FIELD NOTE

Accuracy of Regeneration Surveys in New England Northern Hardwoods

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ABSTRACT

Four 5-ac demonstration harvests were initiated in 1951 on the Bartlett Experimental Forest, New Hampshire: light selection, moderate selection, diameter limit, and liquidation. In 1952 and 1959, regeneration surveys were conducted that measured several different attributes of the seedlings and saplings in the cutover stands. In 2005, the stands were remeasured to determine the relationships of the various regeneration measures to current species composition of the pole-timber portion of the stands. Although predictions were somewhat variable and imperfect, the best measures for shade-tolerant species were those that took account of the sapling layer, and measures based on the dominant stem per small plot were best for less-tolerant species. Combining both attributes, these results suggest that the best approach would be a small-plot survey (milacre or slightly larger) that simply records the dominant stem per plot including stems up through the sapling size classes (less than 4.5-in. dbh). This could be taken before harvest, to predict the effects of a light partial cut, or 5–7 years after harvest, to predict future species composition after any harvest intensity.

Keywords: regeneration, northern hardwoods, regeneration surveys, species composition

There are two basic purposes of regeneration surveys. One is to estimate the future species composition of the stand based on the seedlings/saplings present after a harvest operation. This provides some indication of the success of the harvest or the possible need for additional silvicultural effort. The second purpose is to assess regeneration potentials before the harvest to help in planning the type and timing of the proposed harvest. In the northern hardwood type of New England, most of the regeneration after light to moderate partial cuts comes from the advance regeneration. After heavier harvests—clearcuts, low-density shelterwoods, and group/patch cuts—a high proportion of intolerant or intermediate regeneration develops after the cut. If a preharvest regeneration survey showed an undesirable species mix in the advance regeneration, the best strategy might be to use a heavier cut rather than a light partial harvest.

Because these surveys can be time-consuming and expensive, they are not widely used. However, because of many concerns over the future species composition of Northeastern forests (e.g., Alderman et al. 2005) and the requirements of green certification, some additional effort seems warranted to implement feasible and accurate regeneration surveys.

Accurate and detailed regeneration protocols have been developed for Allegheny hardwoods (Marquis 1994) and for the assessment of beech (*Fagus grandifolia*) understory development (Bohn and Nyland 2003). However, there has been a lack of long-term data for northern hardwood stands in New England on the relationships of regeneration characteristics to future stand composition. An opportunity to develop such information was provided by a series of demonstration harvests conducted on the Bartlett Experiment Forest, New Hampshire.

Methods

Four demonstration harvests were conducted during 1951 in stands of about 5 ac in size: light selection, moderate selection, diameter limit, and liquidation (Blum and Filip 1963). The light selection consisted of removal by cutting or girdling of defective and overmature trees throughout all size classes, leaving a residual basal area of about 95 ft^2/ac (Table 1); a second cut was made in 1959. The moderate selection was similar (with less girdling), leaving a residual basal area of a little over 80 ft^2; a second cut was made in 1964. The diameter-limit harvest removed trees over 14.5 in. dbh, leaving a residual basal area of a little over 60 ft^2. The liquidation harvest removed all merchantable trees, leaving 38 ft^2 of mostly cull trees.

In 1952 and 1959 (after the light selection harvest), regeneration surveys that included several different attributes, were conducted in all four stands. To assess the predictive ability of these surveys, the four stands were remeasured in the summer of 2005 using 20-factor prism plots, 41 plots in the liquidation stand and 17–20 plots in the other three stands—this was about the maximum number without substantial overlap. Trees were classed as acceptable growing stock (AGS) and unacceptable growing stock (UGS). The minimum requirement for hardwood AGS was two clear (or potentially clear) 12-ft faces in the first log, and minimum requirement for softwoods was no evidence of rot or shake and branches less than about ⅓ scaling diameter. Because the species composition of the stands had changed appreciably over the years (Table 2) and because we had an abundance of earlier regeneration data, this seemed like an excellent opportunity to develop and assess regeneration survey specifications.

The regeneration measures available from the 1952 and 1959 surveys provided estimates of percent composition based on:

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Table 1. Basal areas per acre (sq. ft., >4.5 in. dbh) before and after the first harvest, and basal area and percent AGS in 2005.

Time	Light selection	Moderate selection	Diameter limit	Liquidation
Before (1951)	128	124	118	122
After (1952)	95	83	64	38
2005	167	180	185	157
AGS 2005 (%)	73	72	80	74

Table 2. Percent basal area (>4.5 in. dbh) by species in initial (1951) and final (2005) stands by harvest method.

