Acadian Model Validation for use in Hardwood Partial Cut Simulations

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Executive Summary

Before embarking on the creation of hardwood silviculture scenarios and growth simulations for Northern Hardwood Research Institute (NHRI) and the New Brunswick Department of Energy and Resource Development (ERD), it is necessary to look at how the OSM Acadian model (version 1.18.5.2) predicts ingrowth, mortality, and DBH increments for the tolerant hardwood resource in New Brunswick. Using the ERD PSP database, model predictions were compared to actual growth.

Ingrowth is the most challenging to analyse because of the lack of small tree data recorded in the first measurement of most of the PSPs, but of what little data is available the model appears to be growing it forward well. In the future, new tree recruitment (at various ingrowth DBH thresholds) in the model will have to be compared to retrospective data to see how well it performs and if adjustments are necessary.

The model is overestimating tree mortality by about 25% in terms of basal area mortality/year when averaged across plots, and this difference was statistically significant. At the species-level, statistically significant over-predictions were only observed for sugar maple, which had double the predicted basal area mortality (0.12 m^2/ha/year), compared to observed (0.065 m^2/ha/). While beech mortality is higher than all other species, there is no evidence that the model predictions need any special attention. Amendments to the mortality model will be added to bring mortality more in line with the actual PSP mortality.

Using DBH increment data from the PSP data and the OSM self-calibration tools, most species in the hardwood stands had predicted increments that statistically varied from observed for growth increment; however, OSM self-recalibration did not result in any better predictions of plot basal area than the original model because growth differences were subtle and probably only significant because of large sample sizes. Therefore, no changes to current DBH increment predictions are recommended.

For cases when the plot survey excluded small trees, a method in OSM to impute small tree (1-9 cm DBH) distributions and populate the initial tree list before simulation is needed, otherwise ingrowth will be delayed in the model by 5-10 years because ingrowth in OSM occurs at the 1cm DBH threshold. In addition, more validation analysis of ingrowth probability, abundance, and species composition is needed using plots that measure small trees down to 1 cm DBH.

Analysis

The model analysis is restricted to the ERD PSPs that fall in the tolerant hardwood, tolerant mixed and tolerant-intolerant categories. Not all PSP measurements were used due to missing trees. There are likely a number of reasons for these missing trees including lost tags where the trees were renumbered thus removing the link that allows us to follow individual trees throughout all measurement years.

Ingrowth

It is important to predict ingrowth accurately to determine whether proposed silviculture scenarios are sustainable. It is difficult to assess predicted ingrowth because of the lack of PSP measurement data less than 5.1cm. This is evident in the number of small trees that appear in subsequent measurements that very likely existed in the initial measurement, but were not recorded.

What can be analyzed is the DBH increment for small trees (<5.1cm) that have been recorded in the first measurement. There were only 159 small tree increments in the hardwood PSP data. If we separate out the one plot that was a partial cut (Thinning?) there are only 135 small trees in 16 plots, with most trees falling in only three of the plots. All plots have only one measurement interval. Only plots with a BA > 15 m^2/ ha were included.

Increment of Small Trees (<5.1cm)				
n	**End DBH Actual**	**End DBH Pred**	**DBHcm/yr Actual**	**DBHcm/yrPredicted**
135	4.13	4.15	0.093	0.088

There was no significant difference in DBH increment between actual and predicted. There does not appear to be a problem with the model, just the quality of the information we have about the small trees in the plots at the first measurement.

If hardwood silviculture scenarios are created using the PSP data it is possible to back cast the last PSP measurement to get a more accurate estimate of the small trees (1-5cm) at the initial measurement. This will at least provide a possible solution to the lack of small tree data. The question of how well the model initiates ingrowth may have to be tested against the retrospective study that looked at recruitment following harvesting. Ingrowth in the Acadian model may have to be adjusted by adding more trees or by using the recruitment option in the model.

