system (5%) than in the full tree system (11%), since the degree of soil freezing may be greater in an uncompacted soil.

No significant differences in bulk density were detected at the 4-6 inch zone during the second measurement period although significant increases in bulk density followed the thinning operation. These results suggest that freezing and thawing is more prevalent at lower depths in sandy or dry soils, permitting a quicker recovery of compacted soils.

Conclusions

Recovery after one year of sandy soils compacted by a rubber-tired skidder in thinning in a 90- to 100-year-old red pine stand was shown to be greater at 2-4 and 4-6 inch zones in the tree length system than in the full tree system. Increased soil freezing, reduced growth of vegetation on this area, and a small degree of initial compaction were factors which contributed to these results. Measurements of bulk density will be continued for additional winter periods to further determine effects of soil freezing on soil compaction and the length of the recovery period.

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