Method	Time	Be	Yb	Sm	Rm	Pb	Wa	Rs	Eh	Other
Light selection	Initial	42	16	8	12	4	4	1	13	—
	Final	29	13	11	9	2	2	2	32	—
Moderate selection	Initial	49	16	6	16	2	2	1	8	—
	Final	37	8	10	17	1	1	1	25	—
Diameter limit	Initial	52	15	3	5	2	1	3	19	—
	Final	24	7	2	7	—	2	3	55	—
Liquidation	Initial	32	22	13	12	1	6	2	12	—
	Final	24	8	9	8	4	16	1	28	2

Be, beech; Eh, eastern hemlock; Pb, paper birch; Rm, red maple; Rs, red spruce; Sm, sugar maple; Wa, white ash; Yb, yellow birch.

Table 3. Liquidation harvest: Measures of regeneration stocking (%) compared with percent basal area (>4.5 in. dbh) by species in poletimber (trees < 10.5 in. dbh) in 2005.

Measure	Be	Yb	Sm	Rm	Pb	Wa	Rs	Eh	O
Dominant stem 3 ft–0.5 in. (1952)	46	1	21	4	—	5	4	5	14
No. saps 1–4 in. (1952)	39	2	4	1	—	—	11	39	4
Dominant stem 3 ft–1.5 in. (1959)	21	13	12	6	3	11	2	8	24
Commercial seedlings 1.0+ ft (1959)	28	14	32	5	2	14	2	3	—
No. saps 2–4 in. (1959)	29	6	6	5	3	5	2	31	13
Poletimber 2005	21	13	7	5	4	18	2	27	3

Be, beech; Eh, eastern hemlock; Pb, paper birch; Rm, red maple; Rs, red spruce; Sm, sugar maple; Wa, white ash; Yb, yellow birch.

1. 1952. The dominant stem (all woody species) per 0.0025-ac plot between 3 ft tall and 0.5 in. dbh (only plots tallied under more than 0.01-ac canopy openings).
2. 1952. Numbers of saplings in the 1- through 4-in. classes on 1/100-ac plots.
3. 1959. The dominant stem (all woody species) per milacre plot between 3 ft tall and 1.5 in. dbh.
4. 1959. Milacre counts of stem numbers (commercial species) between 1 ft tall and 1.5 in. dbh.
5. 1959. Numbers of saplings (all species) in the 2-, 3-, and 4-in. dbh classes on milacre plots.

In 1952, 1,046 small plots (0.0025 ac) were measured, averaging 40% stocked with a woody species and 139 1/100-ac plots. In 1959, 1,549 milacres (1/1,000-ac) were measured; about 70–90% were stocked with a dominant woody stem of any species.

To assess the influence of these measures over the ensuing 46- to 53-year period, the percent composition of the poletimber (4.5–10.5 in. dbh) in 2005 was deemed the best measure. During this time period, much of the successful regeneration after the liquidation harvest would be in the pole-timber size classes, although a few stems would have attained sawtimber size. After the lighter harvests, it is likely that some of the initial poletimber still might be of pole-timber size after 46–53 years.

Results

All stands increased substantially in basal area over the 50+-year period (Table 1), and all contained over 70% AGS. The high basal areas in 2005 are caused by the increase in softwoods, especially hemlock (*Tsuga canadensis*; Table 2). The site conditions differed somewhat among stands; therefore, direct comparisons among harvest methods are not warranted.

The relationships between the five regeneration measures and the percent poletimber in 2005 varied appreciably in the liquidation stand (Table 3). The liquidation harvest probably provides the best comparisons because of the species variety and the more intensive cruise in 2005. Note first that the high percentage of hemlock poletimber was predicted only by the sapling counts (1952 and 1959). Generally, stocking was quite low in the 1952 survey, so the 1959 numbers probably are more reliable. The percentage of beech declined in all harvest areas (Table 2) and this was well predicted in the liquidation stand by the 1959 sapling numbers as well as by several other regeneration measures (Table 3). Sugar maple (*Acer saccharum*) was well anticipated by the 1959 sapling numbers. Note that seedling numbers greatly overpredicted the sugar maple component in 2005 because of the propensity for sugar maple to develop an understory of small seedlings that frequently do not develop into larger stems unless released. Yellow birch (*Betula alleghaniensis*) and white ash (*Fraxinus americana*) were two species that were poorly anticipated by percentages based on sapling numbers. For both species, the best measures were the 1959 dominant stem and the 1959 percent commercial seedlings; the latter was a measure that worked poorly for sugar maple and required excessive field time. Possibly, yellow birch and white ash occurred as the dominant stem on plots where there were no overtopping saplings.

