2010 Western Mensurationists' Conference
Presentation Abstracts

Session 1. Projections & Processes

08:20 June 21st

Moderated by Renate Bush

Aaron Weiskittel, Nicholas L. Crookston, and Phillip J. Radtke

Mapping current and future potential site productivity: Are process-based models needed?

Understanding regional variation in site productivity and the potential influence of climate change is critical for predicting future growth and long-term forest planning. Output from process-based growth models has been the preferred means for mapping current site productivity across large regions because it is a more mechanistic approach and the output tends to show a strong link with observed site index (Swenson *et al.*, 2005; Waring *et al.*, 2006). This same approach of using process-based models has also been recently extended to mapping future productivity with different projected climate change scenarios (Coops *et al.*, 2010). However, a basic question has not been addressed yet by this work; is the complexity of process-based models needed to accomplish the intended objective of mapping current or future potential productivity? This study attempts to address this question, while providing maps of current and future potential site productivity across the Western United States.

To avoid species and equation differences, individual tree height and age data obtained from the Forest Inventory and Analysis plots (FIA) were converted to a standard Douglas-fir site index. For the majority of species, a strong correlation between the FIA observed site index and the estimated standard site index was found ($r = 0.84 \pm 0.16$). Strong correlations were also observed between the standard site index and the output from 2 process-based models (3PG & MODIS). However, the output from the process-based models was not included in the top variables identified by random forests for predicting site index. Instead, it was found that two climatic variables could predict over 72% of the original variation in site index despite the wide range of conditions covered by the analysis. The two climate variables included the ratios of annual moisture index to growing degree days and precipitation during the growing season to the average difference between monthly max and min temperature.

Maps of current and future site index were developed for the western United States. For the majority locations, the predominant trend was an increase of 0 to 5 m by 2030, with an increasing proportion of sites experiencing reductions of 10 to 15 m in 2060 and 2090. The increases in site index were most evident in the Idaho Central Rockies and western Montana, while the reductions were most severe in the Coast Range and Cascades of Oregon and Washington.

This talk will explore the limitations with using process-based models experienced by this analysis, the implications for mapping current and future climate, and make suggestions for future work in this area.

Elizabeth McGarrigle

Combining historic growth and climate data to predict growth response to climate change in balsam fir in the Acadian Forest region

Permanent sample plot data from plots consisting of greater than 75 percent balsam fir were compiled for the Acadian Forest region. Measurements on these plots date back as far as the early 1960's. Historic growth for these plots was calculated using all trees greater than one centimeter and was calculated for each remeasurement period until stand basal area began to decline. Growth efficiency was calculated using the historic growth divided by leaf area index for each plot at each time period. Growth efficiency for each plot and year was then examined in conjunction with historic climate data for each plot location.

Jack Lonsdale

Creating a hybrid process-empirical model for growth prediction of Sitka spruce in the UK

Static yield tables created by the Forestry Commission are prevalently used by forest managers in the UK. While accurate in many cases, these tables only allow for certain thinning regimes, and do not provide growth predictions for stands younger than 20 years. Predictions for young stands are of increased importance given current emphasis on biomass' role in global carbon balances. Forest growth is usually predicted using either empirical growth models or process-based models, and both have their advantages and disadvantages. The development of a model which combines both empirical and process-based model aspects should allow forecasts of growth for all ages of forest stands with any thinning regime will be possible. Specifically a dynamic systems model will be used for stem and volume development while incorporating physiological variables from the 3-PGS model to account for canopy closure, stand occupancy and potentially site quality. The dynamic growth part of the model will provide a more logical stem growth function than the current model in 3-PG. The use of 3-PGS should allow the model to be easily parameterised using remote sensing data, as well as providing a way to forecast stand development from open to closed stands following planting or thinning. The structure of the model will be discussed, including how it can be adjusted in the future for other species. Preliminary results will also be presented.

