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# HARVESTING IMPACTS ON SOIL PROPERTIES AND TREE REGENERATION IN PURE AND MIXED ASPEN STANDS

Melissa J. Arikian, Klaus J. Puettmann, Alaina L. Davis, George E. Host, and John C. Zasada[1]

ABSTRACT.—Impacts of clearcutting and selective harvesting on pure aspen/mixed aspen hardwood stands were examined in northern Minnesota. We studied these impacts on 18 stands, which were harvested 4 to 11 years ago and received no further treatment. In each stand, residual composition, soil compaction, and tree regeneration were determined along a gradient of disturbance in the summer of 1998. This preliminary assessment investigates interacting effects of soil compaction, residual overstory conditions, and timing of harvests. Compaction levels were much more variable in areas that were harvested in summer rather than in winter. Stands harvested in the winter were associated with higher regeneration stem densities and height growth than those harvested in the summer. Tree regeneration stem densities and height growth decreased with increasing soil compaction and increasing residual basal area. These results show the importance of understanding complex interactions between pre-harvest and post-harvest conditions, harvesting disturbance, and soil properties as they determine future stand composition and productivity.

Long-term sustainability of forest ecosystems demands consideration of ecologically sound principles when formulating management plans. Harvesting of aspen (*Populus* spp.) has increased in the Lake States due to its availability and high demand in the wood products industry. Aspen regenerates through root suckering and is thus especially sensitive to harvesting impacts on soil properties. Harvesting operations often decrease soil aeration and/or damage roots, thereby decreasing the growth potential of roots and aspen's ability to sucker. Recent trends in forest management include leaving reserve trees in clearcut areas. Aspen is known as a very shade intolerant species and achieves maximum stocking under open conditions. To maintain adequate aspen regeneration, management objectives must consider the amount of residual overstory on a stand.

## OBJECTIVES

Preliminary analyses of this study set out to investigate:

- Soil compaction levels in clearcuts harvested during winter and summer;
- Tree regeneration density and height growth patterns along a gradient of soil compaction;
- Regeneration density and height growth patterns along a gradient of residual overstory; and
- Interacting effects of soil compaction and residual overstory on aspen regeneration.

## METHODS

### Study Area and Site Selection

Our study sites encompassed pure aspen stands and stands in which aspen was mixed with northern hardwoods in six counties of northeastern Minnesota (fig. 1). These stands were clearcut or selectively harvested between 1988 and 1994. Eighteen study sites covered a gradient of harvest regimes, including summer and winter aspen clearcuts, aspen clearcuts with low hardwood residual basal area (3 $\pm$ 2.1m$^2$/ha), and aspen cuts with heavy hardwood residual basal area (12 $\pm$ 6.3 m$^2$/ha).

### Field Collection and Description of Data

Twenty-five regeneration plots were systematically placed along gradients of disturbance in each study site (fig. 1). Plots categorized as having "high" disturbance were located on landings or main skid trails, plots "intermediate" disturbance were located on secondary skid trails, and "low" disturbance plots were outside the skid trails. Each regeneration plot consisted of a 0.001-ha (2 x 5 m) plot, on which we measured tree regeneration density and height, and residual overstory basal area. We characterized disturbance in terms of soil compaction with a minimum of 10 samples for each plot using a soil cone penetrometer.

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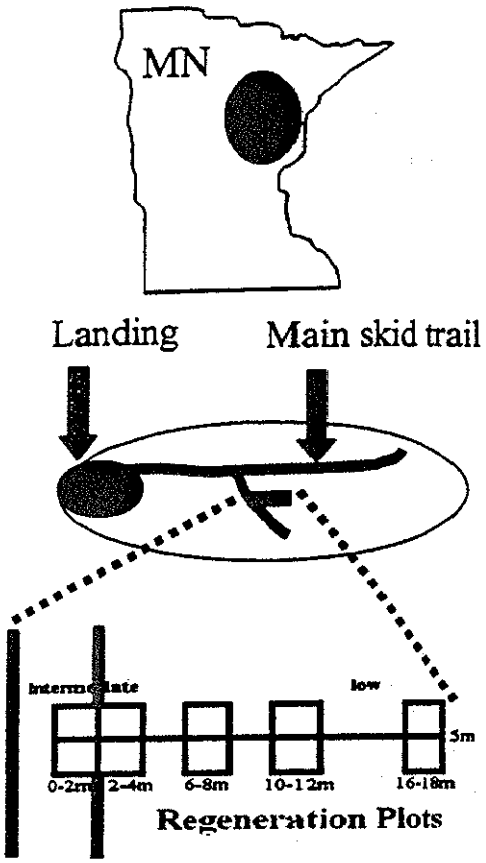


