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Institut de recherche sur les feuillus nordiques Inc.
Northern Hardwoods Research Institute Inc.

Reconstruction of Stand Basal Area in Northern Tolerant Hardwoods of Northwest New Brunswick

September 2015

Technical Note

Silviculture

Introduction

Hardwood stands in northwest New Brunswick were subjected to different intensity partial cuts in the past. Following these cuts, our ability to assess tree growth response via a retrospective approach is limited due to the lack of information on post-logged stand basal area of these stands. In this condition, use of stand reconstruction models is a way to generate information on past forest conditions. Studies have shown that the use of data coming from direct observations of permanent plots for extended periods provides the most reliable information to develop stand reconstruction models. However, it is important that the stands selected for stand reconstruction modeling are indeed true representatives in terms of site quality and stand developmental stage. Forget et al. (2007) presented a detail analysis of hardwood stand development following different intensity selection cut. It is assumed that stand development after different selection cut studies carried out in tolerant hardwood forests located in northern latitudes (Ontario and Quebec) of North America would represent the stand development process after different intensity partial cut in tolerant hardwood stands of northwest New Brunswick. Hence, utilizing such information, this technical note presents an approach to reconstruct post-cut stand basal area at the time of harvest for tolerant hardwood stands of northwest New Brunswick that were subjected to different intensity partial cut.

Highlights

The NRHI developed an approach to reconstruct the past stand basal area of uneven-aged, tolerant hardwood stands when information about stand basal area at a given time since harvest is available, but not immediately after harvest.

Approach

After a certain intensity of disturbance, stand basal area growth will monotonously increase up to a certain time and, eventually, approach a relatively stable maximum. Based on this theory, stand basal area in year (Y_1) (m^2/ha) is the function of post-cut basal area at the time of harvest (Y_0) (m^2. ha^{-1}), time since harvest (Y_1-Y_0) (years) and net basal area growth rate (m^2/ha/yr). In this case, net basal area growth rate is the function of basal area growth rate of residual trees, in-growth rate and mortality rate (all calculated as m^2/ha/yr). NHRI retrospective database consists of information on stand basal area in 2012 and harvesting records.

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Forget et al. (2007) showed that net stand basal area growth rate for northern tolerant hardwoods is the function of post-cut basal area – where stand basal area growth rate declines as post-cut stand basal area increases. This is mainly due to higher levels of competition for space and resources in higher basal area stands (Figure 1). When stand basal area in year (Y_1), time since harvest (Y_1-Y_0) and net stand basal area growth rate are known, a discounting formula can be used to reconstruct the stand basal area at the time of harvest (Y_0) (equation 1).

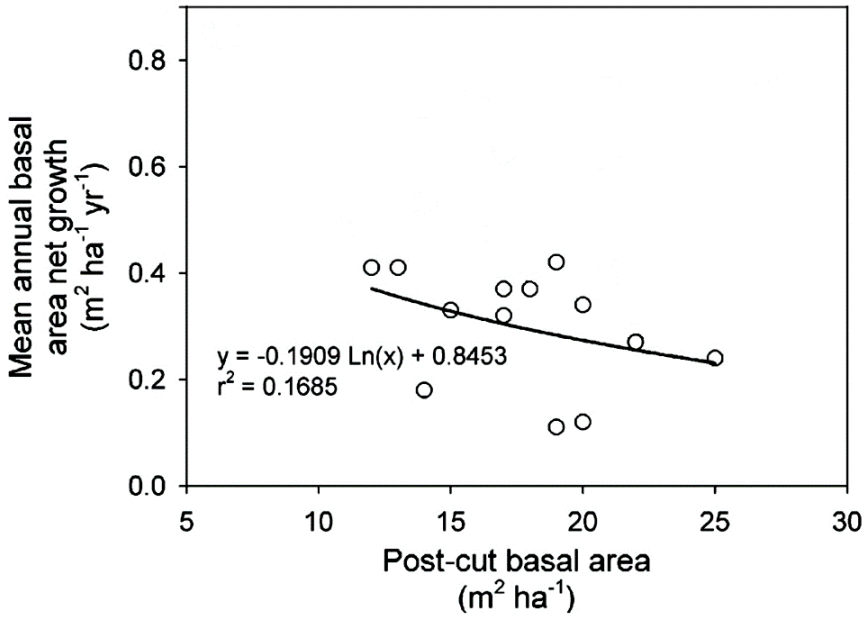

Figure 1: Net basal area growth rate at different post cut basal area stands in tolerant hardwoods of northern latitude northeast North America (adapted from Forget et al. 2007).