Session 2. Sampling Topics

10:50 June 21st

Moderated by David Affleck

James A. Westfall, W.A. Bechtold, and K.C. Randolph

An assessment of repeatability for crown measurements taken on conifer tree species

The Forest Inventory and Analysis program (FIA) of the U.S. Forest Service collects a suite of tree crown data on a subset of sample plots. Measurements are taken on crown position, crown light exposure, crown dieback, foliage transparency, uncompacted crown ratio, vigor class, and crown density attributes. Accurate measurements of these characteristics are important as they are used in a wide variety of applications, including assessments of forest health and as inputs to fire models. The repeatability of these measurements taken on conifer species was evaluated using data from independent remeasurement of the same trees by a second field crew. Preliminary results indicate that crown light exposure, crown dieback, and foliage transparency measures had acceptable repeatability, however, uncompacted crown ratio, crown position, vigor class, and crown density were less repeatable than desired.

Jim Flewelling and Jacob Strunk

The Walkthrough and Beyond solution to the boundary overlap problem

The boundary overlap problem refers to the fact that trees near stand edges often have reduced probabilities of being sampled. Numerous estimators for basal area have been proposed that are unbiased or approximately unbiased in some or all circumstances. The walkthrough method by Ducey *et al*. (2004) is one of the easiest and fastest methods to apply. A modification of that method is proposed. Along the line which connects the sample point and a particular sample tree, distances from the tree to any intersected stand boundaries are recorded if those intersections are within the conceptual tree-centered plot. The recorded distances are used in calculating sample weights that allow for unbiased estimation of basal area under all circumstances. The mean-squared error for this estimator is generally less than that of the walkthrough method, but greater than that for the tree-concentric method.

Z. Haxton, T. Marquardt, and H. Temesgen

N-tree distance sampling in riparian forests of western Oregon: a simulation study

N-tree-distance sampling, a selection method whereby the nearest *n* trees to a given plot center are sampled, has been advocated as an efficient method of estimating stem density and basal area. In addition, the distance measurements that are a byproduct of the method can be used to estimate parameters of the spatial distribution of tree locations, which may be of interest in ecologically-oriented sampling applications. While a wide range of estimators have been devised to minimize the bias inherent in the method under various forest conditions, the performance of n-tree-distance sampling has yet to be tested in conifer-dominated forest types of the Pacific Northwest.

This study evaluated the performance (in terms of relative bias and RRMSE) of selected n-tree distance estimators, in comparison with fixed plot and variable plot sampling, using stem-mapped plots taken from headwater riparian forests in western Oregon. I also examined the performance of n-tree-distance estimators for constructing stand and stock tables by species and diameter class. I found that, with $n \geq 4$, the best n-tree-distance sampling estimator had negligible bias (comparable with fixed plot and variable plot sampling) for both density and basal area estimates. RRMSE values were also comparable with fixed plot and variable plot sampling for both density and basal area. Within most forest types examined, n-tree distance sampling offered reasonable results. However, the method seems to perform poorly when estimating density in clumped hardwood populations, and results from this study should be extrapolated with care.

George McFadden

Creation of a LiDAR field laboratory using Panther Creek Watershed

Light Detection and Ranging (LiDAR) is an emerging technology that is being adapted as an information source in resource management. The creation of field laboratory to study the potential uses and challenges of LiDAR will lead to a better understanding of the technology.

The Panther Creek watershed located in the Willamette Valley of western Oregon is a 5,700 acre field laboratory where several organizations have joined together to acquire LiDAR and associated resource data to study not only LiDAR but also the correlation s that can be derived between the LiDAR data and other resource information.

