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Modeling stand-level indicators of sustainable forest management in TFL 49

By Clive Welham

Highlights

- Computer-based modeling is a useful tool for predicting trends in stand-level indicators of sustainable forest management.
- Three types of models are in use: empirical, process, and hybrid.
- A good model is easy to calibrate, applicable to a wide range of practices, links management to ecosystem functions, and simulates a broad range of ecological attributes.
- FORECAST, a hybrid model, satisfies these criteria and will used to predict stand-level indicators in TFL 49.

Tree Farm License 49 is the site of a multi-disciplinary research project lead by a team of researchers from the University of British Columbia Faculty of Forestry, in collaboration with Tolko Industries Ltd., and funded by the Sustainable Forest Management Network. TFL 49 is an area-based forest tenure in south-central British Columbia held by Tolko, a partner in the Sustainable Forest Management Network. The primary project objective is the development of a decision-support framework for sustainable forest management (SFM) of TFL 49. This research note is one of a series stemming from the project.

Why model indicators of SFM?

To demonstrate social and environmental responsibility, many forest companies are developing criteria that reflect their principal objectives for managing the forest landbase. These criteria typically form the basis of a SFM plan. SFM is an extension of the principles of sustainable development first articulated in the 1987 Brundtland Commission report where sustainable development was defined as development that meets the needs of the present without compromising the ability of future generations to meet their needs. Each of the criteria also has one or more associated indicators which are used to measure success in achieving the objectives (the criteria; further details below).

Selecting appropriate indicators is critical to demonstrating SFM. However, given the dynamic nature of forest ecosystems, few indicators are static. Therefore, it is important to understand how a given indicator might be expected to change with time[†].

[†]Snags, for example, are an important habitat element. They can be especially abundant after a fire because of high mortality in the resident trees. Over several decades, the snag population declines sharply as individuals decay and fall over. Given sufficient time though, snags increase in number once again as some of the new resident trees are killed by competition or disease.

Unfortunately, there is seldom enough empirical data to establish data-based trends for a given indicator. As a result, it usually requires the use of computer-based models to predict trends in indicators. Finally, the spatial scale at which an indicator is applied is also important. Indicators can be modeled at the stand-level or the landscape-level. This note addresses stand-level indicators.

Four features of a good stand-level model

1. Relatively easy to calibrate (adjust for local conditions).
2. Accommodates a wide variety of management practices.
3. Links management practices directly to ecosystem function.
4. Simulates a broad range of ecological attributes.

Empirical, process or hybrid?

Stand-level models are usually constructed using two basic approaches: Empirical and process modeling (Figure 1). A third option, hybrid modeling, is a combination of these two approaches, and the approach used for modeling stand level indicators on the TFL 49 project.

Empirical models

Empirical models are usually based upon statistical relationships within data. As such, they contain little explanation of the processes underlying the relationships. But, their output is relatively easy to interpret, and empirical models also have the benefit of being relatively straightforward to calibrate. When based upon a good data set, they can be used with confidence to project management activities. However, because they have no linkage to underlying processes, empirical models are not reliable when the circumstances differ substantially from the baseline data set, nor can they easily accommodate unique management activities. As well, the output variables they simulate are generally limited to the range of variables entered as input data. As a result, empirical models generally satisfy the first, and sometimes, the fourth feature of good models (see box on page 2). TASS/TIPSY, PROGNOSIS, FVS, and MGM are well-known examples of empirical models (visit **www.for.gov.bc.ca/hre/gymodels** for descriptions of these models).

