University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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MSc (University of Victoria, 2010)
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"Derivation of Forest Productivity and Structure Attributes From Remote Sensing Imaging Technology"

Department of Geography

Friday, December 21, 2018
9:00 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Olaf Niemann, Department of Geography, University of Victoria (Supervisor)
Dr. Cosmin Filipescu, Department of Geography, UVic (Member)
Dr. Frederick Wrona, Department of Geography, UVic (Member)
Dr. Barbara Hawkins, Department of Biology, UVic (Outside Member)

External Examiner:
Prof. Richard Lucas, Department of Geography and Earth Sciences, Aberystwyth University

Chair of Oral Examination:
Dr. Thomas Reimchen, Department of Biology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

There are considerable expenditures by government and private forest industry to enhance the growth of forests and reduce time required for crop rotation. The effectiveness of some of these treatments is dependent on site productivity. In addition, as responsible stewards of the forest resource and habitat, it is important that the state of forests are actively monitored, especially in the face of a changing climate and increased rates of disturbance. This dissertation reports on the development of a method for estimating and mapping forest productivity.

The Shawnigan Lake thinning and fertilization forest installation, established in 1971 by CFS, was selected as the study site largely for its rich mensuration history. Square treatment plots were 0.04ha in area and included two thinning levels (1/3 & 2/3 of the basal area), two fertilization treatments (224kg & 448kgN/ha) with repeated fertilizations and macronutrient experiments (S, P) and control plots. A sample of plots was selected for high precision ground based lidar reference surveys. In September of 2012 a multi-sensor airborne survey of SLP was conducted that collected high-density lidar (up to ~70pnts/m^2) and VNIR imaging spectroscopy. A thorough empirical radiometric calibration was conducted in addition to a spatial calibration at the Victoria International Airport.

A combination of area based height percentile, point density ratios and statistical moments with individual lidar tree metrics including height distribution and proximity metrics were generated. Topographic metrics were also generated from the lidar ground classified point cloud. A library of spectral indices was computed from the imaging spectrometer data, with an emphasis on those indices known to be associated with vegetation health. These metrics were summarized to the plot level for a coarse scale regression analysis. A control survey and ground based lidar was used to facilitate an individual tree based fine scale of analysis, where reference data could unambiguously be matched to airborne collected data through the projected positions.

Regression analysis was conducted applying the best subset regression with exhaustive feature selection search criteria and included a critical evaluation of the resulting selected features. Models were investigated considering the data source and in combination, that is, lidar metrics were considered independent of spectroscopy as well as the converse, and lidar metrics in combination with spectral metrics.

The contribution of this study to the remote sensing knowledge base is that productivity as represented by periodic annual increment in volume is accessible to estimation from remote sensing technologies. In this study the use of gridded generalizations of the individual tree approach provided for reduced estimation errors for both structural and productivity attributes. At the plot-level productivity was best estimated by features related to both crown structure and crown health, the spatial resolution of the spectrometer was insufficient to benefit estimates at the individual tree level. The study emphasizes the dangers of empirical modeling; at the even-aged SLP installation, growth is strongly tied to structure and the extrapolation to other sites is not expected to provide unbiased values. It is my perspective that physical lidar structural models of the dominant and co-dominant crown classes be used to augment spatially explicit tree and stand growth models. In addition, direct measures should be obtained by multi-temporal lidar surveys or as an alternative photogrammetric point clouds after an initial lidar survey to quantify growth and aid in calibrating growth models.