The data collection plan includes 5-years of annual collection of discrete return leaf-off LiDAR, a minimum of 2 leaf-on discrete return LiDAR sets, a minimum of 1 leaf-on wave form LiDAR data set, a minimum of 1 Quickbird 4 band color imagery, 2 sets of NAIP 3 band color imagery, and a minimum of 1 hyperspectral set of color imagery. Associated data sets include physical and chemical analysis of 35 soil pits, 78 stem mapped 1/5th acre vegetation plots that are part of three different sample designs one of includes the 35 soil pits, supplemental soil carbon and bulk density core samples, installation of a remote weather station and monitoring of soil moisture and temperature at each of the soil pits. Potential plans include collection of terrestrial LiDAR on a subset of the vegetation plots along with high density discrete return leaf-on LiDAR for the same plots. This data is available to anyone that wants to use the data sets.

Session 3. Invited Session on Conifer Crown Modeling 13:15 June 21st

Moderated by Chris Keys

Doug Maguire

Response of crown and canopy structure to stand density regime in western conifers

Crown structure influences tree growth and vigor, habitat structure, wood quality, ecophysiological processes, biomass allocation, and fire behavior. Specific attributes of interest depend on the objective being pursued, and range from simple crown length and width, to primary and higher-order branching structure, to full three-dimensional characterization of branch and foliage distribution. Stand canopy structure is commonly manipulated by silvicultural interventions such as controlling density and spatial arrangement of individual trees; however, the effects of silvicultural treatment on individual-tree crown structure are more subtle. Mixed species spacing trials in central Oregon (Pinus ponderosa-Pinus contorta and Pinus ponderosa-Abies grandis) have demonstrated systematic variation in crown length, foliage distribution, branching structure, and crown bulk density among different initial spacings, but also among plots of differing species composition at a given spacing. Thirty years after planting, close spacings (6-ft) have resulted in stratified mixtures, but wide spacings (18-ft) exhibit a main canopy with more equitable mix of species. Projecting these plots forward by simulation with the growth model ORGANON demonstrate the rise and fall of branch litter production with crown closure, crown recession, and deceleration in height growth over a 100-year rotation. Periodic annual production of dead branches can reach 2 tons/ac/year, and total cumulative production can reach 100 tons/ac over the 100-year period. Results from other studies show that the number of whorl and/or interwhorl branches varies among western conifer species and among stand density regimes within a species. For some research and associated management objectives, additional work is needed on crown profile models, needle age class dynamics, and sources of within-crown and between-tree variation in foliar nutrient content in western conifers.

Harry T. Valentine

Remembrance of crowns past

I present updates on two published models: the `crown-rise model' and the `bridging model.' The crown-rise model is concerned with the estimation of crown length from average tree height and spacing. The bridging model, which incorporates the crown-rise model, is concerned with estimation of the development of stem diameter and taper from the rates of change in tree height, crown length, and local spacing. Some results are presented for loblolly pine, including projected stem profiles that demonstrate the effect of spacing on both diameter and height. I also briefly touch on the theory of allometric scaling and the estimation of foliage mass, providing references that may serve as good entry points into these literatures.

Tara Keyser

Influence of crown biomass estimators and distribution on canopy fuel characteristics and potential fire behavior for ponderosa pine in the Black Hills

Two determinants of crown fire hazard are canopy bulk density (CBD) and canopy base height (CBH). The Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) is a model that predicts CBD and CBH. Currently, FFE-FVS accounts for neither geographic variation in tree allometries nor the non-uniform distribution of crown mass when estimating CBH and CBD. We develop allometric equations specific to ponderosa pine (Pinus ponderosa Dougl. ex Laws.) in the Black Hills to predict crown mass and use the Weibull distribution to model the vertical distribution of crown mass within individual trees. We present parameter prediction models that, in turn, predict the vertical distribution of crown mass based on stand- and tree-level attributes. Using a FFE-FVS executable incorporating local crown mass equations and the parameter prediction models, new estimates of CBD and CBH were produced. Locally-derived biomass equations predicted substantially greater estimates of foliage mass than currently predicted by FFE-FVS. The increase in CBD resulting from the local biomass and vertical distribution models averaged 78% over original estimates. These results suggest locally-derived crown mass equations in addition to non-uniform estimates of crown mass distribution be used to calculate CBH and CBD as used in fire prediction models.

