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Resource Monitoring and Assessment

Program Review Briefing Book

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Pacific Northwest Research Station

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Introduction

This document provides a summary of information presented during the Resource Monitoring and Assessment (RMA) Program Review conducted by the Pacific Northwest (PNW) Research Station in February, 2016. This is intended as a briefing for the program review, including background information and details to help inform the discussion around four review components – Vision and Strategy, Program Delivery, Business Operations, and Challenges and Opportunities facing the program.

We do not attempt to duplicate the information already contained in existing documents produced as a part of our reporting at both a station and national level. At the station level, they include the Strategic Framework, the Safety Program Evaluation Checklist (SPEC) Review, and the published RMA charter. At a national level, they include the annual business reports, the Farm Bill language, the March 2015 draft Forest Inventory and Analysis (FIA) Strategic Plan, and the Forest Service Strategic Plan 2015 – 2020. Those documents provide guidance for our program of work and documentation of fulfillment of organization requirements at a high level. This program review is focused specifically on the local program administrative, production and scientific operations.

Johnny Carson

Janelle Cossey

Program Overview

Program Background

The Resource Monitoring and Assessment (RMA) Program combines the Pacific Northwest (PNW) Research Station's implementation of the national Forest Inventory and Analysis (FIA) Program with the PNW Remote Sensing Scientific Program to leverage the strengths of both programs and provide stronger support of the station's Inventory and Monitoring Research Emphasis Area.

Resource Monitoring and Assessment Program scientists and staff provide baseline inventory information, technical summaries, innovative approaches, advancements of new theory, as well as responses to specific client requests. Clients include research scientists (internal and external to the Forest Service), land managers and other decision makers; federal, state and regional agencies; non-governmental organizations, private industry, investment bankers, and the general public. The program shares knowledge and information through peer-reviewed journal articles, station publications, workshops, and client meetings; direct consultations and partnerships; and web-based applications for accessing and using information, databases, maps, tools, and models. The FIA responsibilities include annual posting of updated inventory data, five-year statewide assessments of forest resources, participation in the five-year National Resources Planning Act publications, and annual reporting of business information to Congress.

The Forest Inventory and Analysis Program was originally established to provide forest inventory estimates that are timely, consistent, and with known precision. Many efforts that characterize regional and national conditions and change over time are reliant on the availability and continual updating of FIA data. Forest Inventory and Analysis data are the foundation for regional and national estimates of carbon (e.g., National Biomass and Carbon Dataset, BioSum), wildfire fuels mapping (e.g., LANDFIRE, CalFire use of FIA data via R5), forest cover mapping (e.g., National Land Cover Dataset), and regional assessments and monitoring (e.g., Northwest Forest Plan Monitoring—gradient nearest neighbor (GNN) mapping, Interior Columbia Basin Ecosystem Management Project). In addition, these derived-databases are in turn used in hundreds of studies conducted by researchers in academia, state, and federal agencies. In aggregate, these studies have supported regional and national policy decisions affecting most natural resource management activities.

There is no other agency in the country that collects and maintains a database of forest conditions with the statistical and quality controls that are hallmarks of the FIA plot data. Many researchers outside of the FIA Program under-value the effort required to design, organize, and execute a program of

field collection and data management. As the nation moves toward operational carbon accounting, FIA data will become increasingly valuable as a key data source for determining how billions of dollars of forest carbon will be allocated.

RMA research topics are broad in scope and highly complex, and include improving statistical methods and application of ancillary data (e.g., for more accurate estimates of forest condition over small areas); developing and integrating efficient methods for monitoring new attributes of interest (e.g., for carbon-dense moss and lichen mats in boreal forest); determining impacts of disturbance and management (e.g., effects of disturbance, harvest, and land-use change on regional carbon stocks); investigating pollution or pathogen threats to forest health (e.g., declines of whitebark pine from blister rust and bark beetles); and providing tools for strategic planning by land managers (e.g., to estimate ecological effectiveness and economic costs of implementing alternative thinning and burning management strategies across a forest). Program expertise is regularly sought by agencies and scientists regionally, nationally, and internationally, Including through USFS International Programs.

Accurate assessment of current conditions and recent changes in forest ecosystems is essential for science, policy formation, and management decisions. The spatial, temporal, and topical scope of research is extensive, as the team analyzes diverse field data, imagery, and models collected and assembled over the last 80 years. Efforts to improve national consistency in methods and definitions must be balanced against maintaining consistency over time and regional needs for specialized forest resource information. Since topical questions change even over the course of a decadal inventory cycle, scientists face the difficult task of anticipating the range of future analytic requirements. This requires broad knowledge of multiple disciplines, including ecology, remote sensing, forest management, economics, statistics, and biometry.

