Monitoring Abundance and Distribution of Non-Timber Forest Products Using the FIA Database

Jobriath Kauffman, a,b James Chamberlain, c and Steve Prisley b

The US Forest Service, Forest Inventory and Analysis (FIA) program collects data on a wealth of variables related to trees in forests. Some of these trees produce non-timber forest products (NTFPs; e.g., seeds, fruit, bark, sap) that are harvested for their culinary and medicinal values. As example, the cones of Pinus edulis and P. monophylla are collected for the edible pine nuts. The bark of more than a dozen tree species that are inventoried by FIA is collected for medicinal, decorative, and construction purposes. Slippery elm (Ulmus rubra) bark has been used for its medicinal values for more than a generation. However, despite widespread use of non-timber forest products, little quantitative information about abundance, distribution, and harvest is available to support sustainable management of NTFPs. In this project, the authors are using the FIA inventory database to assess the effectiveness of plot data to monitor and explain the situation regarding selected non-timber forest products. Our focus is on using FIA data to assess for species of interest: (1) geographic distribution, (2) abundance (number of live trees), (3) applicable metrics (e.g., square feet of bark for trees from which bark is harvested), and (4) trends in abundance and spatial distribution over time. Early results from analyses will be presented for a variety of species.

a Corresponding author (jkauffman@vt.edu).
b Virginia Tech, Blacksburg, VA.
c USDA Forest Service, Blacksburg, VA.

What, Where, and When—History and Status of the Forest Inventory and Analysis Program

John Shaw a,b

The Forest Inventory and Analysis (FIA) program, formerly known as Forest Survey, was one of the first research and development programs established in the US Forest Service. For over 80 years, FIA has been the nation’s "forest census", with a mandate to “… to make and keep current a comprehensive survey of the present and prospective requirements for timber and other forest products in the United States …”. For many years the program’s emphasis was on timber supply, but the program has constantly evolved to measure and monitor many aspects of the forest resource. In addition, changes to the program brought about by the 1998 Farm Bill resulted in greater national consistency and an annual stream of data on all states. Increasing data availability, coupled with national consistency and a freely accessible database and analysis tools, has increased the number of users and applications many-fold in recent years. This presentation sets the stage for the Inventory, Monitoring, and Assessment Training Workshop track, consisting of 24 presentations that illustrate a wide variety of inventory and monitoring activities.

a Corresponding author (jdhaw@fs.fed.us).
b USDA Forest Service, Rocky Mountain Research Station, Forest Inventory and Analysis, Ogden, UT.

Ask Questions First, Collect Data Later: Demo of an Inventory and Monitoring Design Tool

Randall Morin a,b

Inventory and monitoring systems often begin as lists of information needs which lead to data being collected in the field. Too often this occurs without clearly defining what questions the data will be used to answer. We stress the importance of beginning with the end in mind when planning an inventory and monitoring system. The purpose of the Design Tool for Inventory and Monitoring (DTIM) is to guide the development of a forest monitoring plan including the selection of objectives, questions, and metrics and the number of plots necessary to meet the precision requirements. Currently, DTIM has objectives, questions, and metrics, developed for large landscape inventories (like FIA) and National Forest System (NFS) Monitoring and Evaluation (M&E) questions used for Forest Plans, but DTIM also can be used to develop modules with alternative sets of objectives, questions, metrics, and calculations, including application at varying spatial scales (e.g., National Forest Inventories or State Land inventories) and international modules in various languages. This demonstration will include the use of the tool to develop a monitoring plan for a specific scenario.

a Corresponding author (rmorin@fs.fed.us).
b USDA Forest Service, Newtown Square, PA.

