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Satellite imagery as a tool in the inventory of old-growth forest

Remote sensing, and in particular the use of satellite imagery, holds a number of opportunities for the inventorying of British Columbia's old growth forests. The major advantage of use of satellite imagery is in producing very current maps on the status of unlogged forest in districts with on-going logging. However, much of this information should be available through more conventional (and cheaper) inventory sources. A longer-term possibility for the use of satellite imagery is in identification of certain kinds of mosaics of old growth forest, with certain shapes and ranges of environmental gradients, some of which will be more viable and attractive for conservation than others. The major disadvantage of use of satellite imagery is cost - for both acquisition of scenes and the subsequent image processing. The short-term "propaganda" value of satellite imagery should not be under-emphasized. Images of parts of the southern Interior and of the north coast can do much to educate and mobilize the public to the need for more comprehensive management of the forest landscapes of B.C.

There are really two sets of possibilities for the use of satellite imagery: identification of contiguous mosaics of mature forest and monitoring spatial aspects of the impacts of logging. In both cases, satellite images are the least detailed of the types of remote sensing data that are available (including various photographic information and radar as was used in mapping the Amazon rainforest). The primary advantage of satellite imagery is not in its level of detail (which is improving) but rather in being able to provide regional pictures of landscape changes (such as the loss of "old growth forest" (Franklin 1981)). A second possibility offered by satellite data is for very specific aggregation of spectral reflectivity to identify areas with particular old growth attributes (Meslow et al. 1981) within particular biogeoclimatic zones.

In first thinking about the use of satellite imagery for the inventory of old growth in British Columbia, the following questions can be posed. What is the extent of the area, district or region that needs to be "viewed" and what are the necessary scale(s) for both the data base and subseqent (hard copy) scenes and maps? How do we define old growth in a particular biogeoclimatic zone (and sub-zone)? What is the minimum size for an old growth fragment that we want to be able to detect? What are the particular old growth attributes for which we are looking and what is the extent of the degradation of these attributes from adjacent land use (particularly logging, mines and roads)? How significant is landscape / community / (non-logging induced) successional / habitat type diversity (Norse et al. 1986)?

Satellite imagery is only a partial tool in answering these questions and yet it is these questions that make the use of this data worthwhile in the **inventory** of old growth. Of course, such broad brush remote sensing is also very useful for "viewing" the regional extent of logging. But we don't need satellite imagery to "inventory" second growth. Such "views" processed and inevitably "doctored" do provide tremendous educational and propagandizing tools. This could be useful for both proponents of more logging of old-growth as well as for advocates for more old-growth preservation and logging of second-growth.

Satellite imagery simply records the **spectral reflectivity** throughout a particular **scene** at a particular time. Each satellite has a number of devices with differing sensitivities to reflected light and some things on the ground can be better "picked up" than others. Consequently, we cannot assume that a particular attribute in one forest type (for example tree density) that can be detected can be as easily identified under different conditions. And different remote sensing products, particularly LANDSAT and SPOT imagery, have different sensitivities by way of how their sensors record reflectivity.

Reflectivity gets broken down and characterized into a particular **band**. The greater the number of bands and the range of what satellite sensors can detect as differentiating colours, the more "sensitive" is the imagery. But this makes storage and computation more difficult. The question becomes one of should brown-dark-green (maybe there are naturally occurring gaps in the forest) be grouped with yellow-dark-green (perhaps open forest) or with black-dark-green (possibly a different forest type)? In order to know this, we need to **ground truth** and do enough test plots to make a **statistical analysis** and this turns the exercise into a bigger project indeed. And even with this, there is still the problem of margins of error that for old-growth attributes will probably run 10 to 30 %. This means that for discerning more subtle landscape differences than for example that between old-growth and recent clearcuts, an image could be 30 % wrong. It is all in how the many bands of image output are grouped for particular zones, slope classes, times of the year etc.

The second technical issue is the size of the unit that is automatically scanned and characterized by a satellite. These units of information are called **pixels** and they (roughly) correspond to certain areas on the ground (though steep slopes complicate this).

