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Effects of Harvest Intensity and Site Quality on Sapling Recruitment and Dynamics in Hardwoods Stands

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Technical Note

Silviculture

Introduction

In recent decades, management objectives of northern hardwood forests in New Brunswick have shifted from clearcutting and diameter-limit cutting to partial cutting. To meet long-term wood production under a partial cutting system, adequate regeneration recruitment of desired species is critical. The use of partial cutting to recruit and maintain desired species mix in uneven-aged hardwood stands is quite challenging due to the species varying ecological characteristics and species differential responses to disturbance. Sapling recruitment following partial cutting may also be influenced by lack of appropriate microsite and resource availability. Thus, this study examined the effects of harvest intensity and site factors on sapling recruitment in northern hardwood stands in northwestern New Brunswick.

Highlights

- ***Harvest intensity up to a removal of 50% of basal area promotes sugar maple sapling recruitment, whereas 70% or more is favorable for yellow birch.***
- ***Management objectives should focus on yellow birch in low quality sites and sugar maple in high quality sites.***
- ***Use high intensity harvest to limit the recruitment of beech where it is present prior to harvest.***

Methodology

We conducted the study in northwestern New Brunswick, Canada. Three clusters of sites were identified and the stands were selected on the basis of stand types, time since treatment, and treatment type. All trees higher than 1.3m tall and having DBH < 10.0cm were tallied by species on 0.004 ha circular plots. Trees, snags, and stumps having a DBH ≥ 10 cm were tallied using a 3BAF prism. We cored live trees in four DBH classes: (1) 10.0–15.9cm, (2) 16.0–21.9cm, (3) 22.0–27.9cm, and (4) 28.0cm and above. The increment cores were cross-dated and used to reconstruct tree diameter at the time of harvest. We used species-specific stump-to-breast height equations to predict the DBH of stumps at the time of harvest. The harvest intensity at the plot level was estimated following the protocol developed by Deal and Tappeiner (2002) that uses live tree and stump DBH at time of harvest

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and snag information. Physiographic data were extracted from digital elevation models obtained from the Department of Natural Resources, New Brunswick. Site quality (Biomass Survival Growth Index, BSGI) data were obtained from New Brunswick Growth and Yield Unit Site Model (Henningar *et al.,* 2015). Species-specific models were fitted using harvest intensity, time since the last harvest and site factors to assess sugar maple, yellow birch, red maple and beech sapling density in the stands at the plot level. The following model format was used:

$$Y = TSLH + BAcut + canopy\_openness + soil\_text + BSGI + slope + altitude + SDI + Dq + error$$

Where:

Y = individual species sapling density (stems/hectares)
BAcut = percent basal area cut
soil_text = soil texture
slope = slope (%)
Dq = Quadratic mean diameter (m) of residual stand
error = error parameters

TLSH = time since last harvest (years)
canopy_openness = percent canopy openness
BSGI = biomass survival growth index (ton/ha/yr)
altitude = altitude (m)
SDI = residual stand density index

Results

Various best models supporting sapling recruitment in response to partial harvesting and site factors were identified in Table 1. All species responded to percent basal area removed. However, the relationship varied depending on species. For sugar maple and yellow birch, a nonlinear response of sapling recruitment was observed along gradients of percent basal area cut (second order polynomial, Table 1 and Figure 2A). A significantly positive response between percent basal area removed and sapling recruitment was observed for red maple, whereas beech saplings showed an opposite trend (Table 1, Figure 2B). A significant site quality effect on sapling density was observed for sugar maple and yellow birch (Table 1). The results showed that increasing site quality enhanced the recruitment of sugar maple sapling but limited yellow birch saplings recruitment (Figure 2C). Beech sapling density declined significantly with increasing time since the last harvest (Table 1, Figure 2B). We observed increasing sapling density of yellow birch and American beech with increasing slope and altitude, respectively (Table 1). Additionally, coarse soil texture had significantly negative effects on both yellow birch and beech saplings recruitment at the study area (Figure 1).

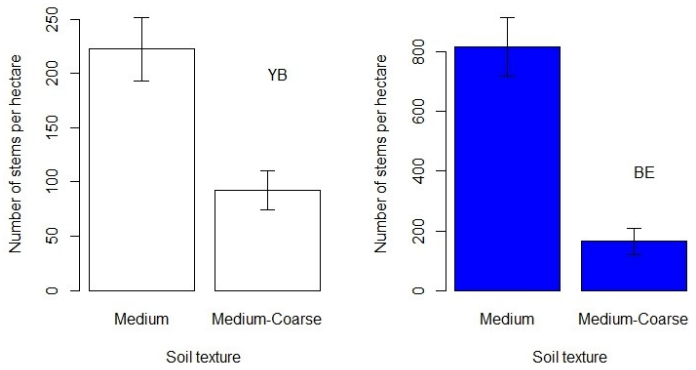

Figure 1: Mean sapling density (number of stems per hectare) by soil texture for yellow birch (YB) and American beech (BE). Error bars indicate ±1 standard error.

