Acadian Variant Calibration

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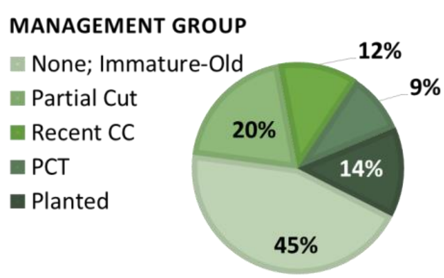
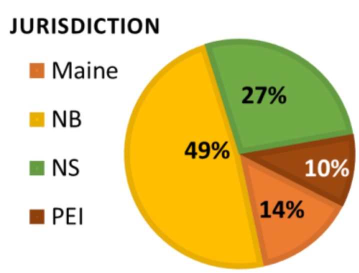
Calibration has been mostly completed for the majority of the Acadian Forest region (NS, NB, Maine, and PEI) using close to 20,000 permanent sample plots and over 3.5 million tree observations. Tree and stand-level models outlined below provide some insight into the variables used, when the models were developed, and who developed them.

Distribution of tree data used during calibration:





Validation of the Acadian calibration in the OSM environment was recently performed by Chris Hennigar at NB Dept. of Energy and Resource Development (ERD) in the spring of 2018 by comparing long-term (20-60 year) observed stand development in repeatedly measured plots to OSM predictions in terms of volume, QMD, density over time. The combined tree-level models generally performed well in most forest types (species composition X maturity), broad management types (Planted, PCT, Clearcut, Partial Cut, and Unmanaged), and across most eco-regions. Adjustment for over prediction of growth, survival, and regeneration was required for poor sites. It was found that the model slightly over predicts volume accrual in Nova Scotia lowland softwoods. The model is not well suited for sites and ecoregions with severe regeneration, stocking, and growth limitations, which was especially evident in Nova Scotia's Atlantic Coastal, Western Barrens, Taiga, and Cape Breton Highland eco-regions/districts.

As this is a regionally calibrated model, users should test this calibration against local data. Where local bias is evident, consider using OSM's auto-calibration routines and/or prediction amendments via OSM commands.

Model revision will continue for the foreseeable future, so expect updates over time. Contact Chris Hennigar for latest source code, updates on calibration, or more detailed information.

Models

Model	Description and Discussion
Background Mortality	Non-linear logistic regression model as a function of Zone, Management (PCT or Planted – yes/no), DBH, basal area, QMD, and basal area of larger trees. Each species

March 2018	model was fit independently and not all variables were used in each model depending on available data. Species group (genus) models were also developed. Fit by C.R. Hennigar, NB ERD, March 2018. These models can run stochastically if Simulation.Model.IsRandom is set to TRUE (Default = FALSE). Updated in June 2019 to always operate stochastically when trees/ha are < 0.5 (kills individual trees randomly according to mortality probability), rather than deterministically (proportion of tree record stems/hectare killed equal to mortality probability). This hybrid approach is used even when Simulation.Model.IsRandom = FALSE. When Simulation.Model.IsRandom = TRUE, mortality of individual trees in every tree record will be set stochastically. To ensure results are repeatable from run to run, for testing, benchmarking, and validation work. Use command Simulation.Model.SetRandomSeed #, where # is a fixed positive integer. Do this for each stand simulation to force the random number generator to provide exactly the same series of random numbers during simulation. For example, the Seed value could be the plot number.
Self-Thinning Mortality March 2013	The maximum stocking relationship was developed with a wealth of NB forest development surveys collected since the 1980s. The relationship was formulated as a function of basal area weighted species specific-gravity. This relationship was fit at the stand-level (>= 3 plots per stand), rather than plot-level, so it may over-estimate mortality for some plot-level comparisons. Fit by C.R. Hennigar, NB DNR 2013, following methods from Chris Woodall et al. (2005, For. Ecol. Manage. 216: 367-377). In April 2018, the specific gravity for red-pine was reduced from 0.46 to 0.36 when used in this maximum stocking equation because self-thinning was occurring too early in red pine plantations (C.R. Hennigar, NB ERD 2018). Default A-Line set to 0.85 in this Variant. In some regenerating types, especially for single plantation plots, this default A-Line (0.85) has been observed to cause competition induced mortality too early during stand development. Increasing the **Simulation.Model.ALine** to 0.95-1.00 may be required for some of these intensively managed types.
Ingrowth 2011	Estimates ingrowth probability, density, and composition at the 1 cm DBH boundary in each simulation cycle based on pre-cut stand conditions according to Li et al. (2011; CJFR 41: 2077-2089). This model can run stochastically if Simulation.Model.IsRandom is set to TRUE (Default = FALSE).