Harold E. Burkhart

Modeling crown characteristics of loblolly pine trees

Crown measures are essential for informed decision making when managing loblolly pine plantations for production of wood products. Crown size influences response to silvicultural treatments and it has a major influence on wood quality and value for certain products. Loblolly pine crowns are highly variable and difficult to model. Measurements taken and modeling methods employed will be reviewed for two past studies aimed at modeling loblolly pine crown morphology. Challenges and opportunities for further research in modeling crown morphology in the context of intensively-managed pine plantations will be proposed.

Session 4. Modeling Silvicultural Impacts 08:15 June 22st

Moderated by John Goodburn

Ralph L. Amateis and Harold E. Burkhart

Impact of pruning young loblolly pine trees: 10-year growth results

In the Spring of 2000, a designed experiment was established to study the effects of pruning on juvenile loblolly pine (*Pinus taeda* L.) tree growth, and the subsequent formation of mature wood. Four blocks were established at each of two locations in the Piedmont region of Virginia. Trees were planted at a 3m x 3m square spacing in plots of six rows with six trees per row; the inner 16 trees constituted the measurement plot. The treatments were an unpruned control and four pruning treatments where half the live crown was removed (live crown length was reduced by half) at age 3, age 6, age 9 and the fourth plot with crown removals at ages 3, 6 and 9. Annual measurements from age 3 for each tree included dbh, total height, height to base of live crown, crown width within the row and crown width between the row. Results are presented that show the initial impact of early pruning on tree growth through age 10.

Gilciano Saraiva Nogueira, Peter L Marshall, Helio Garcia Leite, Valerie M LeMay, and João Carlos Chagas Campos

Thinning impacts on even-aged stands of eucalyptus in Brazil

Thinning in eucalyptus forests can help increase Brazilian participation in the global market for solid wood products and may reduce pressure on Brazilian native forests. There are few studies on the impact of thinning in stands of eucalyptus in Brazil since most plantations were established for the production of fibre for pulp. Thus, an experiment was conducted in eucalyptus forests to analyze the effect of thinning on tree and stand variables. This thinning experiment was located in Bahia State, Brazil, in stands containing the *Eucalyptus grandis* x *Eucalyptus urophylla* hybrid. It was based on level-of-growing-stock experiment with three installations. Each installation was comprised of six blocks. Each block contained eight permanent rectangular plots, with an area of 2,600 m^2, for a total 48 plots at each installation. There were four treatments, corresponding to different basal area percentages removed in each thinning (20% without pruning, 35% without pruning, 50% without pruning, 35% with pruning. The initial spacing between trees was of 3.0 x 3.0 m. The plots were measured at 27, 40, 50, 61, 87, 76, 87, 101, 112, 122, 137, 147, 158 and 165 months. Two thinnings were applied at 58 and 142 months. The presentation will provide a summary of stand-level variables and the growth of these variables over time by thinning treatment, as well as variance analyses for gross periodic annual increment for basal area and total stem volume.

Leah Rathbun

Modelling tree growth under varying silvicultural prescriptions for mixed-species stands in coastal British Columbia

Gap dynamics define the forest structure and natural successional processes on Vancouver Island (Lertzman et al. 1996), with Douglas-fir as the dominant, pioneer species and western hemlock and western redcedar as late-successional species often aggregated within gaps (Getzin et al. 2006). In juvenile stages of growth, shade intolerant species, such as Douglas-fir, utilize photosynthate to height growth rather than diameter growth (Chen and Klinka 2003), outcompeting western hemlock, a shade-tolerant species. These differences in growth patterns due to levels of shade-tolerance are further complicated by species composition. In this area, Douglas-fir grows above shade-intolerant western hemlock and it has been suggested that resources between the two species are used in complement (Erickson et al. 2009). Management practices in this area have included clearcutting, thinning, variable retention harvesting, and fertilization. The complexity of stand structure is further supported by diversity within treatments applied as thinning intensity, timing of thinnings, and number of thinning. Forest management planning requires the development of growth models as a component of stand development under varying silvicultural treatments (Palahi et al. 2003). To model growth increment under different silvicultural treatments found on Vancouver Island, a flexible increment model is required. The Box and Lucas model is based on the metabolic processes governing tree growth, which unlike other models, allows for direct interpretation and can result in accurate predictions. The Box and Lucas model was fitted for three main species: Douglas-fir, western hemlock, and western redcedar using a random coefficients modeling (parameter prediction) approach to determine parameters. To estimate the impacts of thinning and fertilization on increment growth, a two-step additive approach was tested, in that increment was modified due to fertilization, and then again due to thinning.