Species	Parameter	Est.	P. value	Species	Parameter	Est.	P. value
Sugar Maple	Intercept	1.386	0.1607	Red Maple	Intercept	6.3076	**0.0140**
	TSLH	-0.0086	0.6810		BSGI	-0.6694	0.5172
	BAcut	0.0266	**0.0001**		BAcut	0.0187	**0.0109**
	$BAcut^2$	-0.0003	**0.0013**		Altitude	-0.0042	0.0646
	BSGI	2.146	**<0.0001**				
Yellow Birch	Intercept	7.993	**<0.0001**	American Beech	Intercept	8.1400	**<0.0001**
	BAcut	-0.0328	**<0.0001**		TSLH	-0.0882	**0.0079**
	$BAcut^2$	0.0005	**<0.0001**		BAcut	-0.0243	**<0.0001**
	Soil_text_M-C	-0.8888	**<0.0001**		Soil_text_M-C	-1.2030	**<0.0001**
	BSGI	-1.4190	**0.0514**				
	Slope	0.0202	**0.0375**				

Table 1: Summary of coefficients, parameter estimates and probability values for best species-specific models describing the relationship between sugar maple, yellow birch, red maple, and beech saplings density with harvest intensity and site factors in tolerant hardwood stands of northwestern New Brunswick.

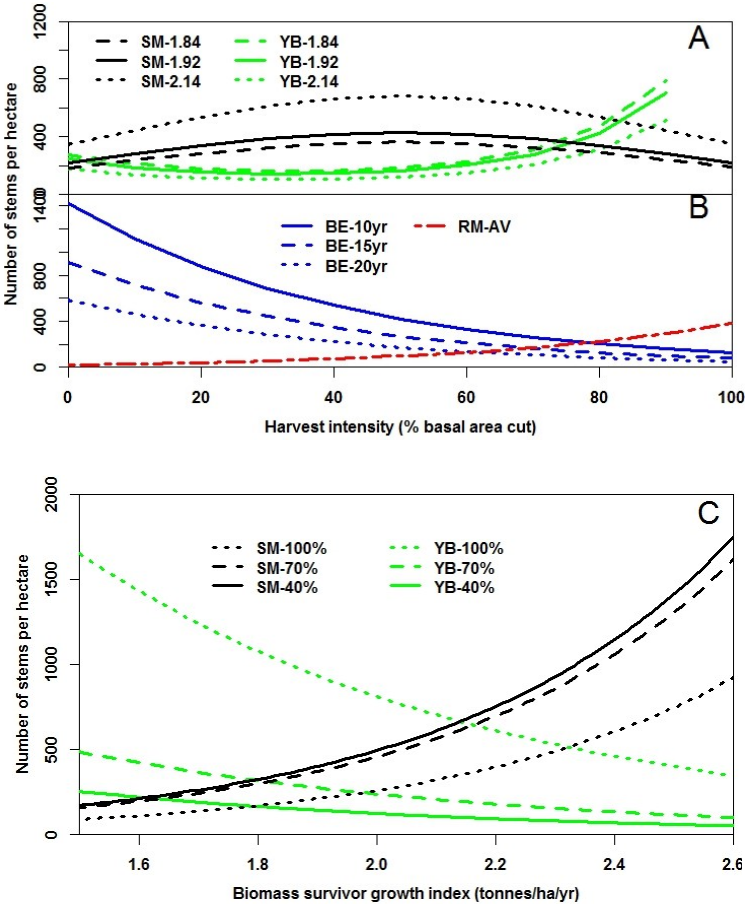

Figure 2: Relationship between predicted sapling density and predictor variables: (A) sugar maple and yellow birch along percent basal area cut with varying biomass survival growth index (tonnes/ha/yr); (B) red maple and beech sapling density along percent basal area cut with varying time since the last harvest (years) for beech; (C) sugar maple and yellow birch sapling density along gradients of biomass survivor growth index (tonnes/ha/yr) with varying percent basal area cut.

Conclusion

Sapling recruitment may respond differently to selection cutting depending on site. For instance, yellow birch sapling recruitment showed inversed relationship with increasing site quality across all harvest intensities. The success of medium intensity selection cutting (40 –50% basal area cut) to recruit sugar maple may be more beneficial on more productive sites. All the species except beech showed positive increased sapling recruitment with increasing harvest intensity up to a point. Beech sapling density declined steeply with increasing harvest intensity and time since the last harvest. In beech-dominated stands, forest managers can use high intensity partial cutting to limit beech sapling recruitment. The study further demonstrates the importance of site productivity on sugar maple sapling recruitment. Sugar maple is known to be a nutrient-demanding tree species that requires high quality site for growth and high vigour. Currently, single-tree or group selection are used to promote the recruitment of shade-tolerant and mid– to intolerant species, respectively, across all sites. However, this study shows the challenge of using harvest intensity alone to ensure constant production of high quality sawtimber in uneven-aged tolerant hardwood forests. Site-specific management strategies are required to facilitate the recruitment of saplings of the desired species in this region.

References

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For more informations, contact:

Gabriel Danyagri

info@hardwoodsnb.ca

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