$$(1) \quad SBA_{\gamma 0} = {SBA_{\gamma 1}}/{(1 + BAGR(\%))^{(T)}}$$

Where:

$SBA_{\gamma 0}$ = Stand basal area at the time of harvest

$SBA_{\gamma 1}$ = Stand basal area observed in 2012 (for this study)

T = Time since harvest (Y_1-Y_0) in years

BAGR(%) = Percent basal area growth rate, which is obtained as:

$$(2) \quad BAGR(\%) = BAGR/SBA_{\gamma 0} \times 100$$

Where:

BAGR = mean annual basal area growth rate (m^2/ha/yr) for the stand of given post-cut $SBA_{\gamma 0}$ which is obtained from the equation given by Forget et al. (2007):

$$(3) \quad BAGR = -0.1909 \cdot Ln(SBA_{\gamma 0}) + 0.8453$$

Eventually, the extended form of equation (1) becomes:

$$(4) \quad SBA_{y0} = {}^{SBA_{y1}}\Big/_{(1+((-0.1909 \cdot Ln(SBA_{y0}) + 0.8453)/SBA_{y0} \times 100))^{(T)}}$$

Out of three variables in equation (4), SBA_{YI} and T are known. SBA_{Y0} should be estimated using the known values of SBA_{YI} and T. However, it is complicated as $BAGR$ varies with SBA_{Y0} which is unknown. Therefore, it requires to guesstimate SBA_{Y0} and predict SBA_{YI} using equation (4) and then adjust the guesstimated value of SBA_{Y0} until the equation yields exactly the same SBA_{YI}. The SBA_{Y0} value that predicts exactly the same SBA_{YI} is considered as stand basal area at the time of harvest (Y_0). To simplify the implementation of the above-mentioned process, the NHRI has developed a user-friendly computer tool based on MS Excel.