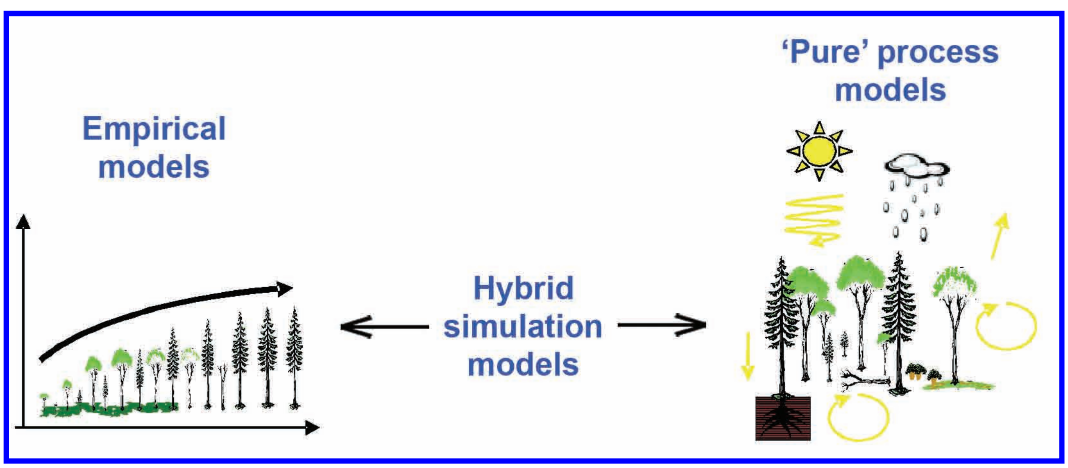

Figure 1. Two basic approaches to constructing stand-level models: empirical models and 'pure' process-based models. Each approach has its benefits and limitations. Hybrid simulation models represent a compromise between these two approaches.

Process models

Process models deal with many of the difficulties associated with empirical models, and therefore might be more suited to the complexities of SFM planning. A process model uses representations of many key processes that drive ecosystem function. This approach allows process models greater flexibility in the management activities that can potentially be simulated. They can also project growth response to a wide range of environmental conditions. On the down side, a large amount of data is required for calibrating a process model. This 'calibration load' renders a process model much less portable than its empirical counterpart. Process models can also be extremely complex making it difficult to interpret the output. Process models satisfy features 2, 3, and 4, but not the first feature of a good model (see box on page 2). To date, there are no 'pure' process models in widespread use in British Columbia. For a good review of process modeling, refer to Dixon and others (1990), listed below. For a good example of a process model, refer to the MAESTRA model website at **www.maestra.unsw.edu.au.**

Hybrid models

A third approach – hybrid modeling - is gaining widespread application and represents a compromise between the empirical and process models (Figure 1; also see Messier and others, 2003). In a hybrid simulation model, the rates of many key ecosystem processes are derived directly from empirical data. This reduces the number of parameters required for estimation, and thereby minimizes the calibration load. While hybrid simulation requires less calibration than a 'pure' process model, the model is fundamentally process-based. Consequently, it can accommodate a much broader range of management options. FORECAST – a model developed by Dr. Hamish Kimmins at the University of British Columbia – is a well-known example of a hybrid simulation model (see **www.forestry.ubc.ca/forestmodels/**, for further details). FORECAST has elements of each of the four features that characterize a good SFM planning tool (see box on page 2). It can simulate a wide range of management activities and their effect upon a variety of ecosystem attributes and values (Table 1). It is this hybrid model that will be used to project many of the stand-level indicators listed in Table 1, for the TFL 49 project.

Potential output from the FORECAST hybrid simulation model

Biophysical Indicators	Growth & Yield	Economic Indicators
Species composition	Total volume	Value of timber
Site productivity	Merch. volume	Management costs
Stand structure	Height growth	Employment
Soil organic matter	Individual stem size	Carbon budgets
Snags & CWD	Distributions	Energy budgets
Carbon pools		

Table 1. Potential output of FORECAST, a hydbrid simulation model developed by Dr. Hamish Kimmins at the University of British Columbia.

For more information

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Links and further reading

www.for.gov.bc.ca/hre/gymodels

Brundtland, G.H. 1987. *Our common future: the Report of the World Commission on Environment and Development.* Oxford University Press, New York, USA.

Dixon, R.K., R.S. Meldahl, G.A. Ruark, and W.G. Warren (eds.) 1990. *Process modeling of forest growth responses to environmental stress.* Timber Press, Portland, OR.

Kimmins, J.P., and others. 1999. *Modelling forest ecosystem net primary production: the hybrid simulation approach used in FORECAST.* Ecol. Modelling 122: 195-224.

Messier, C., and others. 2003. "Modeling tools to assess the sustainability of forest management scenarios" **In:** *Towards Sustainable Management of the Boreal Forest* (P.J. Burton, C. Messier, D.W. Smith, and W. L. Adamowicz, eds). NRC Research Press, Ottawa, ON. pp. 531-580. (available from the Sustainable Forest Management Network office in Edmonton).

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