Figure 1.—*Study location and field collection methods.*

## RESULTS AND DISCUSSION

### Compaction Levels and Timing of Harvest

Soil compaction is a highly variable measurement in itself, highly correlated to the soil moisture content and soil particle size distribution of a given area. For these reasons and other site factors not investigated in this analysis, our preliminary results can only begin to explain disturbance patterns in terms of soil compaction. Regeneration plots we classified as "high" and "intermediate" disturbance have similar values of soil compaction (fig. 2). This supports other studies that indicated that the initial passes of harvesting machinery create most of the disturbance. The higher variation in compaction in summer aspen clearcuts may occur because summer harvesting operations take place under a range of soil moisture conditions. We did not see a lower mean compaction level in winter versus summer harvests. One reason for this might be the different soil properties in areas where operationability is limited to winter months. Another possibility is that operations labeled as "winter harvests" did not necessarily occur only during frozen conditions.

### Compaction Levels Versus Regeneration Density and Height Growth

Tree regeneration density (fig. 3a) and height growth (fig. 3b) after winter harvests were greater than in areas harvested during summer. These patterns support the notions that aspen sucker more vigorously when cut with higher carbohydrate reserves belowground. In both summer- and winter-harvested areas, regeneration density and height trends are negatively associated with soil compaction. Decreased soil aeration and/or root damage inhibit root growth and productivity, limiting the level of resources available for tree growth.

### Residual Basal Area Versus Regeneration Density and Height Growth

Aspen regeneration density (fig. 4a) and height growth (fig. 4b) were reduced in areas with more residual overstory. Areas we defined as "high," "intermediate,"

