Can Postharvest Regeneration in Group Selection and Patch Cutting Predict Future Species Composition?

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Abstract.—In Quebec, Canada, multicohort forest management in hardwood and mixedwood stands include group selection cutting and patch cutting. We assessed the success of these cuts in regenerating the intermediate shade tolerant yellow birch (*Betula alleghaniensis* Britt.; YB) at an operational scale and over a large territory using surveys conducted at 2, 5, 10, and 15 years after harvest. Regeneration of the target species was successful, with YB showing a mean stocking around 60 percent and a mean sapling density around 3,400 stems ha^{-1} after 15 years. The relative presence of YB in 15-year-old canopy openings—a proxy for future species composition—was best predicted by that species' relative abundance, stocking based on one stem per sampling unit, and mean maximum height measured in year five (rather than year two) using smaller sampling units (6.25 m^2 rather than 25 m^2). See Bilodeau-Gauthier et al. (2020) for further details.

INTRODUCTION

In hardwood and mixedwood stands, multicohort forest management (Hupperts et al. 2018) may be the best way to successfully regenerate tree species of intermediate shade tolerance (Raymond et al. 2018), such as yellow birch (*Betula alleghaniensis* Britt.; YB). The creation of large gaps in the canopy increases light availability (Webster and Lorimer 2002), while soil scarification provides suitable germination seedbeds (Elie et al. 2009). Evidence of the success of these methods nonetheless remains mostly the purview of experimental studies rather than operational tests (Gauthier et al. 2016).

METHODS

The present study tested two multicohort methods, group selection cutting and patch cutting, implemented in Quebec, Canada during 2000–2005 at an operational scale and over a large territory in hardwood-dominated and mixedwood stands (39 groups and 32 patches). Groups covered areas of 500 to 1,500 m^2 (12 to 22 m radius) while patches spanned 1 to 2 ha.

Tree species composing the forest stands prior to harvest were mainly sugar maple (*Acer saccharum* Marsh.) and YB for hardwood stands, or balsam fir (*Abies balsamea* [L.] Mill.), YB, northern white cedar (*Thuja occidentalis* L.), and spruces (*Picea glauca* [Moench] Voss. or *P. rubens* Sarg.) for mixedwood stands. Main companion species were American beech (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), paper birch (*Betula papyrifera* Marsh.), trembling aspen (*Populus tremuloides* Michx.), American larch (*Larix laricina* [Du Roi] K. Koch), and eastern hemlock (*Tsuga canadensis* [L.] Carr.). The most common competing trees and shrubs (hereafter "noncommercial species") encountered in the regeneration surveys included pin cherry (*Prunus pensylvanica* L.), striped maple (*Acer pensylvanicum* L.), mountain maple (*Acer spicatum* Lam.), beaked hazel (*Corylus cornuta* Marsh.), bush honeysuckle (*Diervilla lonicera* Mill.), hobblebush (*Viburnum lantanoides* Michx.), red elderberry (*Sambucus pubens* Michx.), wild raspberry (*Rubus idaeus* L.), and willow (*Salix* spp.).

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We assessed the efficacy of these cuts in promoting natural regeneration of commercial hardwood trees, notably YB. Regeneration surveys were conducted at 2, 5, 10, and 15 years after harvest to tally seedlings (≥ 1 m in height) and saplings (diameter at breast height [d.b.h.] > 1 cm and ≤ 9 cm) of all woody species. Our aim was to test whether the early postharvest surveys could predict the future species composition.

To identify the best predictors, and when and how they should be measured, we compared several explanatory variables assessed in year two or year five after harvest, and in two different sizes of sampling units (2.5 × 2.5 m [6.25 m^2] or 5 × 5 m [25 m^2]). At the time of analysis, some sites had not yet reached 15 years of post-harvest age, thus $n = 49$ (i.e., 28 groups, 21 patches). Various statistical analyses were conducted on the data (Bilodeau-Gauthier et al. 2020), but this text focuses on the linear regressions and uses only the relative abundance (i.e., stem density of a given species relative to the total density of all woody species, including noncommercial ones) of YB in year 15 as the response variable.

RESULTS AND DISCUSSION

Regeneration Success

Our study showed that multicohort forest management that creates large or very large gaps in the canopy (group selection and patch cutting, respectively) can be generally successful in regenerating YB and other commercial tree species. All but one of the 49 sites met the threshold of 1,500 saplings ha^{-1}. All commercial species combined (Fig. 1) met the recommended density required for producing a merchantable stand (Leak et al. 1987).

YB showed a mean stocking around 60 percent and a mean sapling density of approximately 3,400 stems ha^{-1} after 15 years. YB densities (i.e., seedlings and saplings) that were above 1,500 stems ha^{-1} were found in 42 out of 49 sites. Densities of YB saplings were often satisfactory as well: 31 sites out of 49 had densities above 1,500 YB saplings ha^{-1}.

