EcoGen – A Model for Predictive Ecosystem Mapping

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Introduction

Over the past few years, predictive ecosystem mapping (PEM) approaches to resource inventory have come on the scene as an alternative to more conventional mapping and classification methods such as Terrestrial Ecosystem Mapping. This PEM information, as with TEM, is purported to support a wide variety of resource planning needs ranging from strategic-level planning to more detailed on-site applications. Even though PEM is new to British Columbia, PEM models have been in development through the past decade. The EcoGen model is a PEM method being developed by the B.C. Ministry of Forests. Its development has been driven by the need to obtain TEM-like information for more geographically extensive areas, more readily and more cost-effectively, for application in determining site quality and ecologically-based yield analyses.

Conventional resource inventories, as we have known them for decades, are undergoing both a technical and business model paradigm shift. The technical evolution is being driven by new capabilities for acquiring, processing, integrating and sharing resource information and knowledge digitally. It is enabled by various technologies like remote sensing, image processing, GIS, knowledge-based systems and information networks. Concurrent with this is a trend towards greater data and information integration across inventory programs. With the present fiscal environment, people are now looking at opportunities for gaining efficiencies and greater information integration. Predictive ecosystem mapping is a result of these changes.

Predictive Ecosystem Mapping

Ecological classification systems provide a framework to organize and communicate our knowledge about the nature of physical and biotic features of landscapes. In British Columbia, the Biogeoclimatic Ecosystem Classification (BEC) system has provided a classification of the basic ecological units in the province and is an integral component of forest management. PEM and TEM are approaches to map the ecosystem units of BEC at a large scale.

Predictive Ecosystem Mapping (PEM) is a new and evolving inventory approach designed to use available spatial data and knowledge of ecological-landscape relationships to automate the computer generation of ecosystem maps. It typically involves the spatial overlay of mapped themes and the processing of the resultant attributes against a formalized knowledge base using automated inference methods. It offers the promise of providing surrogate terrestrial ecosystem maps. Figure 1 demonstrates the overall principle of PEM – that ecological map delineations can be derived from other digital maps and the attributes associated with their polygons.

EcoNotes are produced by the Ecology and Earth Sciences Section, Research Branch, BC Ministry of Forests. Eco Notres are available online at http://www.for.gov.bc.ca/

research/ecogen/furinfo.htm. Contact Del Meidinger, Research Ecologist at Del.Deidinger@gems2.gov.bc.ca for further information.

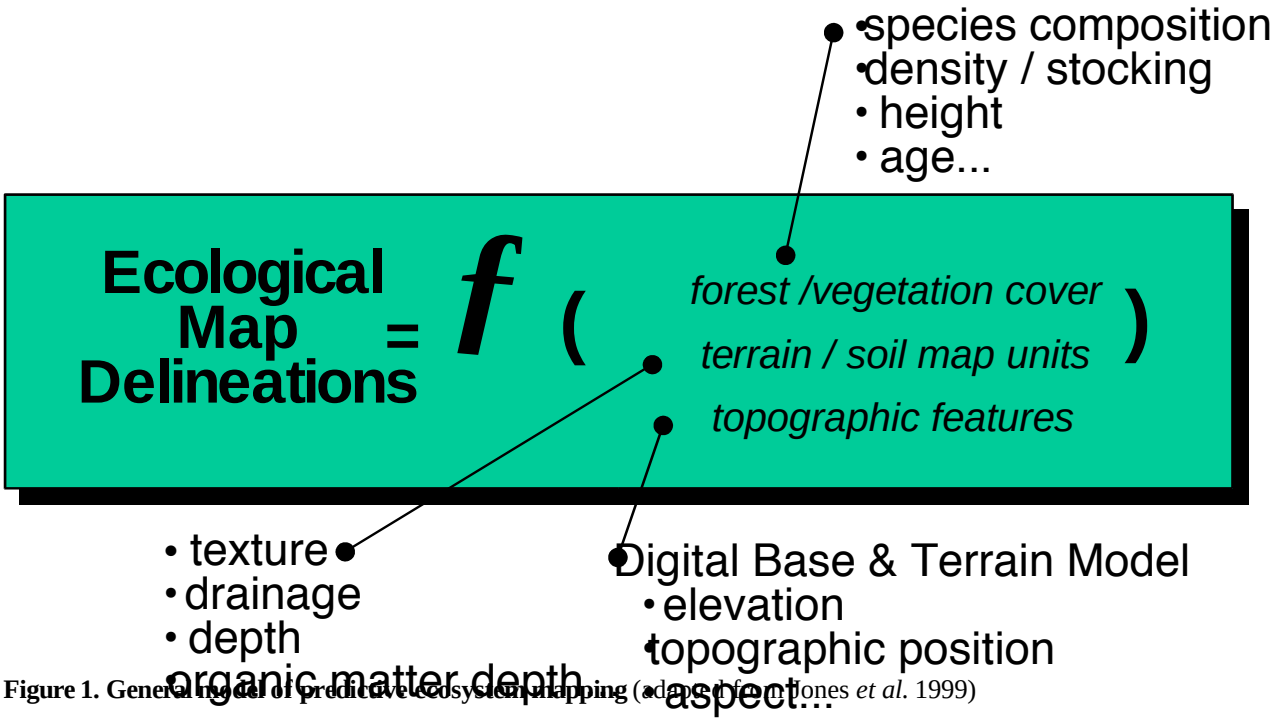

Figure 1. General model of predictive ecosystem mapping (adapted from Jones *et al.* 1999)