Session 5. Advancing Methodology

10:15 June 22st

Moderated by David Affleck

Suborna Ahmed

Modeling tree mortality for large regions using combined estimators and meta-analysis approaches

Regular mortality models for aspen, white spruce, jack pine, and black spruce across the Boreal Forest of Canada are commonly developed using a generalized logistic model at a local scale. To obtain models at a regional scale, a number of approaches could be used: i) one or more existing local scale models could be used to model mortality; ii) all available data could be pooled to fit new models; or iii) a meta-analysis approach using existing models and data could be used. In this research, combined estimators and meta-modeling approaches were used to combine data and local scale models to obtain a general model for the regional scale to improve model precision over naïve approaches. Alternative estimators were proposed for this purpose, including Stein-type estimators and hierarchical related regression models. Results of applying a few of these estimators are presented in this paper, using data from Alberta.

Nicholas L. Crookston and Gerald E. Rehfeldt

How to solve a classification problem with 45 class levels using Random Forests

Large classification problems with many class levels are especially challenging to solve. The Random Forests algorithm has proven exceedingly powerful in solving classification problems but it limits the number of class levels to 32. In this presentation we show how we built an ensemble classifier of 100 individual Random Forests to classify 45 biotic communities using climatic variables. The method provided a side benefit of supplying an indication of extrapolation when the classifier was used to predict biotic communities in future climates. This was accomplished by providing an additional class, of "none of the above", in each of the Random Forests in the ensemble. The additional class joined 10 real classes in each ensemble member and subsequently, the prediction of "none of the above" was interpreted as being a novel climate. Classification errors of less than 10 % are partly attributed to obvious errors in the source data which could not be addressed. The method could be used to solve even larger classification problems.

Guillaume Thérien

Models and smoke-screens

Les modèles de prédiction sont souvent employés en foresterie, particulièrement en dendrométrie. Ces modèles sont généralement construits avec une équation mathématique relativement simple, quelques paramètres qui doivent être estimés et un petit nombre de postulats. Les critères dévaluation des modèles de prédictions sont généralement concentrés sur la précision plutôt que le biais. Pourtant, le biais devrait être le premier critère d'évaluation pour un modèle de prédiction. Parce qu'on ignore souvent le biais local, le manque de flexibilité des modèles paramétriques n'est jamais remis en question. D'un autre côté, les modèles non-paramétriques sont très flexibles mais peu utilisés, probablement parce que mal connus. Pourtant, leur grande flexibilité en fait des candidats idéaux pour les modèles de prédiction. Dans cette présentation, je défendrai la cause des modèles non-paramétriques.

Predictive models are widely used in forestry, particularly in dendrometry. These models generally rest on relatively simple mathematical forms, a few estimated parameters, and a small number of assumptions concerning the underlying data generating mechanisms. Although bias ought to be a primary evaluation criterion for predictive models, model evaluations often focus on precision over bias. Indeed, local model bias is typically ignored and, as a consequence, the lack of flexiblity of parametric predictive models is seldom noted or discussed. Non-parametric models by contrast are highly flexible but less familiar and rarely used. The greater flexibility of non-parametric models makes them ideal candidates for predictive modeling and in this presentation I take up their cause.

[Translated from the French by the Chair.]