Coarse Woody Debris Carbon Dynamics: Research Insights from FIA’s Downed Woody Materials Indicator

Matthew Russell a,b

A key component in understanding forest carbon is assessing downed dead wood attributes and understanding their dynamics through time. Recent research has employed the FIA’s downed woody materials (DWM) dataset to further our understanding in this knowledge gap. Using the DWM inventory, woody debris attributes (e.g., biomass by US state, type of woody debris, and decay stage) have recently been summarized across the US. In the eastern US, repeated DWM inventories have invited research into quantifying coarse woody debris dynamics through time (e.g., estimating the duration of woody debris biomass in eastern US forests). These findings are applicable to a variety of forest managers, including those interested in understanding fuel loadings, assessing bioenergy feedstocks, and maintaining forest health features such as wildlife habitat and biodiversity.

a Corresponding author (rusellm@umn.edu).
b University of Minnesota, St. Paul, MN.
We demonstrate three methods of using Forest Inventory and Analysis (FIA) data to assess and quantify wildlife habitat at the landscape scale. Standard FIA estimation procedures using existing plot data can be used if habitat components well known and are routinely measured on FIA plots. For those applications needing to account for habitat attributes not measured by FIA field crews, study plots can be co-located with plots in the FIA grid. Where habitat attributes are not well known for the focal species, off-grid, or “phantom” plots can be established at activity sites and measurements can be related back to standard FIA plot data in order to produce area estimates for a given habitat feature. We outline the procedures for each method and provide examples of current applications in the Interior West.

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One of the critical steps in forest inventory systems is the analysis of data and presentation of results in a way that provides useful information for forest management and policy decision making. The presentation will include a framework for generating meaningful analytical reports that answer monitoring questions, information on types of estimates that can be generated, methods for creating compelling graphical and tabular outputs, and discussions of other practical aspects of distributing natural resource information to users.

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Trends in US forest biomass and carbon are assessed using annual Forest Inventory and Analysis (FIA) data, relative to baseline assessments from periodic inventories conducted in the 1990s or earlier. The integrity of baseline data varies by state and depends on the comparability of periodic versus annual forest inventory designs. In most states in the Interior West FIA region, the periodic inventory’s sample design, plot configuration, estimation procedures, and definitions were incompatible with those for the annual inventory, which are nationally consistent and spatially representative. Direct comparisons of periodic versus annual inventory estimates may therefore reflect changing protocols rather than actual changes, yet they comprise the best available method of assessing recent trends in some states. This study first clarifies trends in above-ground tree biomass in the Interior West by comparing estimates at matched plots that were sampled during both periodic and annual inventories. To illustrate the ramifications of ignoring changes in inventory protocols, trends at paired plots were compared to those exhibited by unpaired comparisons of entire periodic and annual inventories. In some states, the two methods produce contradictory results. Second, this study presents a method for calibrating periodic estimates of forest attributes using current data. Given the apples-to-oranges comparisons being made in states where periodic estimates are derived from biased or incomplete samples, periodic inventory estimates of tree biomass were calibrated using stratified regression models based on current annual inventory data and the paired plots. This approach presents an alternative baseline for long-term trend analysis.

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An effective, efficient design for forest inventory and monitoring systems is critical to their success. Effectiveness is primarily measured by the ability to answer critical forest resource questions using the estimates calculated from the collected data. Efficiency entails obtaining the desired precision of the estimates for minimum cost. To facilitate the planning process, a series of sequential and logical steps were developed that help ensure key design considerations are carefully examined and not overlooked. These steps include defining objectives, establishing cost and precision constraints, selection of sampling and plot designs (including the potential use of remotely-sensed information), and the development of data collection, compilation, and analytical infrastructure. While the steps are described in a forest inventory context, the general concepts can be readily adapted to suit other natural resource applications.
Statistically Rigorous Map-Based Estimates of Inventory Parameters
Ronald E. McRoberts*1,2

Remote sensing-based maps have become a staple of many natural resource assessments including most kinds of forest inventories. However, because maps are subject to classification and prediction errors, they only inaccurately depict spatial distributions of resources. Further, they do not directly provide estimates of parameters such as total forest area or mean volume per unit area which are the two primary forest resource parameters of interest. Further, even if map unit predictions are aggregated to produce such estimates, map accuracy indices provide no direct information regarding bias or uncertainty resulting from classification and prediction errors. Fortunately, a straightforward statistical approach can be applied to remedy all these deficiencies. Assuming a sample of ground or other accuracy assessment data has been acquired using a randomized sampling scheme, the model-assisted regression estimator provides not only an adjustment for estimated bias resulting from classification and prediction errors, but it also provides a traditional estimate of variance for the parameter estimate of interest. Two applications are presented, one illustrating estimation of forest area using a Landsat-based forest/non-forest map and the other illustrating estimation of biomass per unit area using a lidar-based map.

