Development of a cartographic index of forest stand vitality using an Ikonos satellite image

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Abstract

For a better forest planning and management, improvements of methods used to estimate and map the vitality of forest stands need to be made (Glon, 2003). In New Brunswick, a timber shortage is being felt, arising from an imbalance between industrial wood supply and forest yield. Thus, it becomes urgent that effective methods of wood supply assessment be readily available for use by foresters, while they develop forest management plans. In forestry, stand vitality is an index of the production capacity of a forest stand, composed of a given species growing in a given location (Rondeux 2004). Traditionally, forest field inventory data are used to compute the vitality index. However, such data collection procedures are costly and time consuming (Canadian Forest Service, 2004). The advent of new generations of high performing sensors in remote sensing has made possible the automatic extraction of dendrometric data (tree species, height, canopy structure, stand vitality, biomass ...) from aerial photos and satellite images (Hall *et al.* 2000). Arising from the need to develop an automated method for forest stand vitality assessment, the objective of the current study was to develop a cartographic index of forest stand vitality based on remote sensing.

Dendrometric data (dbh, height, age) were collected during field inventories of various forest stands mainly composed of fir, intolerant hardwoods and tolerant hardwoods species typical of the study area of Gounamitz, in the north-west of New Brunswick. These data were used to compute reference estimates of stand vitality for each sample stand, using the Lebel's vitality equation (Lebel, 1996). Subsequently, corrected reflectance values for inventoried tree species were extracted from an Ikonos satellite image of the study area, after fusion, segmentation and classification were performed. Vegetation (NDVI, MSAVI, TSAVI, etc.) and texture (homogeneity, contrast, entropy, etc.) indices were also extracted from the Ikonos image. Regressions were then established between reference estimates of stand vitality computed earlier (as the dependent variable) and extracted remote sensing data (as independent variables). Three models of multiple regressions (linear, polynomial and logarithmic) were tested. Individual species were grouped into three classes: fir, intolerant hardwoods and tolerant hardwoods; subsequently the three regression models were tested on the data set of each class and the one with the best R^2 was selected as the single regression equation to be applied on all stands of that species class in the study area.

Of the three regression models tested, the linear one had the highest R^2 and yielded good estimates of stand vitality. Computed coefficients of determination (R^2) were 0.771, 0.783 and 0.776 for fir, intolerant hardwoods and tolerant hardwoods, respectively. To validate the chosen model, stand vitality values obtained by prediction with the regression equation were compared to those computed from field inventory data of 32 validation sample plots. Residual error values obtained with these validation plots were 0.17, 0.29 and 0.10 for fir, intolerant hardwoods and tolerant hardwoods, respectively. Further, the results of this study were applied over the whole study area, using remote sensing data to generate a map of stand vitality index for the area. This study allowed us to explore the usefulness of high resolution Ikonos satellite images for the mapping of forest stand vitality.

References

Andersen, G.L. (2003) Classification and estimation of forest and vegetation variables in optical high resolution satellites: A review of methodologies. *International institute for applied systems analysis, Interim report. 20p.*

Beaudoin, A., Guindon, L., Lambert, M.-C., Ung, C.-H., Simard, G., Luther, J.E. and Fournier, R. (2003) A method for scaling up biomass of Canadian subarctic forests from tree to landscape levels using ground plots, Quick bird and Landsat data. *25 th Canadian Remote sensing Symposium & 11th Congress of the Association Québécoise de Télédétection, Université de Montréal, Montréal, 10 p.*

Canadian Forest Service. (2004) Décroissement causé par les insectes et les maladies des arbres au Canada. *Rapport d'informations ST-X-8. Ressources naturelles Canada, Ottawa.*

Fournier, R.A., Mailly D., Walter, J.-M.N. and Soudani, K. (2003) Indirect measurement of forest structure from in situ optical sensors. *in Remote sensing of forest environments: Concepts and case studies, p. 77-113*, Edited by Wulder M. and Franklin S., 519 p.

Franklin, S.E. (2001) Remote sensing for sustainable forest management. *Lewis publishers, 407 p.*

Glon, M.S., Franklin, S.E. and Wulder M.A. (2003) Object-based analysis of Ikonos-2 imagery for estimation of forest species composition and crown closure. *25 th Canadian Remote sensing Symposium & 11th Congress of the Association Québécoise de Télédétection, Université de Montréal, Montréal, 10p.*

Hall, F.G., Shimabukuro, Y.E. and Huemmrich, K.F. (2000) Remote sensing of forest biophysical structure using mixture decomposition and geometric reflectance models. *Ecological Applications, vol. 5, n0 4, p. 993-1013.*

Lebel, R. (1996) Assessment of tree vigour and the merchantable volume of wood in stands of mature and over mature spruce and balsam fir using remote sensing techniques. *Projects 5.1 Applied R & D Canada / New Brunswick Cooperative Agreement on Forest Development*, *75 p.*

Rondeux, E. (2004) Tree vigour and height growth in Black Spruce. *Trees 5 : 158-163*