Looking at the other three harvest methods and three of the more promising regeneration attributes (Table 4), percentages based on sapling numbers worked moderately to very well in predicting hemlock and beech pole-timber composition, and 1959 sapling percentages correlated closely with sugar maple pole-timber percentages in

Table 4. Regeneration percentages based on sapling numbers in 1952 and 1959 and 1959 dominant stems compared with pole-timber species composition (percent basal area <10.5 in. dbh) in 2005 by harvest method.

Harvest method	Regeneration measure	Be	Yb	Sm	Rm	Pb	Wa	Rs	Eh	O
Light selection	Saps 1952	34	5	6	1	—	1	7	40	6
	Saps 1959	22	1	11	1	—	—	6	57	2
	Dominant stem 1959	38	2	8	—	—	3	7	23	19
	Poles 2005	37	13	10	5	—	—	3	32	—
Moderate selection	Saps 1952	40	4	6	1	—	1	9	33	6
	Saps 1959	36	2	4	2	—	—	7	43	6
	Dominant stem 1959	42	8	15	1	1	4	2	10	17
	Poles 2005	36	—	9	—	3	—	—	52	—
Diameter limit	Saps 1952	17	2	—	1	—	—	10	69	1
	Saps 1959	22	2	4	—	—	1	7	58	6
	Dominant stem 1959	30	8	6	2	3	—	9	26	16
	Poles 2005	21	11	—	5	—	—	—	63	—

Be, beech; Eh, eastern hemlock; Pb, paper birch; Rm, red maple; Rs, red spruce; Sm, sugar maple; Wa, white ash; Yb, yellow birch.

the light selection stand. The pole-timber component of yellow birch in the light selection area was underestimated by sapling percentages and dominant stem percentages; however, this probably was caused by the presence of slow-growing yellow birch poles established before the 1950s. Neither the light nor the moderate selection would produce many successful yellow birch stems over time. Under the diameter limit, yellow birch was best estimated by percentages based on 1959 dominant stems—a result similar to that in the liquidation stand.

In summary, percentages based on sapling numbers generally provided the best forecasts for shade-tolerant species: hemlock, beech, and sugar maple. Percentages based on stocking of the dominant seedling provided the best future estimates for less-tolerant species: yellow birch and white ash. Probably, these less-tolerant species became established or developed after the harvests, probably in areas where there were no overtopping saplings.

Management Implications

Regeneration surveys provide variable results because there are many unforeseen circumstances affecting establishment, survival, and growth. It is important to document regeneration success to the extent possible, but the methods should be as efficient as possible. This study indicated that percentages based on sapling numbers were effective for predicting future pole-timber composition of certain tolerant species, and the dominant stem per small plot was useful for other species, notably white ash and yellow birch. Hindsight would suggest that there are many other likely measures, quite possibly more effective than the ones examined in this study. However, these preliminary findings indicate that one very feasible approach would be to tally the species of the dominant (tallest) stem per plot, making sure to include stems up through the sapling size classes (less than 4.5 in.). This approach would appear to capture the useful attributes found in this study. It appears reasonable that this approach could be used as both a preharvest or a postharvest survey method. The preharvest survey would indicated whether the existing understory, mostly tolerant saplings, would provide a future stand of acceptable species under a light to moderate partial harvest. The postharvest survey, probably taken 5–7 years after cutting, would be most useful after a heavier cut and would indicate whether the existing crop of tolerant and less tolerant seedlings/saplings would develop into an acceptable stand.

This study used milacre (1/1,000 ac) plots and 0.0025-ac plots (as well as 1/100-ac plots for the 1952 sapling tally). Other suggestions are to use plots with radii of 6 ft (Marquis 1994) or 4.45 ft (Leak et al. 1987); these plot sizes approximate the area required by one small pole-sized tree. Using circular plots with these small radii and a measuring stick, it becomes very efficient to tally the dominant stem.

The effects of overtopping weed species needs careful consideration. In the area of the Bartlett Experimental Forest, dominant pin cherry has been shown to have fairly minor effects on commercial species under open canopy conditions. In other words, tally the dominant commercial species even when the plot has a taller pin cherry present. Dense stands of pin cherry have been shown to have limiting effects in other regions (Heitzman and Nyland 1994, Ristau and Horsley 1999). Dominant striped maple and hobblebush have a greater suppressing influence and it is less likely that a commercial stem, especially a shade-intolerant or intermediate species, will survive when severely overtopped by these species (Leak 1988). Similarly, all available local experience regarding relative species growth rates should be applied in conducting a regeneration survey. For example, a red oak or yellow birch under a minimal canopy after a heavy harvest will easily outdistance a beech stem of similar size.

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