* Corresponding author (rmcroberts@fs.fed.us).
1 USDA Forest Service, St. Paul, MN.
2 USDA Forest Service, Newtown Square, PA.

Forest Inventory Design: Challenges and Some Solutions
Andrew Lister1,2, Charles Scott1,3, and James Westfall3

Large area forest inventory design is a complex task and requires a multidimensional approach. The US Forest Service's Forest Inventory and Analysis (FIA) program conducts the national forest inventory of the United States. FIA's National Inventory and Monitoring Applications Center (NIMAC) has participated in the design of several large-area forest resource monitoring programs in recent years, both in the United States and in other countries. The presentation will contain an overview of several of these efforts, and reveal principles of effective monitoring system design through a combination of anecdotes and presentation of survey sampling methods that address design challenges in temperate and tropical forests.

* Corresponding author (alister@fs.fed.us).
1 USDA Forest Service, St. Paul, MN.
2 USDA Forest Service, Newtown Square, PA.
3 USDA Forest Service, Northern Research Station, St. Paul, MN.

Customizing the EVALIdatorPC Tool for Forest Inventory Estimation and Reporting
Andrew Lister4,5, Patrick D. Miles6, and Charles Scott6

The estimation and data presentation procedures are critical components of a forest inventory system. Desirable properties of such procedures include implementation with commonly available software, ease of use, portability, and customizability. The Forest Inventory and Analysis (FIA) program of the U.S. Forest Service has developed a freely available Microsoft Access-based tool, EVALIdatorPC, that meets these criteria. EVALIdatorPC generates tables of estimates of forest parameters and their variance using FIA data. The presentation will demonstrate the use of the tool for analyzing FIA data as well as provide straightforward methods for adapting it to accommodate not only new FIA variables, but also inventory information from non-FIA inventories. Case studies of the use and modification of the tool with data from both the US and the Peruvian National Forest Inventory will be presented.

* Corresponding author (alister@fs.fed.us).
1 USDA Forest Service, Newtown Square, PA.
2 USDA Forest Service, PIBO Monitoring, Logan, UT.
3 USDA Forest Service, Northern Research Station, St. Paul, MN.

Collaboration between Long-Term Ecological Inventory Programs
Jeffrey Ojala7,8, Sara Goeking9, Andrew Van Wagener10, Eric Archer11, and John Shaw11

Long-term monitoring programs with seemingly disparate missions may have opportunities to collaborate and fill in data gaps to provide a broader understanding of large-scale linkages between forests and riparian systems. The PacFish InFish Biological Opinion Monitoring program (PIBO) collects data on a wide array of metrics for riparian plant communities, stream habitat & morphology, and stream macroinvertebrate biota. The Interior West Forest Inventory and Analysis program (IWFIA) collects an equally broad range of upland forest stand metrics. Both programs use a spatially balanced design over similar spatial extents to uncover ecological status and trend over time through on-site visits and remote sensing data. By scaling their respective observations to compatible spatial scales, the programs have established a conceptual framework to explore options for mutual data support. Because riparian forests are often constrained by stream hydrology, these nearly linear forests often fail to meet size requirements for sampling by IWFIA. Riparian vegetation data collected by PIBO could help assess these often unenumerated forest tracts. As upland forest conditions have been shown to affect riparian and stream habitat more discrete upland forest data may yield linkages not previously understood. IWFIA plot data and remote sensing products, analyzed at the scale of watersheds delineated by the PIBO project, can be used to explore these linkages.

