THE EFFECTS OF ALTERNATIVE DIAMETER-LIMIT CUTTING TREATMENTS: SOME FINDINGS FROM A LONG-TERM NORTHERN CONIFER EXPERIMENT

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Abstract

Partial harvests in which only large and valuable trees are removed have long been common in the United States and Canada. These types of cuttings often have degrading effects on residual stand condition, though there is little data on the topic. Fortunately, modified and fixed diameter-limit and commercial clearcutting, as well as the uneven-aged silvicultural system of selection, have been applied by the USDA Forest Service on the Penobscot Experimental Forest in Maine for over 50 years. Results suggest that the degree of degradation, and thus potential for future management, are affected by both the removal criteria and the number of previous harvests. Treatment differences were not great following a single harvest. However, repeated applications of fixed diameter-limit and commercial clearcutting resulted in residual stands that were similar to one another in some aspects of structure and composition, and distinct from selection and modified diameter-limit cut stands.

Introduction

High-grading is a common practice in which the most valuable trees are removed from a forest stand. This is often applied as diameter-limit cutting. This practice involves the use of a specific size threshold, or diameter limit, above which all merchantable trees are cut and below which no trees are harvested. Though this approach is easy to apply and often maximizes current volume and value production, inattention to residual stand condition can result in degradation (Kenefic et al. in press, Nyland in press). An alternative has been suggested in which high-risk trees below the diameter limits are cut, capturing mortality and upgrading quality in the lower size classes. This is called modified or flexible diameter-limit cutting (see Miller and Smith 1993).

Another common type of exploitative harvest is commercial clearcutting. This should not be confused with silvicultural clearcutting. The latter is an even-aged regeneration method in which all trees are removed in order to regenerate from seed, stump sprouts, or root suckers. Commercial clearcutting is simply the harvest of all merchantable trees from a stand. Alternatively, this may be viewed as a diameter-limit removal in which the size threshold for removals is the lowest limit of merchantability. This type of harvest thus differs from diameter-limit cutting as described above in terms of the volume, but not quality, of trees removed.

Though there is a great deal of anecdotal evidence regarding the effects of these practices, few long-term field studies have been conducted. Recently completed papers by Kenefic et al. (in press) and Nyland (in press) establish the effects of fixed diameter-limit cutting relative to the selection system over multiple cutting cycles. However, little is known about the different types and intensities of diameter-limit removals, and the effects that these have on residual stand conditions. The objective of this study was to assess the effects of selection and diameter-limit cutting alternatives over multiple harvests in northern conifers.

Study Area

The stands sampled in this study are part of a long-term silvicultural experiment on the 4000-acre Penobscot Experimental Forest in east-central Maine. The most common species on the forest are eastern hemlock (*Tsuga canadensis* (L.) Carr.), balsam fir (*Abies balsamea* (L.) Mill.) and spruce (*Picea* species). Research began in 1950 when the USDA Forest Service initiated an experiment to study even- and uneven-aged silvicultural systems and exploitative cutting. Treatments and remeasurements have continued to the present and follow a long-term study plan. The eight stands

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used for the research reported here are two replicates each of selection (SC), modified diameter-limit (MDL), fixed diameter-limit (FDL) and commercial clearcutting (CC). Average stand size for these treatments is 27.2 acres, with a range of 17.7 to 43.2 acres.

Treatments

The SC treatment utilized a BD*q* structural goal with a *q*-factor of 1.4 on 1-in. diameter at breast height (dbh) classes, residual maximum diameter of 16 in. dbh, and residual basal area (BA for trees ≥ 0.5 in. dbh) of 80 ft^2/acre. Treatments were applied in years 0, 20, and 40 of the experiment. Marking guidelines were used to prioritize removals in order to improve stand quality and growth. Species composition goals, expressed as a percentage of stand BA, resulted in efforts to increase the proportion of spruce and decrease balsam fir and eastern hemlock.

The MDL treatment was applied at years 0, 20, and 40 of the experiment. All merchantable trees above species-specific diameter limits were removed at each entry, unless desired for seed or wind protection. Trees below the diameter limits were harvested as needed to capture future mortality. The size thresholds used for removals in the first entry were 10.5 in. dbh for eastern white pine (*Pinus strobus* L.), 9.5 in. for spruce species and eastern hemlock, and 7.5 in. for paper birch (*Betula papyrifera* Marsh.). All merchantable trees of other species were removed. The volume removed in subsequent harvests was limited to net periodic growth, and diameter limits were raised prior to the second and third harvests (see Sendak et al. 2003). The minimum merchantability threshold was lowered in this and other treatments from 6.5 in. dbh in year 0, to 5.5 in. in year 20, and 4.5 in. in year 40.