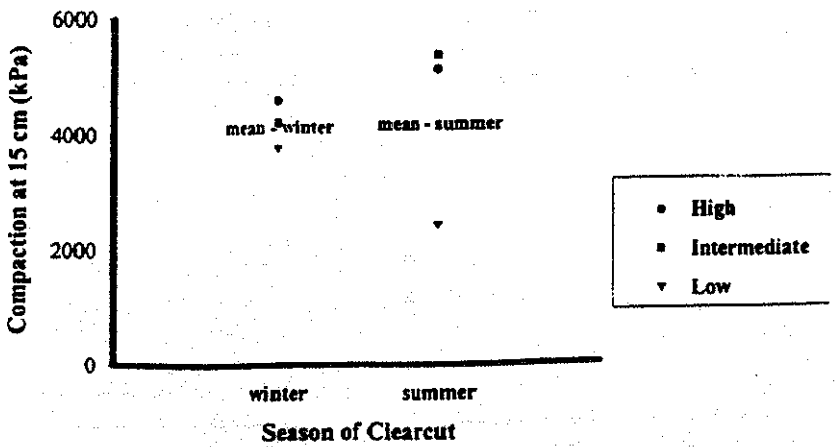


Figure 2.—*Compaction levels in summer versus winter aspen clearcuts.*

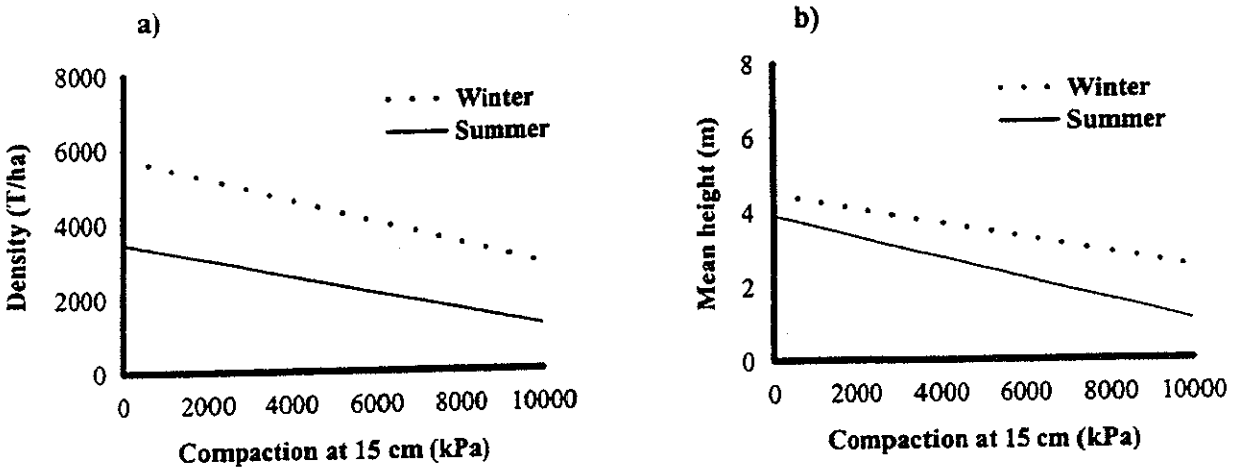


Figure 3.—*Compaction versus a) density and b) mean height of regeneration (trees greater than 2.54 cm dbh).*

and "low" disturbance, i.e., different compaction levels, also separated out along this gradient. Aspen regeneration seems to be affected by the interactions between the amount of residual overstory on a site, and the corresponding levels of soil compaction. Thus, the practice to leave more residuals after a harvesting operation will impact future aspen growth and productivity. Also, avoiding soil disturbances is even more critical in areas with heavy overstory residuals.

## CONCLUSIONS AND MANAGEMENT OBJECTIVES

Managing aspen stands for future productivity requires the integration of ecological factors as well as economic and other influences. Minimizing site disturbances, and therefore minimizing soil compaction, can be brought about in several ways. Harvest operations should take place when soils are frozen, and summer harvests should be done when soil moisture is at a minimum. Regardless of the timing, harvest operations should minimize landings and skid trails because they make up most of a site's disturbance impact. Aspen suckering can be maximized when sites are harvested in the winter. This maximizes root carbohydrate storage, and inhibits apical dominance when the soil and roots are warmed from solar insolation. Heavy overstory residuals will reduce aspen regeneration, and harvesting impacts on soils are more detrimental under these conditions. Understanding the interacting effects of harvest operations on soil compaction and residual basal area, along with a site's pre-harvest conditions, can lend valuable insight to land managers trying to maximize aspen regeneration and predict the future productivity of a stand.

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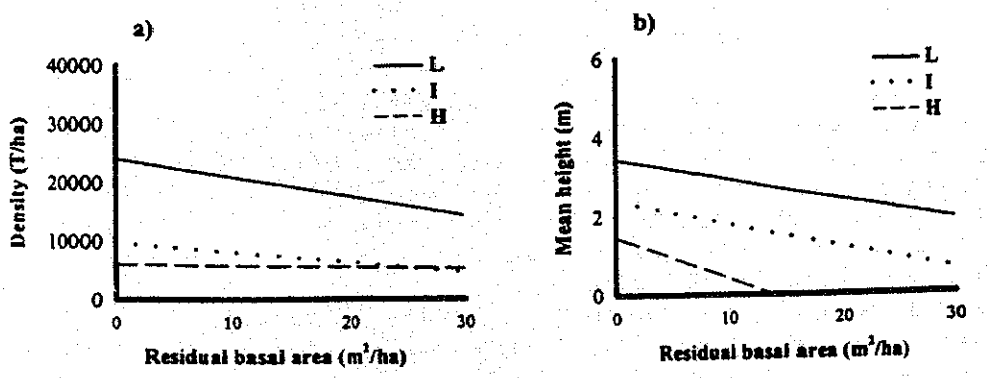


Figure 4.—*Residual basal area versus a) density and b) mean height of regeneration (trees taller than 1 meter).*