* Corresponding author (jojala@fs.fed.us).
7 USDA Forest Service, PIBO Monitoring, Logan, UT.
8 USDA Forest Service, Ogden, UT.
9 USDA Forest Service, Northern Research Station, St. Paul, MN.
10 Utah State University, Logan, UT.

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The Development of an Unprecedented Tree-Ring Network for the Interior West FIA
Justin DeRose, John Shaw, and James Long

Tree-rings provide invaluable temporal information regarding tree growth and can be excellent proxies for climate data. The Forest Inventory and Analysis Program (FIA) measures forest conditions at unparalleled spatial resolution. We describe the development of an unprecedented spatiotemporal tree-ring data set for the Interior West FIA that combines measured ring-width increment with associated plot data. A protocol consistent with conventional tree-ring preparation techniques was developed to ensure proper processing, labeling, crossdating, measurement, and archiving. Increment cores had to be cross-referenced with the FIA database to determine origin and measurement year. Then cores were measured on a sliding-stage paired with a digital readout at 1 or 10 micron resolution. Quality control is conducted by crossdating with the closest available public chronology from the International Tree-Ring Data Bank. Increment cores and their ring-width measurements are archived by state and county. This ongoing project has resulted in the successful measurement of over 10,000 increment cores collected during the Periodic Inventory. Approximately 10% of those cores have been crossdated providing quality control of annual resolution. Additionally, over 2,000 increment cores collected during the Annual Inventory have been measured. We demonstrate the usefulness of the resultant gridded tree-ring data as both a climate proxy and spatiotemporal growth patterns. The protocol described here could be applied to other FIA Programs.

FIA’s P3 Vegetation Diversity and Structure Database
Bethany Schulz

The Forest Inventory and Analysis Program collected detailed vegetation data at 2832 plots locations as one of the suites of the Phase 3 (P3) indicators from 2001 through 2011. Although the detailed Vegetation Diversity and Structure Indicator (VEG) data collection is currently suspended, existing data provides a wealth of information regarding trends in species richness, species composition, and the distribution of individual species in forests. Data has been available via the FIADB website since 2009, but unless users are familiar with working with FIA data, simply downloading the data for an area of interest can be daunting. The Master P3 VEG Database (a free-standing Access database) brings together all FIA plot data corresponding to the VEG plot locations with the VEG data, and provides users with standard queries to generate common estimators. This database is comprised of the P3 VEG data recorded during 3371 plot visits (539 plots visited twice), the P2 data collected for each visit, plus other P3 indicators collected on the same plot locations. Other indicator suites are Down Woody Materials, Lichens, Soils, and Crown Conditions. The goal is to provide users with a ready-to-use database and guidance to jump start investigations dependent on vegetation datasets collected over large areas using consistent methods.

The History of Forest Disturbance in the US: Annual Maps of Causal Agent from Landsat Time Series
Gretchen Moisen

Currently in its third phase, the North American Forest Dynamics (NAFD) project is completing nationwide processing of historic Landsat data to provide a comprehensive annual, wall-to-wall analysis of US disturbance history over nearly the last three decades. Because understanding the cause of disturbance is important to quantifying carbon dynamics, work was conducted to attribute causal agents to these nationwide change maps. Developing empirical models of the diverse causal agents involves many decisions. Alternative response designs were evaluated in terms of their costs and benefits for national mapping applications. Many classes of predictor variables were developed and tested for their contribution to classification models. Random Forests models were coupled with simple rule-based models reflecting expert knowledge. And decisions about appropriate modeling subpopulations were made in light of available training data, diversity of ecological zones, and computational efficiency. Here we present our methods and resultant annual 30m resolution maps of forest disturbance and cause for the conterminous US, 1986–2011. We also discuss how these causal disturbance models have enabled extensive analyses of temporal and spatial patterns in causal agents across the US.

