Complex Stand Structures and Associated Dynamics: Measurement Indices and Modelling Approaches

Introduction

Complex forest stands arising from paradigm shifts in forest management practices (e.g., variable retention silvicultural systems, natural disturbance pattern emulation, systematic/selection mechanized thinning treatments) represent an increasing proportion of the productive forest land base throughout many of the world's forested ecosystems. Characterized by structural heterogeneity (e.g., multimodal diameter, height and age distributions with aggregated and segregated spatial patterns), complex stands are intrinsically difficult to measure and model, particularly in terms of their structural attributes (e.g., size distributions and spatial patterns) and temporal dynamics (e.g., survivor growth, ingress (regeneration), mortality, succession vectors and spatial dynamics).

In response to this analytical challenge, discussions were initiated with various members of the regional (Ontario Forest Research Institute), national (Canadian Forest Service) and international (Units 4.01.02 (Growth models for tree and stand simulation), 4.01.00 (Forest mensuration and modeling), 4.01.03 (Instruments and methods in forest mensuration), and 1.05.00 (Uneven-aged Silviculture) of the International Union of Forest Research Organizations (IUFRO)) forest science and management communities. The resultant consensus derived from these discussions was the need to benchmark the current state of knowledge, share successes and compare various measurement and modeling approaches via an international scientific conference. Consequently, the conference, entitled "*Complex Stand Structures and Associated Dynamics: Measurement Indices and Modeling Approaches*", was held in Sault Ste. Marie, Ontario, Canada over the July 29th – August 2nd, 2007 period.

The conference program consisted of six plenary sessions, concurrent poster sessions and a field tour day in which some of the complex stand structures common to the Great Lakes – St. Lawrence Forest Region of central Canada were visited. The plenary sessions consisted of a state-of-the-art overview of the session theme by an invited keynote speaker followed by a series of volunteer oral presentations. Specifically, the sessions were entitled Overview of Complex Stand Structures, Dynamics of Complex Stand Structures, Measuring Complexity I, Measuring

Complexity II, Modeling Complexity, and Managing Complex Stand Structures: Economic Consequences, Operational Challenges and Decision-support Tools. In total, approximately 100 participants representing 15 countries attended.

This mini-Special Issue of *Forestry* augments the Popular Summaries presented previously by Newton and LeMay (2007) by highlighting a subset of the submitted conference papers.

Ignacio Barbeito and co-authors examine the effect of stand structure on regeneration dynamics within simple and complex Stone pine (*Pinus pinea* L.) stand-types situated in the Northern Plateau of Spain. Conceptually, they link the results of a series of spatial pattern analyses with species-specific ecological characteristics to explain regeneration processes and patterns. The results from univariate and bivariate spatial analyses revealed a facilitative relationship between the overstory and understory populations. This positive relationship was partially explained by the limited seed dispersal distances and localized crown-induced regeneration niches provided by the overstory trees. Operationally, the results suggest that implementing uneven-aged management strategies in order to generate complex multi-aged structures would increase regeneration success within Stone pine stand-types. In conclusion, the delineation of the principal environmental determinates underlying spatial pattern formation as demonstrated in this study represents an analytical advancement and framework for further work in spatial analyses.

Shawn X. Meng and co-authors presents an innovative site-dependent dynamic species composition model for describing the temporal change in trembling aspen (*Populus tremuloides* Michx.) composition within boreal mixedwood stands. Parameterization involved an indepth evaluation of a suite of covariance structures in association with a nonlinear mixed model approach. The results clearly demonstrated the importance of including site quality within the model specification when describing succession change. The impressive ability of the resultant model to precisely describe the temporal pattern of species composition change suggests that the proposed model would be of utility when developing species-specific growth and yield projection systems for boreal mixedwoods.

Hubert Sterba introduces a new application of species and diversity indices based on angle count sampling data for characterizing complex Spruce (*Picea*) – Fir (*Abies*) - Beech (*Fagus*) stand-types situated in the Austrian Alps. The indices include spatially inexplicit (Shannon index,

coefficient of variation, Gini coefficient, skewness coefficient) and explicit (Pielou's segregation index, Clark and Evans index, and differentation index) measures. Application of the indices to a large 750-ha forest management district revealed that the indices could be successfully used to discriminate among the various complex stand-type variants. These results suggest that the indices may have wider applicability in forest inventory and silvicultural decision-making including differentiating and detecting management transitions between even-aged and individual tree selection systems.

Yuqing Yang and co-authors develop site-dependent dynamic stocking models for white spruce (*Picea glauca* (Moench) Voss), lodgepole pine (*Pinus contorta* Dougl. var latifolia Engelm.) and black spruce (*Picea mariana* (Mill.) B.S.P.). The employment of spatially-explicit permanent sample plot measurements combined with the difference equation technique and direct error modeling represents an innovative analytical approach which may have wider utility. The authors also demonstrate the utility of the models in deriving stocking indices and examining interspecific competition relationships. Operationally, the incorporation of the resultant stocking models within growth and yield projection systems will play an important part in quantifying the linkage between reforestation success and long-term stand performance.

Collectively, these papers and the others presented at the conference illustrate some of the quantitative challenges faced by the forest science and management communities in the measurement, modeling and management of complex stand-types. The plausible solutions and innovative approaches offered by the authors should provide the foundation for future advances in this area.

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References

Newton, P.F. and LeMay, V. 2007. *Complex Stand Structures and Associated Dynamics: Measurement Indices and Modelling Approaches - Popular Summaries*. Forest Research Information Paper No. 167. Ontario Forest Research Institute, Ministry of Natural Resources, Sault Ste. Marie, Ontario, Canada.