ON THE USE OF GROWTH AND YIELD MODELS IN FORESTRY APPLICATIONS

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Introduction

Growth and yield modelling is an essential prerequisite for evaluating the consequences of a particular management action on the future development of forest ecosystem and is, now a day, has been central theme of Forest Management. Technologically advanced growth and yield prediction tools can help foresters make more informed management decisions, but foresters must first learn to be selective and cautious with these new tools.

Each model has a unique niche; no one model is applicable in all situations. To get the most benefit from these models, foresters have to understand the basic differences among them to select the appropriate model for a given situation. Differences among models stem from differences in the databases used to calibrate them and differences in model architecture. Perfect databases do not exist. Data quality and quantity are always in short supply since funds are limited and long-term growth data requires time (www.for.gov.bc.ca).

Likewise, there is no one "best" modelling approach. A model's architecture stems from the modelling approach chosen by the modeller based on the intended application and available data. Limited databases along with the limited knowledge of tree and stand growth necessarily lead to different approaches for different needs and applications. For instance, a primary emphasis on supporting silvicultural prescriptions is likely to lead to a different model than an emphasis on inventory or planning. Similarly, an emphasis on single-rotation yields will produce a different model than an emphasis on long-term sustainability.

Growth and yield prediction models?

Growth and yield prediction models are abstract or simplified representations of some aspect of reality used primarily to estimate the future growth and yield of forest stands. A *stand growth* model represents an abstraction of the natural dynamics of a forest stand, and depicts growth, mortality and other changes in stand composition and structure. It also mathematically describes the growth and yield of trees and stands. Some models are developed to predict *Yield*, which is the final accumulated growth at the end of a certain period (e.g., total volume growth in cubic meters per hectare); while others predict *Growth*, which is the total increase in dimensions of one or more individuals in a forest stand over a given period of time (e.g., total volume growth in cubic meters per hectare and per year), as well as *Yield*.

Traditional growth and yield models are classified into two major groups. The models which require stand summary information (e.g., volume per hectare and stand average diameter) are called *Whole Stand Models.* The models which require a sum of individual tree information (e.g., tree heights, diameters and crown lengths) to produce estimates of yield are called *Individual Tree Models*. These models are further subdivided according to how the stand density is modelled. For instance, variable density whole stand models can assess the effects of yield on variation in stand density (e.g., crown cover, basal area). Of the individual tree models, only distance-dependent models maintain a spatial record of the point density around individual trees (Munro, 1974).

Managed vs. Unmanaged stands?
The distinction is important because managed stands tend to be more productive (Nussbaum, 1998).

Managed stands
Managed stands are even-aged stands which have benefited from management activities to encourage their growth potential. They have known establishment conditions including species, density, and distribution of stems. *Managed* stands can be:

- planted or natural origin but have not experienced repression or over-story competition.
- harvested stands regenerated, say, after 1990 which have achieved "free growing" status, as specified in the regional free growing guide books. For stands regenerated before 1989, silviculture records, management plans, and local knowledge are needed to determine if stands are managed.
- young spaced and fertilized stands if the establishment conditions can be approximated.
- partially harvested stands, such as commercially thinned stands if they were unsuppressed or unrepressed during establishment, establishment conditions can be approximated, and removals be documented.

Unmanaged Stands
Even-aged stands have not had the benefits of management and their establishment conditions are unknown. Although some stands may achieve their potential, others may have inadequate stocking, experience over-story competition, or repression.

Uneven-aged stands are considered *unmanaged* for this exercise, as the concept of establishment conditions holds little meaning and a large number of stems could be suppressed by an over-story. These stands generally contribute to non-timber objectives where maximizing growth is not the primary concern. They have historically been handled as "naturals".

Models decision tree

Forest growth and yield models have been developed for many different purposes. It is important to choose the proper model and understand it's assumptions and limitations. Models can be sophisticated computer models or simple yield tables derived from appropriate data. The distinction between *managed* and *unmanaged* stands helps in choosing an appropriate yield model for your particular application.

Caution about models!

Forestry and statistically-based biological experimentation are both relatively new sciences whose joint development is governed largely by the (slow) rate of tree growth. Seeming contradictions among the limited existing experiments serve to highlight our imperfect understanding of complex biological systems and discourage risk-laden investment decisions based on limited (or select) information. Decision making given imperfect information requires risk analyses which take into account the uncertainties regarding future biological and economic consequences. Models can be important tools, but one should not rely solely on them for making decisions. Professional judgment should be used to examine the data and assumptions before making the final management decision.

Model application and use

Selecting a model is only half the battle. Proper use of a model also depends on proper selection and preparation of the input data and proper interpretation of the model output.

The main uses of growth and yield predictions are to:

- increment and update forest inventories
- compare silviculture treatments by simulating treatments and predicting outcomes
- influence stand and forest level decision making
- provide input for forest management planning including timber supply analysis, Allowable Annual Cut (AAC) determinations and policy making
- assess the impact of timber losses due to pests and fire
- allow extrapolations for missing or inadequate data
- explore and teach tree and stand dynamics

The application of any model in silvicultural decision support also requires a clear statement of management objectives translated into appropriate quantitative values that can be identified in model output. Care must be taken to understand the implications and limitations of using various quantitative measures as surrogates for management objectives.

For instance, the common use of average diameter as a surrogate for piece size is easily misinterpreted when exploring thinning response. The immediate shift in diameter distribution (and average diameter) due to the thinning operation itself (alias "the chain-

saw effect") confounds later interpretations of average diameter and thinning response. Thinning from below immediately narrows the diameter distribution and increases the average diameter. This in turn exaggerates the effect of thinning on the time required to reach a certain piece-size. Examining the largest diameter classes via stand and stock tables, provided by some models, gives a clearer picture of thinning response than average diameter does (www.for.gov.bc.ca).

Remarks

Growth and yield modelling is an essential prerequisite for evaluating the consequences of a particular management action on the future development of forest ecosystem and is, now a day, has been central theme of Forest Management. The number of growth and yield models applicable to forests is rapidly increasing due to readily available efficient computing technology. Technologically advanced growth and yield prediction tools can help foresters make more informed management decisions, however foresters must first learn to be selective and cautious with these new tools. No one model is applicable in all situations. To get the most benefit from these models, foresters have to understand the basic differences among them to select the appropriate model for a given situation.

References

Munro, D.D. 1974. Forest Growth Models - A Prognosis. In: Fries (Ed.) Growth Models for Tree and Stand Simulation, Royal College of Forestry of Sweden, Res. Note No. 30. pp. 7-21.

Nussbaum, A. 1988. Which Stands are "Managed" for Yield Curve Generation and What Models Might be Used? Description for TFL/TSA Data Package. Unpublished Note, BC. Ministry of Forests, Research Branch, 3 pp.

http://www.for.gov.bc.ca/hre/gymodels/GY-model