FIA 101: Accessing FIA Data for Analysis
Jim Menlove

Many potential Forest Inventory and Analysis (FIA) data users are daunted by the size and complexity of the FIA database (FIADB). Even tools designed to simplify data retrieval can seem overly complex and confusing to those not familiar with the data collection methods and database design. This course will introduce potential FIADB users to on-line sources of information on the collection and storage of FIA data. Users will then be instructed in the use of on-line FIA tools (FIDO and EVALIDator) to construct reports on forest attributes (area, volume, biomass, growth, mortality, removals, etc.). They will be taught how to restrict output to specific forest attributes like ownership, forest types, or species. Public access to FIADB currently consists of downloading FIADB tables on a US State basis. Students will learn how to find and download the data. One download option is an MS Access database preloaded with a single State’s complete FIADB. These databases include not only all the FIADB tables, but also multiple basic queries and tools similar to the on-line FIA tools. Use of these capabilities will be explored as well.
The Impact of the Mountain Pine Beetle Epidemic in Colorado on the Live Inventory of Lodgepole Pine
Michael Thompson\textsuperscript{a,b}

Extensive and widespread lodgepole pine mortality due to a mountain pine beetle epidemic has occurred in Colorado. The Forest Inventory and Analysis (FIA) annual inventory system began in Colorado in 2002 which coincided with the onset of elevated lodgepole pine mortality rates. The current mortality event coupled with collection of ten years of annual inventory data provided an opportunity to test the usefulness of the FIA annual inventory system for quantifying rapid change in the lodgepole pine resource over a large geographic area. Using an independent panel design to quantify an inventory estimate of mortality and live inventory is discussed. Trends over time are presented. Statistical procedures that are appropriate for validating mortality estimates are discussed. A nonparametric statistical procedure was considered to be an appropriate test for validating annual inventory estimates is presented as an example.

\textsuperscript{a} Corresponding author (mthomps@fs.fed.us).
\textsuperscript{b} USDA Forest Service, Forest Inventory and Analysis, Ogden, UT.

Estimators for Photo-Based Measurements
Paul Patterson\textsuperscript{a,b}

There is an interest in the use of aerial photography to estimate population characteristics of a landscape. Two examples are the Nevada Photo-Based Inventory Pilot conducted by the USDA Forest Service, Forest Inventory and Analysis (FIA) program, which sought to improve precision in estimates of forest parameters, reduce field data collection costs on margin lands that are covered by slow growing woodland species, and address the potential of strategic-level inventory on lands not traditionally sampled; and the Image-based Change Estimation being developed by USDA Forest Service, Remote Sensing Applications Center, which seeks to develop an image based approach of estimating land cover and land use changes. Both involve establishing a sample of photo-plots and interpreting the characteristics of a grid of points within each of the photo-plots. Historically, FIA derives the properties of estimators based on the finite sampling paradigm. This approach has the theoretical difficulties of specifying what the population unit is and whether area is subdivided into distinct, non-overlapping population units. In the context of the infinite sampling paradigm and using the support region construct one is able to address these and other theoretical issues. In this theoretical framework an unbiased estimator can be constructed, the variance of the estimator derived, and an unbiased estimate of the variance can be issues. In this theoretical framework an unbiased estimator can be constructed, the

\textsuperscript{a} Corresponding author (ppatterson@fs.fed.us).
\textsuperscript{b} USDA Forest Service, Rocky Mountain Research Station, Forest Inventory and Analysis, Ogden, UT.
Using FIA Plot Data and MTBS Data Products to Analyze the Effects of Fire on Forests in the Interior

Charles Werstak\textsuperscript{a,b}

Fire is an important disturbance that influences the structure and dynamics of forests in the Interior West. To gain a better understanding of the interaction between fire and forests, we developed methods to analyze the effects of fire on forests in the Interior West by assessing changes in forest attributes with respect to fire damage captured by data products from the MTBS program. These methods include several different types of analyses aimed at providing summary information on fires and forests and to quantify the effects fire has on specific forest attributes over time. For example, general summary information on fires and forests such as the number of forest, nonforest, and nonsampled FIA plots that fall within the boundaries of fire perimeters for a given time period will be explored. In addition, comparisons of FIA plot-based area estimates and MTBS fire area estimates will be discussed as well as the sampling noise inherent in small area estimation. Further, production of per-acre estimates to quantify changes in live tree volume, live tree biomass, total basal area and live basal area, and mortality of trees due to fire will be examined. Finally, we will review potential analyses that can be conducted with remeasurement FIA plot data and MTBS data.