Results

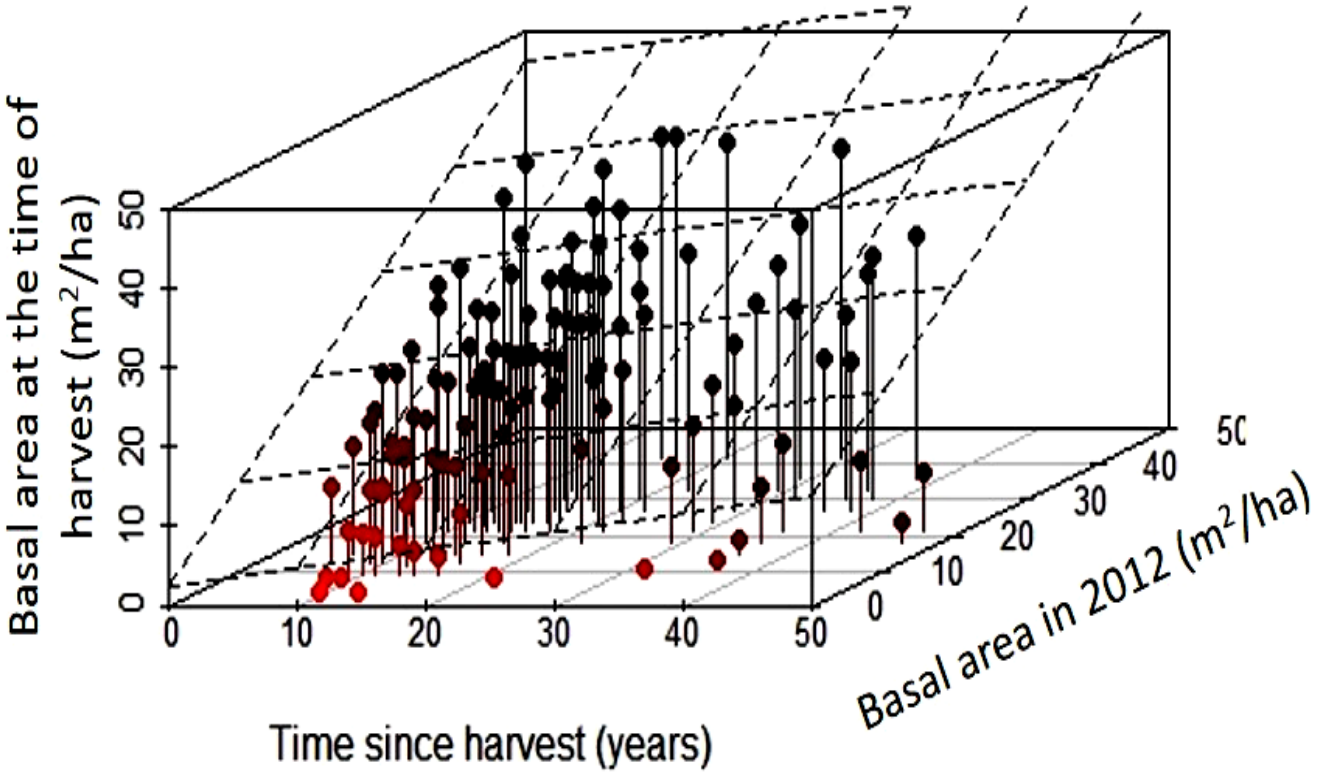

Figure 2: Reconstructed stand basal area at the time of harvest using time since harvest, basal area in 2012 and net basal area growth rate (Equation 3).

Figure 2 shows that change in basal area for a given time period is higher for lower basal area stands, indicating this basal area reconstruction approach behaves logically with biological phenomenon of stand development. The residual trees' basal increment was high and ingrowth is maximum in lower basal area stand. To the contrary, residual trees' growth and ingrowth is lower in higher basal area stands due to higher levels of competition for space and resources.

Tool

Change this value until C4 and C5 are not the same	Observed	Forget et al. 2007		Observed (C4)	Predicted (C5)
Initial basal area [SBA(Y_0)]	**Time since harvest (T)**	**(BAGR, m^2/ha/yr)**	**BAGR %**	**Final basal area_observed [SBA(Y_1)]**	**Final basal area_predicted [SBA(Y_1)]**
18,8	20	0,29	1,43	25	25,0
23,6	15	0,24	1,61	30	30,0
33,6	40	0,17	0,44	40	40,0
10,1	10	0,40	4,04	15	15,0
38,9	30	0,15	0,49	45	45,0
10,1	7	0,40	5,77	15	15,0
21,7	25	0,26	1,03	28	28,0
18,8	35	0,29	0,81	25	25,0
7,7	8	0,46	5,70	12	12,0
3,3	10	0,62	6,17	6	6,0
44,3	10	0,12	1,22	50	50,0
49,8	10	0,10	0,99	55	55,0

Figure 3: Screen view of the interactive tool developed by NHRI. Example: post cut basal area at the time of harvest was estimated to be 23.6 m^2/ha for a stand of 30 m^2/ha basal area in 2012 which was subjected to partial harvesting 15 year ago.

Application and limitation

This is an effective approach to reconstruct the past stand basal area when stand basal area at a given time and time since harvest are available, but there is no information available about the growth trend and spatial location of individual trees. In this study, net basal area growth information obtained from different post-cut basal area growth studies carried out in Ontario and Quebec was used. This may not totally represent the growth conditions of northwest New Brunswick. Therefore, net basal area growth rate information obtained from representative forests in terms of site quality and stand developmental stage is always suggested. For long term projection, it is also suggested to update net basal area growth rate periodically based on basal area of the stand at the given time (*T*) to obtain more accurate prediction. Again, to simplify the process, a computer tool is available from NRHI, and the Institute is ready to partner with any potential users for their operations.

References

Forget, E., Nolet, P., Doyon, F., Delagrange, S., Jardon, Y., 2007. Ten-year response of northern hardwood stands to commercial selection cutting in southern Quebec, Canada. For. Ecol. Manage. 242, 764–775. doi:10.1016/j.foreco.2007.02.010

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For more informations, contact:

Sharad Kumar Baral

Researcher

info@hardwoodsnb.ca

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