The advantages of PEM are many. Much of the drive behind PEM development has been to address the high cost of conventional ecosystem mapping approaches. While cost and time savings are possible over traditional approaches, there are other advantages that should be given equal emphasis. For example:

- Improvements in inventory cost, production and human resource capacity — PEM approaches provide a more systematic, consistent and repeatable stratification process; have reasonable flexibility, and can adjust to changing information and knowledge sources; and, offer opportunities to increase mapping efficiency and the rate of mapping.
- Capitalize-on, add-value to and protect investments in classifications and resource inventories — since much of the inventory is already available digitally, and we have an existing ecological classification system, PEM will provide more explicit and documented capture of the relationship knowledge. This will provide greater understanding of ecosystem and landscape relationships and how to best map these features in subsequent iterations.

There are also some disadvantages. For example:

- Existing map information bases lacking in quality — existing map input sources for PEM may be absent, non-digital, of an inappropriate scale or survey intensity level, or may simply be of poor positional or thematic quality.
- Existing ecological knowledge of inadequate quality — ecological classifications may be absent or of limited value for the area under consideration.
  Relationships between ecosystem classes and attributes in existing digital data are poor — poor linkages may result in unacceptable or ambiguous predictions.

EcoGen Model

Figure 2 provides an overview of the EcoGen model. EcoGen uses available geographic and inventory data to map site series. Ecosystem maps from EcoGen can be used for wildlife interpretations in land management planning, for analyses of potential timber yields using site

index – biogeoclimatic ecosystem classification (SIBEC) relationships, or for any other ecosystem-based interpretive needs.

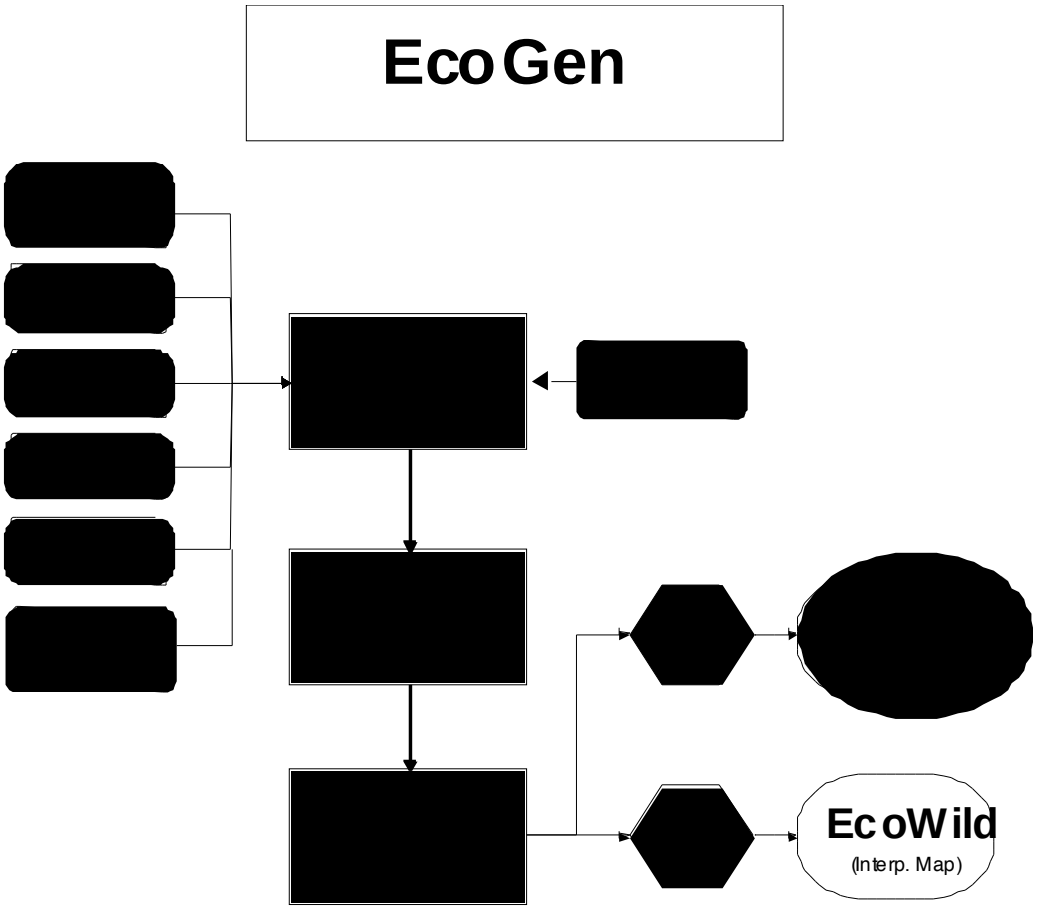

Figure 2. Components to EcoGen Model (see also: www.for.gov.bc.ca/research/EcoGen)

At present, the EcoGen program is fully functional, however, the post-modules of EcoYield and EcoWild are still under development. New developments will continue to be added to the program as we learn more about ecological patterns and attribute derivations. It is expected that future versions of EcoGen will be available on the web page over the next few years. The present status of each of the components of EcoGen is discussed below.