\textsuperscript{a} Corresponding author (cewerstak@fs.fed.us).
\textsuperscript{b} USDA Forest Service, Interior West Forest Inventory and Analysis, Ogden, UT.

FIA Urban Inventory Overview: Design, Data Collection, Data Flow, Processing, and Analysis

Tonya Lister\textsuperscript{a,b} and Rachel Riemann\textsuperscript{c}

More than 80\% of the US population lives in urban areas. Tree cover in these areas offers a wide range of environmental benefits including the provision of wildlife habitat, aesthetic appeal and visual barriers, microclimate control, water quality improvement, and air and noise pollution control. Historically, the US Forest Service Forest Inventory and Analysis (FIA) program has collected tree data only in areas defined by FIA as forest, which often does not include urban trees. Similarly, few cities have urban tree monitoring programs. To address this information gap, FIA, in partnership with the Forest Service’s i-Tree program and the Vibrant Cities Initiative, will begin the first national FIA urban inventory in 2014. Tree data within both forest and nonforest areas are being collected annually on FIA plots in certain urban areas around target cities. In this session, we will present an overview of the FIA urban inventory and discuss its rationale, data collection methods, data flow, processing, and analysis. We will discuss the future analytic potential of the FIA urban data as well as limitations, especially in relation to comparisons across the urban to rural gradient. Example analyses and summaries of FIA urban data will be presented and FIA’s plans for future public data distribution will be discussed.

\textsuperscript{a} Corresponding author (tlister01@fs.fed.us).
\textsuperscript{b} USDA Forest Service, Newtown Square, PA.
\textsuperscript{c} USDA Forest Service, Northern Research Station, Troy, NY.

FIA Biosum Analysis Tool: Whole Landscape-Scale Simulation of Management Effectiveness and Economics

Jeremy Fried\textsuperscript{a,b}, Sara Loreno\textsuperscript{c}, and Larry Potts\textsuperscript{b}

We demonstrate a newly released, analyst-friendly tool, FIA Biosum 5.0, a dynamic system for bioregional inventory-oriented simulation under management. Biosum facilitates integration of forest inventory data, a treatment cost model, a user-defined treatment effectiveness model, a raw material hauling cost model, and a stand projection system to create a rich and comprehensive dataset essential to informed landscape-scale forest management. Innovative and alternative treatment scenarios spanning a thirty year time-frame can be evaluated with regard to cost, value of harvested materials, and achievement of management goals. Biosum can be applied to any area in the US for which FIA plot and road network data are available, enabling users to test treatment scenario effectiveness and feasibility at a variety of scales, up to the national level. The modular system design encourages customization based on user specific research or policy relevant questions. Examples are shared of past and current analysis with the system, such as estimating biomass supply and identifying promising facility sites, evaluating landscape-scale fuel treatment effectiveness and feasibility, and assessing carbon implications of fuel treatments. We expect that this forecasting tool will become indispensable to analysts interested in assessing, at the whole forest landscape scale, the effectiveness of silvicultural treatments over time, and their resulting economic implications. The FIA Biosum simulation software will be distributed, free of charge, in DVD format, with included sample dataset and user guide. Additional data from all 50 states can be obtained at fia.fs.fed.us.

\textsuperscript{a} Corresponding author (jfried@fs.fed.us).
\textsuperscript{b} USDA Forest Service PNW Research Station, Portland, OR.
\textsuperscript{c} Portland State University, Portland, OR.

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