The smaller the pixel size, the finer the data as the satellite sensors average the light reflectivity given off a particular area. So if half a pixel has old growth forest and the other half is shoreline, the sensors might "choose" a band for one or the other (depending on which ever is greater in area) or could assign the area a wierd sort of averaged value. Now sometimes this problem can inadvertently yield some interesting results, for example in detecting certain ecological edges, but generally this requires even more work in ground truthing. The bigger the pixel size, the more there are requirements for **correction** and the less fine and dependable is the data. SPOT imagery is by far better than LANDSAT data in this respect but its use brings up the costs and it has greater requirements for computer storage.

The most important use of remote sensing in old growth inventorying in the coming years will be for districts with rapid change from logging (such as the Queen Charlottes and Kyoquot Sound) where there are major contrasts between recent clearcutting and thick, coastal hemlock zone forest. Except in the few cases where an area was all clearcut within a year, LANDSAT data would be more accurate. For the interior dry Douglas fir zone, it will not be as easy to detect human induced differences with forest mosaics because the natural gaps are larger - except where there is major soil disturbance. Possibly SPOT data would be workable for this.

In both cases, the greatest value of such projects would be in illustrating the loss of contiguous areas of mature forest and to highlight the need to conserve the remaining fragments. But as far as propagandizing goes, it would also show that there is still a lot of areas of non-marketable timber which while not really having the necessary old growth attributes, as determined by socially derived biological conservation and recreation criteria, give off the same reflectivity as, for example, "cathedral" old growth - at least with a particular pixel size and type of spectral sensitivity.

From a technical and costing standpoint, the resources required for data acquisition and ground truthing suggest that more in-depth field work and compilation of inventory data will still be necessary. But the major obstacle is not technical but rather conceptual and the problem is in defining key old-growth attributes for each biogeoclimatic zone, sub-zone and landform type in the province and then being able to process the imagery consistently.

There is a maze-like decision-tree to scramble up through and the fruits of these labours will not solve the dilemmas in inventorying old growth that we are now faced with. The longer-term opportunities for use of satellite imagery are more attractive but this will require ground truthing and evaluation of various scenes of the same areas over decades.

Research priorities

Biogeoclimatic zones:

Coastal western hemlock (with LANDSAT - better differentiates greens)
Interior dry Douglas fir (with SPOT - better differentiates human-induced from natural gaps)
Coastal Douglas fir (with SPOT - better identifies small fragments of mature phases)
Interior black spruce (with Landsat - better differentiates seral phases and the impacts of fire over regions)

Land use settings:

Areas of currently undergoing rapid and large-scaled landscape alterations

Types of scales for hardcopy maps:

1:25,000 to 1:100,000 (SPOT is optimal)
1:100,000 to 1:250,000 (LANDSAT is optimal)

Scientific questions:

What are the key old-growth attributes to be inventoried for each biogeoclimatic zone?
What combinations of old-growth attributes as detected through satellite imagery constitute the highest priorities for conservation?

Technical issues:

1. determination of the minimum level of accuracy acceptable for the purposes of particular old-growth inventory project
2. determination of the maximum number of spectral aggregations (colours) for a particular monitor scene/hardcopy output
3. determination of a minimum level of sampling and monitoring over time including size and number of plots and on-the-ground characterization criteria

Equipment and costing

1. a Unix-based workstation with a large colour monitor and a 36" colour plotter

(large digitizing tables are optional) (For work with more than just a scene and especially with SPOT data a DOS-based microcomputer is too slow and there is not enough storage.)

2. tapes of the satellite scenes (not cheap and for regional views problematic if more than one scene are taken at different times) (Some kind of pre-processing of the data is usually necessary.)

3. imagery processing software

4. geographic information system (storage oriented) software (ARC | INFO is unfortunately still the best for current models of workstations.)

5. geographic information system (modelling oriented) software such as SPANS-TYDAC or GRAS.

references

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