EcoPrep

EcoPrep involves the extraction of attributes and the manipulation of digital data layers in preparation for input into the model. In addition, knowledge tables that express the relationships between attributes of the digital data and the ecosystems to be mapped are prepared. The following steps are undertaken in the EcoPrep phase:

- Digital data layers (e.g., forest cover) are selected based on which ones are available or can be made available.
- Polygons are created using existing photo-interpreted base polygons further divided by slope and aspect classes. These polygons form the basis of the PEM attribute database.
- Attributes of the digital layers that have predictive capability in the determination of site series are selected and added to database.
- The data may be manipulated to derive new data layers, e.g., identification of ridges or toe slopes using Digital Elevation Model (DEM) from TRIM, and added to the database.

- New attributes may be created through combinations or queries of the data, e.g., spruce in any of species 1 through 6, or spruce as any of first or second species, and added to the database.
- Ecological relationships between these attributes and the site series or other ecological map entities are then determined by the Ecologist and entered into Knowledge Tables.
- The database and knowledge tables are then formatted to mesh together via a series of interface programs.
- The database and knowledge tables are then run through the EcoNGen program which combines the two to determine the ecological site series for each polygon.

The EcoPrep phase also involved the development of large-scale biogeoclimatic maps by modeling the biogeoclimatic relationships onto TRIM maps (see http://www.for.gov.bc.ca/research/bigbgc/).

The first version (Version 1.0) of EcoPrep has the programming to allow the following attributes to be derived from the TRIM DEM:

1. Slope class (used in deriving PEM polygon)
2. Aspect class (used in deriving PEM polygon)
3. Density of streams in each PEM polygon
4. Riparian benches off of lakes and rivers
5. Gullies and influence of gullies
6. Hilltops and influence of hilltops
7. Ridges and influence of ridges
8. Toes of slopes
9. Elevation
10. And adjacency to features

In addition to these derivations, other sets of features are extracted from the TRIM and Forest Cover data files. Firstly, the presence of landform features, i.e., esker, cliff/scarp, slide, beaver dam, flooded area, spring, moraine/skree, lavabed, avalanche track, and snow/ice/glacier. And secondly, various attributes of the forest stand description that are useful in describing the ecosystem unit, such as species composition, stand height, crown closure, stand age or presence of veteran trees.

EcoNGen

The EcoGen model engine, EcoNGen, is available and is being used to process data and knowledge tables for several large projects. The model has been released on the EcoGen web site: http://www.for.gov.bc.ca/research/ecogen/)

The EcoNGen is the processor that works like the venturi of a carburetor. The fuel is the GIS database that provides the foundation for the map, the air is the knowledge table that provides the ecological meaning, and the resulting power is the EcoMap showing the location of the many ecosystems across a landscape. A series of interface programs were written to assist in the preparation of the knowledge tables to mesh with the database in the EcoNGen program. These are also available for download. Contact Del Meidinger for these.

EcoMap

The EcoMap module is the final step in the production of the ecosystem maps. The resulting output file from the EcoNGen is re-attached to the polygon database. A color legend is created to display these ecosystem units as colors rather than assigning them as labels, due to the small size of many of the polygons. The colors range from reds representing the driest ecosystems, through yellows and greens, to blues representing the wettest ecosystems. The original forest cover polygon is reapplied to the map to show context and location of the ecosystem units. Roads and water networks are also displayed on the maps for georeference.

Interpretive Products

The interpretive products possible from predictive ecosystem mapping are similar to those that can be derived from TEM. These include ecologically-based yield analysis, wildlife capability mapping, conservation planning, and other landscape- or strategic-level planning decisions. In EcoGen, we are preparing modules to assign site index to PEM polygons for ecologically-based yield analyses, and to develop wildlife habitat capability assessments. These are called EcoYield and EcoWild respectively.

Many "mid-operational" questions can also be asked of these PEM maps in order to assist forest managers in meeting their work objectives. As an example, for pure Aspen stands that require post-harvest treatment, which ones are located on mesic sites versus subhygric sites? Or for a series of blocks that require inspection, which ones have the greatest complexity and therefore require the most attention? Or for a given mule deer habitat type, which ones are on steep south-facing slopes that will be preferred during the winter months? Or for grizzly bear habitat, which berry-producing stands are located near wetlands that will be preferred during the fall? Many other questions can be asked of these PEM maps that will assist in making ecologically-sensitive forest management decisions.

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