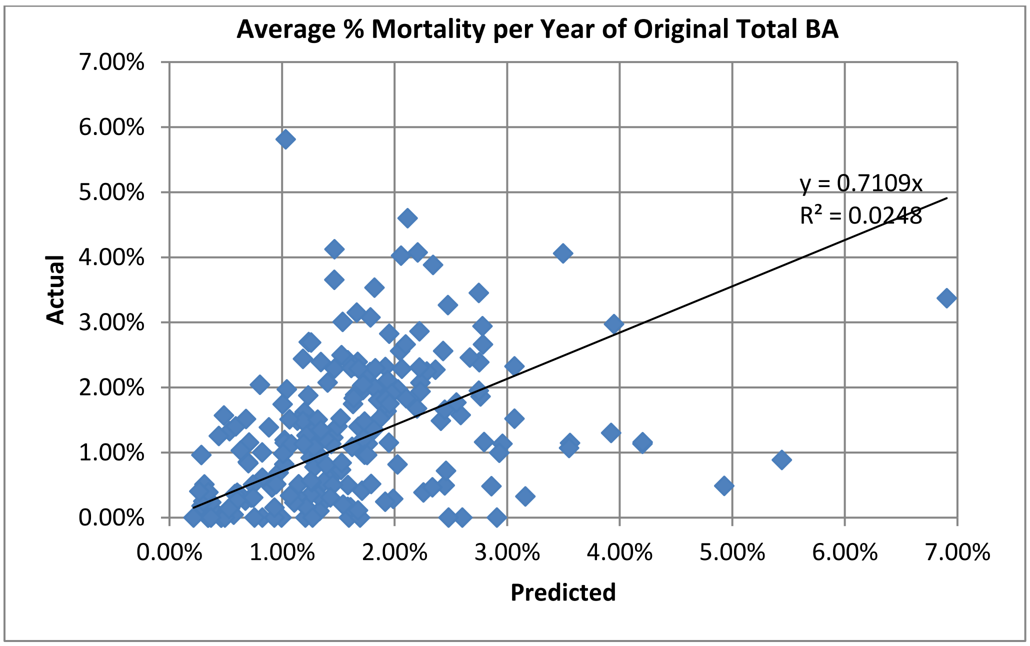
Mortality

The first analysis was limited to plots with no recent history of harvesting, and included only plot measurement years not affected by harvesting. In total, there were 212 valid plots for this analysis.

Overall Mortality (Plots with no harvesting history)

Mortality	n	Predicted	Actual	P(T<=t)
BA/yr	212	0.503	0.404	0.005
%BA/yr of Start BA	212	1.64%	1.33%	0.002

This shows a significant difference between predicted vs actual.



The relationship between predicted and actual is not strong, which is not surprising as predicted mortality is more continuous and deterministic, and actual is discrete and stochastic (as seen by the number of zero percent mortality).

Individual species mortality was also inspected to see where the difference between actual and predicted might be accounted for. Only plots where the individual species composed at least 10% of the starting basal area were included.

Species mortality (%BA/yr) as a percent of starting species basal area

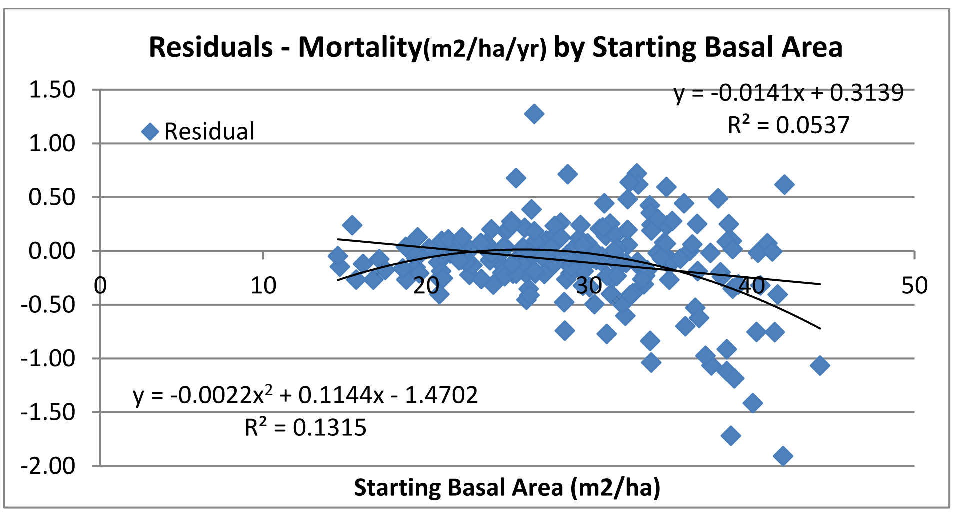
Species	n	Predicted	Actual	P(T<=t)
BE	73	3.87%	3.55%	0.395
SM	145	0.85%	0.43%	0.004
YB	79	0.62%	0.54%	0.741
RM	97	0.82%	0.92%	0.518
IH	30	1.72%	1.39%	0.409

Species mortality in absolute value (BA/yr)

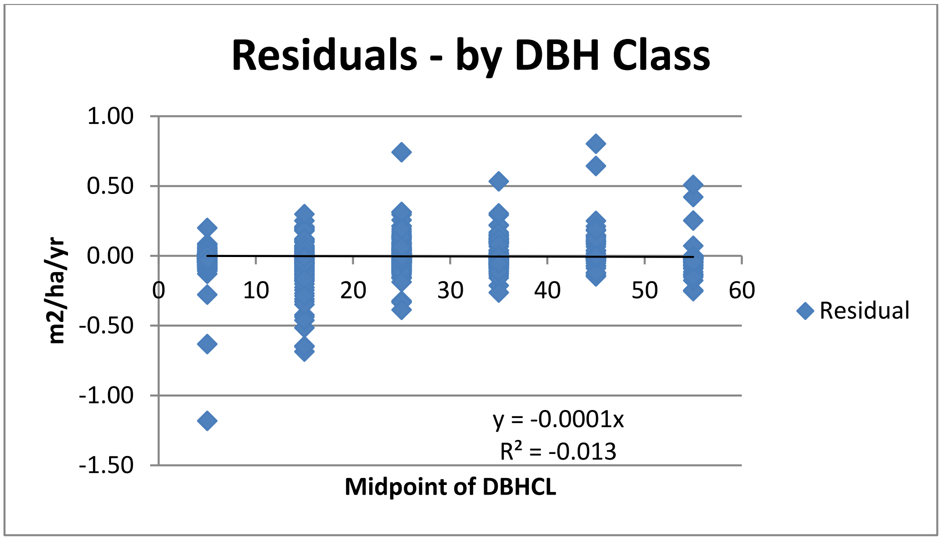
Species	n	Predicted	Actual	P(T<=t)
BE	73	0.385	0.334	0.340
SM	145	0.120	0.065	0.006
YB	79	0.053	0.035	0.207
RM	97	0.085	0.083	0.884
IH	30	0.158	0.128	0.406