The FDL treatment was applied three times, at years 0, 20, and 40 – 45 of the experiment (there was a 5-year time lag between replicate treatments for the third cut). All merchantable trees above species-specific diameter limits were removed. Size thresholds for removal were 11 in. dbh for eastern white pine, 9 in. for spruce and eastern hemlock, and 8 in. for paper birch and northern white-cedar (*Thuja occidentalis* L.). All merchantable trees of other species were removed. Over the course of the experiment the diameter limits varied ±1.0 in. from the above diameters. The study plan specifies that the treatment be applied when the volume available for harvest equaled that removed in the initial entry.

The CC treatment was applied twice, at years 0 and 30 of the experiment. All merchantable trees were removed and the stand was re-entered when initial harvest volume had regrown.

Methods

Nested 1/5- and 1/20-acre plots were established in each stand on a systematic grid with a random start in year 0 of the experiment. Overstory data were collected on these permanent fixed-radius plots before and after every harvest and at about 5-year intervals between harvests. Trees ≥ 0.5 in. dbh were numbered and species, dbh, and condition (merchantability) were recorded on the 1/20-acre plots. On the 1/5-acre plots, the same data were recorded for trees ≥ 4.5 in dbh. These plots provide an approximately 15% sample of each treatment. Between-treatment comparisons of overstory data were made in years 0 and 40 using analysis of variance (degrees of freedom (df); model=3, error=4) and Bonferroni pairwise comparsions ($\alpha = 0.10$). The analysis reported here included five variables: volume, percent cull, percent spruce species, and volumes of harvest and mortality.

Findings

Application of the partial cutting treatments described above differentially affected stand structure and composition (Table 1). Pre-treatment comparisons of volume, percent cull, and percent spruce species revealed no significant differences. Residual stocking and quality (expressed as percent cull) were not differentiated by treatment after the first harvest. Though there were no treatment differences in mortality or harvested volume over the measurement period (which included three cuts each in MDL, FDL and SC, and two cuts in CC), volume at the end of the period was higher in the MDL and SC than CC and FDL. Differentiation of the treatments into these two groups is supported by the species data, which showed significantly more spruce in the MDL and SC than CC and FDL. Stand quality expressed as percent cull was only different between the SC and FDL treatments.

Table 1.—Treatment comparisons before and after the first harvest and in year 40[1] of the experiment.[2]

	Table 1a. *Total volume (ft^3/ac).*			Table 1b. *Percent cull volume.*		
	Year 0 (pre)	Year 0 (post)	Year 40	Year 0 (pre)	Year 0 (post)	Year 40
SC	2163	1604	1255 a	6.3	6.8	1.2 b
MDL	2040	1434	1455 a	7.9	7.9	11.8 ab
FDL	2095	1091	464 b	7.3	11.1	26.2 a
CC	1881	821	229 b	9.2	14.3	16.7 ab
SE	156	203	93	0.9	2.2	4.4

	Table 1c. *Percent spruce BA.*			Table 1d. *Volume removals.*	
	Year 0 (pre)	Year 0 (post)	Year 40	Harvest (ft^3/ac)	Mortality (ft^3/ac/yr)
SC	14.9	17.9 a	30.0 a	2518	14.9
MDL	19.6	22.8 a	28.5 a	2434	14.1
FDL	21.4	19.8 a	15.0 b	3527	11.6
CC	15.3[3]	7.1 b	5.6 b	2775	14.1
SE	2.3	1.9	2.1	260	3.1

[1]Data are post-cut for SC, MDL, and FDL, and 10 years post-cut for CC. Year 45 data were used for one FDL replicate, due to delayed treatment application.
[2]Means followed by the same letter within a column or in columns without letters are not significantly different (α = 0.10, model df = 3, error df = 4). SE = standard error.
[3]Calculated for trees ≥ 4.5 in. dbh due to missing sapling data.

Conclusion

Though more complete analysis is needed to fully understand the effects of these treatments, the data reported here suggest some important findings. Structural effects of the diameter-limit treatments were not distinguishable from SC after a single entry. Yet, multiple entries resulted in quantifiable differences, with less volume and a lower proportion of spruce in FDL and CC stands. Stands repeatedly cut with FDL were also differentiated from SC stands by stand quality (expressed as percent cull). Modified diameter-limit cut stands were similar in structure, composition, and quality to SC stands, even after repeated entries. These findings suggest important differences in the diameter-limit cutting variants, and will be of use to managers and landowners who are faced with decisions about partial cutting alternatives.

Literature Cited

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