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TREND ANALYSES AND PROJECTIONS USING NATIONAL FOREST INVENTORY DATA

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Abstract. We present a collection of papers derived from the 2012 Forest Inventory and Analysis (FIA) Symposium held on December 4-6, 2012 in Baltimore, MD, USA. The symposium featured 128 oral presentations with nearly 200 attendees from the United States and other countries. A proceedings from the symposium included 75 papers as well as abstracts for all presentations and posters. The symposium theme, *Moving from Status to Trends*, focused on the ability to perform trend or time series analysis using national forest inventory data. A wide range of topics were covered including forest products, social dimensions of forestry, landscape change, analytical tools, Landsat time series, forest carbon, and many others. Based on these presentations, we have assembled a selection of several papers that presented examples of trend analyses and projections using forest inventory data. This Special Issue contains four of these papers that passed the MCFNS double-blind peer-review by a minimum of three peers.

Keywords: forest inventory; forest monitoring; trends; projections; time series; FIA.

1 Background

The passage of the McSweeney-McNary Act in 1928 by the United States (U.S.) Congress authorized the U.S. Department of Agriculture (USDA) to conduct periodic forest inventories, and work began shortly after in the early 1930s by the USDA Forest Service under the program named Forest Survey (LaBau et al., 2007). While the early focus was on timber inventory, the program eventually evolved into a multi-resource inventory and became known as the Forest Inventory and Analysis (FIA) program. A state-by-state inventory approach (i.e., periodic design) persisted for nearly seventy years, but then the Agricultural Research, Extension, and Education Reform Act of 1998 (PL 105-185) shifted the FIA program to an annual design whereby some information is gathered in all states every year (Gillespie, 1999).

Coincident with this shift to the annual design, the FIA program began a symposia series in 1999. The series was an annual event until 2006 and became biannual thereafter (proceedings can be accessed at http://www.fia.fs.fed.us/symposium/proceedings/). The symposia have been forums for sharing problems and solutions in the realm of forest inventory and eventually began drawing international attendees who are involved in national forest inventory programs in their respective countries.

A collection of peer-reviewed papers derived from the 2008 FIA Symposium was assembled in the Vol. 3, No. 2 issue of Mathematical and Computational Forestry & Natural-Resource Sciences (MCFNS) (see Cieszewski and McRoberts, 2011). Building on that effort, we have gathered papers based on the 2012 FIA Symposium. The 2012 symposium was held December 4-6, 2012 in Baltimore, MD, USA, drew nearly 200 attendees, and featured 128 oral presentations and a poster session. In addition to researchers and practitioners from federal agencies, state agencies, academia, private industry, and non-governmental organizations within the U.S., there were also participants from Colombia, Indonesia, Mexico, Peru, and the Philippines.

The symposium theme, *Moving from Status to Trends*, recognized the 20th anniversary of the first of two Blue Ribbon panels that recommended transitioning the FIA program to an annualized national forest inventory and monitoring program (with the legal authority coming later under the aforementioned 1998 act). Information on the FIA Blue Ribbon panels can be accessed at http://www.fia.fs.fed.us/library/fact-sheets/overview/FIA_BRP_FS.pdf. Since more than a

decade has elapsed since the shift to the annual design, a significant volume of re-measured annual data is now available for analyzing trends.

A collection of 75 papers was published in the 2012 FIA Symposium proceedings (Morin and Liknes, 2012). This Special Issue of MCFNS provided authors an opportunity to submit expanded versions of papers published in those proceedings, subjecting articles to a double-blind peer review process consistent with MCFNS criteria. We have selected a subset of topics that illustrate the breadth of uses of national forest inventory data as well as some of the challenges and solutions in working with inventory data, particularly as they relate to trend analysis or projections of future conditions.

2 Contents of the Special Issue

The four papers selected for inclusion in this Special Issue span a temporal gradient from recently-collected information to near-term projections to long-range predictions and clearly illustrate the enhanced power of the annual panel design over traditional periodic survey designs. They highlight the variety of information inventory programs are asked to provide (i.e., recent trends or future conditions). Topics covered include carbon sequestration, inventory methods, wildlife habitat assessment, climate change, land use change, and tree species migration.

The first paper by Clough and Green (2013) highlights the challenge of estimating forest inventory attributes that may be sparsely sampled in space. Using field data collected in New Jersey, USA, the authors examine methods for modeling soil organic carbon (SOC), which is critical to carbon accounting for forested environments. At the sampling intensity of their study, methods that account for spatial autocorrelation were found to provide no advantage over non-spatial regression methods. Their examination reminds us that each time series begins with a single point in time and that methods to accurately quantify a variable spatially must be developed in concert with sustained observations over time if we are to accurately detect trends across the entire landscape.

In the second paper, Van Deusen and Roesch (2013) apply an imputation approach to FIA data that has gained traction in the political and social sciences. Using coarsened exact matching, the authors are able to match attributes of plots that have been visited multiple times with attributes of plots that have been visited a single time. In this way, a re-measured plot can "donate" its updated information to other plots, and a very short-term projection can be constructed for any attribute of interest. This procedure is viable because of FIAs annual survey design and is a way to temporally sharpen estimates from a full cycle (e.g., 5 years) to a shorter time frame while maintaining similar precision. In addition, a procedure for generating projections under stochastic scenarios that is compatible with the methodology is also developed. This allows for the construction of what-if scenarios such as whether or not a particular forest can sustain a timber supply if harvest rates are doubled.

Moving from short-term to long-term projections, Tavernia et al. (2013) linked canopy closure status of inventory plots under future climate and land-use scenarios to a wildlife habitat matrix in order to provide projections of changes in habitat. The project builds upon a suite of models that use FIA data to provide projections of potential changes to the landscapes of the Northeast and Midwest U.S. (Wear et al., 2011; USDA Forest Service, 2013). Their coarse-filter approach to habitat assessment reveals that a shift to heavy utilization of biomass fuels could have a significant impact on wildlife and hints at the need for strategic-scale planning in this regard.

While Tavernia et al. (2013) examine future habitat conditions based on canopy closure, Potter and Hargrove (2013) predict the range of 172 tree species in the year 2050, and both studies utilize Intergovernmental Panel on Climate Change scenarios. Potter and Hargrove (2013) use current FIA trees species information and Multi-Temporal Spatial Clustering to make the predictions and also present a series of four metrics that quantify geographic differences between current and future conditions and indicate the magnitude of projected changes.

We present a sample of the state-of-the-art in inventory science with authors demonstrating both the challenges of and solutions to resource questions that require commitment to sustained observations through time. Such commitment is present in national forest inventories around the globe, and a growing body of literature utilizing data from these multi-resource inventories suggests we can not only monitor trends in resources, but we can also investigate interesting ecological questions. By assembling a collection of peer-reviewed papers here, we hope to enhance the quality of the information and to increase the visibility of the knowledge contained within the discipline.

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