Although BE mortality is significantly greater than the mortality of the total of all species there is no significant difference between actual beech mortality and predicted by the model. Although predicted mortality is higher for all species except red maple, only sugar maple showed a significantly higher predicted mortality over actual.

Residuals Analysis



Predicted Mortality overestimated for larger BA, but relationship is weak.



There is no apparent relationship between the residual of mortality and DBH Class

Residual – Mortality by DBH Class

MidPtDBH	n	Act-BA/yr	PredBA/yr	Residual
5	211	0.04	0.07	-0.03
15	212	0.10	0.14	-0.04
25	210	0.08	0.08	0.00
35	164	0.05	0.05	0.00
45	89	0.06	0.03	0.03
55	51	0.04	0.06	-0.02

Mortality Amendment

By applying an amendment to mortality based on findings above, it is hoped to improve the predicted values. The following amendment (OSM code) that was tested:

def HWMR #Mortality amendment
Operable 0..100
Cycle >= 0
Amend # reduces mortality especially in SM, increases mortality in RM
*MR * 40% in ACSA3 with DBH >= 5*
*MR * 120% in ACRU with DBH >= 5*
*MR * 90% with DBH >= 5*

BA/yr mortality

n	Predicted	Actual	P(T<=t)
212	0.46	0.40	0.080

While the amendment did reduce overall predicted mortality, modifications will have to be made to further reduce it The mortality amendment also had a positive effect on improving plot future basal area.

Basal area			
n	**Actual**	**Predicted**	**Predicted with Mortality amendment**
212	31.14	30.09	30.51

As far as the effects on individual species mortality the improved trend was what would be expected for sugar maple, beech and red maple but opposite for yellow birch, where mortality actually increased. Some more fine tuning may be required before applying it to hardwood silviculture scenarios.

BA/yr mortality by species

Species	n	Predicted	Actual	P(T<=t)
BE	73	0.364	0.334	0.567
SM	145	0.088	0.065	0.237
YB	79	0.048	0.035	0.333
RM	97	0.075	0.083	0.729

Partial Cuts

There are only 27 valid hardwood plots representing the partial cut scenarios (Dataset=1) and some other plots where there was a partial cut before the first measurement. Average predicted mortality is greater than actual mortality but not at a statistically significant level. This is probably due more to the small sample size. Partially harvested scenarios will likely have to be modelled the same as the un-cut plots.

Mortality	n	Predicted	Actual	P(T<=t)
BA/yr	212	0.289	0.255	0.699
%BA/yr of Start BA	212	1.27%	0.96%	0.325

Diameter Increment

Diameter increment calibration, using OSM's self-calibration routine, was carried out on the 212 plots with no harvest history. Plots with significant missing trees were again excluded. This translated to 506 growth intervals included in the calibration process. Most of the re-measurement intervals are 5 years, but there are also many 3-year intervals. The rest ranged from 1 to 12 years. Model calibration was carried out at both 1-year and 5-year increments for a five-year period.

For the 1 year growth model increments the species recalibrated were as follows:

HT – SM, BE, YB, RM, BF
DBHI – RM, SM, YB, BF, RS, Pch, WB, PO, EC, GB, Wash, LTA
HTI – SM, YB, BE, BF

For the 5 year growth model increments the species recalibrated were the same as those for 1 year increments, except for red maple HT, where recalibration failed.

Rerunning the 212 plots through OSM with the new (1-year increment) and comparing to the model runs using the original calibration shows the following results for the predicted end basal areas against actuals:

Comparison of End Basal Area (m^2/ha-trees>=5.1cm)		
Actual	**Predicted(uncalibrated)**	**Predicted (calibrated)**
31.14	30.09	29.91

While both predictions slightly underestimated the actual basal area, the calibrated model was actually slightly worse. In this case, high sample sizes may be resulting in significant differences between observed and predicted DBH increments, even though differences are very subtle. In this case we may be at risk of Type I error; that is, concluding there is statistical difference between observed and predicted when there in fact is no difference, in which case the base OSM-ACD diameter models are probably fine to use as is.