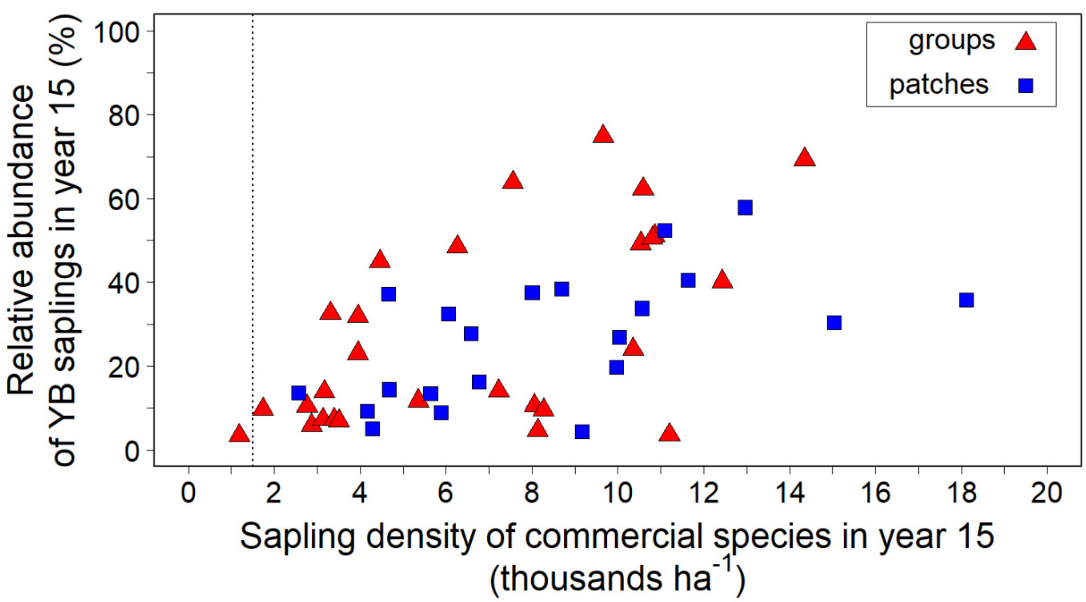

Figure 1.—Relative abundance of YB saplings (calculated in relation to the total sapling density of all woody species, commercial and noncommercial) compared to the absolute sapling density of commercial species 15 years after harvest by group selection or patch cutting. The vertical-dashed line represents the theoretical threshold of 1,500 saplings ha^{-1} required for producing a merchantable stand (Leak et al. 1987).

Table 1.—Simple linear regressions of the relative abundance of YB in year 15 (response) with one of three different regeneration indices (explanatory) measured in year two or year five. All variables were assessed in 6.25 m^2 and 25 m^2 sampling units. Data were site means (n = 49). Maximum height is in cm. Relative abundance and stocking are on a scale of 0 to 100. SE: standard error

Explanatory variable	Model coefficients	Size of sampling units and year of the survey			
		6.25 m^2		25 m^2	
		Year 2	Year 5	Year 2	Year 5
Maximum height	Estimate	0.546	0.268	0.400	0.216
	SE	0.06	0.024	0.059	0.025
	t-value	9.03	11.1	6.75	8.54
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
	Adjusted R^2	0.63	0.72	0.48	0.60
Relative abundance	Estimate	1.54	0.973	1.18	0.982
	SE	1.4	0.06	1.1	0.066
	t-value	1.09	16.1	1.12	15
	P-value	0.28	<0.0001	0.27	<0.0001
	Adjusted R^2	0.0037	0.84	0.0054	0.82
Stocking (1 stem)	Estimate	0.605	0.651	0.875	0.864
	SE	0.098	0.079	0.21	0.16
	t-value	6.2	8.21	4.26	5.24
	P-value	<0.0001	<0.0001	< 0.0001	<0.0001
	Adjusted R^2	0.44	0.58	0.26	0.36

The relative abundance of YB in year 15 was almost never above 70 percent and was below 25 percent in about half the sites (Fig. 1). The spatial distribution of the desired regeneration was not always homogeneous within openings, as revealed by some low coefficients of distribution. Moreover, at some sites, noncommercial woody species still represented a nonnegligible proportion of the total sapling density in year 15 (mean = 35 percent, standard deviation = 18 percent). Consequently, a cleaning treatment meant to eliminate trees of species that are not primary targets, undertaken not past the sapling stage, might be required in the future to increase the YB proportion.

Predicting Species Composition

The linear regressions revealed that the relative abundance of YB in year 15 was best predicted by the mean maximum height, the relative abundance, and stocking based on one stem per sampling unit (Table 1). Using the year-five indices resulted in a greater number of significant relationships than with the year-two indices. Where the relationships were significant using either year, those with the year-five indices always yielded stronger coefficients of determination (R^2). The relationships were also stronger with indices computed in smaller sampling units (6.25 m^2) than in larger ones (25 m^2), though in both cases the values were averaged per site.

CONCLUSIONS

Densities of commercial stems at least 1 m in height were generally satisfied according to Leak et al. (1987) stocking recommendations for commercial northern hardwood stands. Even considering YB alone, a majority of sites would have been deemed well stocked. However, the relative abundance of YB was not very high. A cleaning treatment might be considered in order to increase the relative presence of YB.

Future species composition, as represented by the relative abundance of YB within canopy openings in year 15 after harvest, was best predicted by the following regeneration indices measured in year 5 using the smaller, 6.25 m^2 sampling units: the mean maximum height, the relative abundance, and the stocking based on one stem per sampling unit.

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