	A number of conditional adjustments to the base Li et al. (2011) ingrowth model were introduced by C.R. Hennigar, NB DNR in 2013 to improve realism in the context of harvest, current overstory species composition, and pre-existing stand ingrowth expected from small trees and seedlings in survey records or inserted in a previous cycle via OSM commands. In April 2018, C.R. Hennigar made further adjustments to reduce ingrowth in well managed plantations and PCTs and increase in growth in recently clearcut conditions.
DBH growth 2016	Non-linear regression models as a function of Zone, BGI, Species, DBH, basal area, QMD, and basal area of larger trees. Each species model was fit independently and not all variables were always used depending on available data. Species group (genus) models were also developed. Each species model was fit independently and not all variables were used in each model depending on available data. Fit by C.R. Hennigar, NB DNR 2016.
Height model Sept 2017	Non-linear (Weibull) model as a function of Zone, BGI, Species, DBH, basal area, QMD, and basal area of larger trees. Height prediction can be boosted if a sub-sample of height trees are available in the survey data. This boosting occurs automatically on loading of the tree list if heights are present. Each species model was fit independently and not all variables were used in each model depending on available data. Fit by C.R. Hennigar, NB ERD 2017. For more specifics on tree height imputation procedure used here, see OSM.Acadian.Calibration.HeightModel.
Height increment	Currently deduced from DBH growth and height predictions. A formal height increment model by Zone and Management type will hopefully be developed over the next year or two.
Crown models 2014	Maximum and largest crown width models for Maine (Russell and Weiskittel 2011. Nor. J. Appl. For. 28: 84-91). Height to crown base models for 13 species in the Acadian region (Rijal et al. 2012. For. Chron. 88: 60-73). Height-to-crown base increment in the Acadian region (Russell et al. 2014. Eur J. For. Res. 133:1121–1135).
Grade model 2015	Preliminary calibration available for New Brunswick for sugar maple and yellow birch. Fit by Walter Emrich, Northern Hardwood Research Institute 2015.
Snag model 2016	The default snag fall rate model for the Acadian region was ported from STAMAN by C.R. Hennigar, NB DNR 2016. This STAMAN snag fall model was based on northeast snag literature (pre-2010) and no formal documentation of the original calibration

	work is available. Fall rates seem realistic when simulated based on comparisons between steady state simulated inventory and NB snag inventories collected in the field. There is currently no snag decay transition model for the Acadian region. Decay models exist in the literature in Maine, Ontario, and Quebec and may be introduced in future development of this Variant. A snag inventory imputation/initialization model has been developed for this Variant using forest development surveys collected throughout the province of NB between 2006 and 2012. The model predicts the probability of snag occurrence and snag abundance across 10cm DBH classes and can be used to initialize the simulation with snags if none were collected in the field. Developed by C.R. Hennigar, NB DNR, 2016. This model always runs stochastically regardless of Simulation.Model.IsRandom state. This is necessary to reduce the number of snag record divisions over multiple simulation cycles. Default Snags.MinDBH = 9999 (OFF). To turn snag modeling on, set Snags.MinDBH to 10 cm.
Taper & Volume 1983	Total and merchantable bole volumes based on Honer et al. 1983. Metric timber tables for commercial tree species of central and eastern Canada. Maritime For. Res. Centre. Info, Rep. M-X-140. Default merchantable bole stump height set to 30 cm and top height set to 8 cm inside bark for all species; adjust these defaults using Simulation.Species. Volume does not influence stand development. These estimates are only calculated if desired during reporting.

Switching Model Calibration

A number of different models exist in this Variant for each type of model described above. As new models are developed, older versions are retained to allow comparison. These models include those developed by A. Weiskittel and J. Kershaw between 2010 and 2014, models ported from STAMAN (NB tree cohort growth model), and many others recently developed by C.R. Hennigar from 2013-2018. The current (**Default**) calibration is a blend of the 'best' of these available models for stand development forecasting.

It is possible to switch entire calibration sets (e.g., use all available STAMAN models) with a single command in OSM. This functionality is useful for testing differences in stand development between models. It is also possible to switch tree growth or mortality models one by one to isolate cause of result differences. Contact Chris Hennigar for more information on available models contained in this version.

SIMULATION.Model.Switch **Default** Uses the 'best' equations available for zone & management based on simulated vs. observed growth trajectories across the region. It is recommended that users stick with this default calibration.

SIMULATION.Model.Switch **STAMAN** Switch to STAMAN Calibration (NB DNR 2012). Includes ported STAMAN models for DBHI, HTI, HT, and Mortality. These models require *NbSite*, *NbClimate*, and *Management* attributes; see input columns in OSM_StandList.

Aaron Weiskittel at the University of Maine continues to develop an ever increasing number of Acadian forest models with his team of graduate students, and continues to integrate most of this work into R and 'FVS online' modelling platforms. Contact Aaron Weiskittel to get access to his latest models, as this version has not kept up with integration of his team's work. In future work, we hope to port his new models into this Variant to allow his latest calibration to be optionally run through OSM.

Future Plans

Minor tweaking to current models is likely through 2018 by C.R. Hennigar and the Norther Hardwood Research Institute. Documentation of new models will be a priority in 2018 as well. Work on development of climate change modifiers for OSM growth, survival, and regeneration under climate change is ongoing now through to 2021 by CFS, NB DERD, UNB, and NHRI.

The next major calibration effort will need to go back to the drawing board to improve site productivity classification and mapping resolution in order to make sizable improvements in the accuracy of this model. This site productivity mapping revision work has started in 2018 through the Cooperative Forest Research Unit, University of Maine with involvement from FORUS Research with the aim of better leveraging LiDAR and satellite resources, and any new soils, drainage, site classification work available.