The Resource Monitoring and Assessment Program has several aspects that make it unique within the PNW Station. We are responsible for specific congressionally-mandated products that we must deliver for the national FIA Program (compiled annual inventory data publicly available within six months of completing data collection; statistical reports on state-level status and trends produced every five years). Our program implements the national FIA Program for all 73 million hectares of forested lands in the Pacific region (i.e., Alaska, Washington, Oregon, California, Hawaii and the Pacific Islands); this production mandate consumes the majority of the RMA effort and available resources. The responsibility for FIA in California, Hawaii, and the Pacific Island Territories, areas that are the focus of the PSW Station's mission, is another aspect of RMA that is unique in the PNW Station. We also require a high level of cross-functional interdependence and close coordination between the data collection, information management, analysis, and science teams that make up the program.

Vision and Strategy

Program Charter and Long-Term Goals

Activities of the Resource Monitoring and Assessment Program focus on three major problem areas that cover the PNW Station's responsibilities for implementing the national Forest Inventory and Analysis Program, integrated with station research and development of remote sensing tools and applications. The combined research enables the program to expand the scope of inventory and monitoring and develop new techniques and applications of inventory and monitoring information to current and emerging issues.

Janelle Cossey

The goals and problem analyses identified in the 2009 Program Charter are helpful for organizing and communicating the nature of our work. Although work in some areas has been greater or less than anticipated in 2009, the charter describes the research in the program well. Items 1.4 and 1.5, identified on the next page, concerning conducting annual inventories of rangeland and urban areas, were prospective and anticipating potential future directions of the FIA program nationally. The program has participated in pilot studies of rangeland monitoring and one-time assessments of urban areas, but the program is not currently funded to conduct inventories on these lands.

The existing charter also provides a valuable framework for future research priorities, and the program expects to concentrate on certain topic areas that we anticipate being relevant to the agency's mission over the next decade. The program benefits from a strong and diverse array of scientific backgrounds within its ranks, including ecology, engineering, biometrics, and remote sensing – all with a common link to the rich, spatially-balanced, and comprehensive FIA plot network – and therefore RMA is well-positioned to provide relevant and timely information to support resource management and policy decisions at a variety of scales.

The research problems identified in the RMA Charter that guide our work are:

***Problem 1**:* How can we provide essential information on the status and extent and characteristics of forest and rangeland in the Pacific region and their change over time to decision makers?

1.1 Conduct the annual inventory of all forest land within the states of Alaska, Washington, Oregon, California, Hawaii, and the six Pacific Islands
1.2 Monitor the Timber Product Output component of the national FIA Program
1.3 Participate in the annual National Woodland Owner Survey
1.4 Conduct an annual inventory of rangeland within the Pacific region
1.5 Conduct an annual inventory of forested urban areas
1.6 Reporting and monitoring of coarse-scale indicators of conditions and trends

***Problem 2*:** How can we increase the efficiency and add value to inventory and monitoring efforts through the development of new tools, techniques, and methodology?

2.1 Improve estimation techniques to increase precision and accuracy
2.2 Incorporate new types of ancillary information to improve estimates
2.3 Develop and test new methods for new types of ecosystem attributes
2.4 Develop more precise ways to generate maps from remote sensing and plots
2.5 Improve projection of long-term and large-scale trends in ecosystems
2.6 Develop methods to assess management effects on ecosystem processes

Problem 3: How can inventory and monitoring data be used to understand the effects of human use, climate, and natural disturbances on the forest and rangeland condition?

3.1 Identify the ecosystem services and resource product potential of forest and rangeland ecosystems over different temporal and spatial scales
3.2 Quantify the impact of disturbance on forest and range extent, condition, and use
3.3 Provide projections of future scenarios of change and management with regard to human needs and uses of the ecosystems
3.4 Develop tools that transform inventory and monitoring data into answers that land managers need

USFS Strategic Plan and PNW Strategic Framework

The Forest Service Research and Development branch (R&D) organizes its research around seven Strategic Program Areas (SPA): (1) invasive species, (2) inventory, monitoring and analysis, (3) outdoor recreation, (4) resource management and use, (5) water, air and soil, (6) wildland fire and fuel, and (7) wildlife and fish. The FIA Program is the key effort in the inventory, monitoring, and analysis SPA, and provides foundational research that underpins work across the agency. In addition, researchers in the RMA Program are engaged in significant work in all of the SPAs.

The 2015 PNW Strategic Framework has five research emphasis areas (REA): (1) climate change, (2) inventory and monitoring, (3) natural disturbances, (4) resource management and landscape resilience, and (5) socio-economic dimensions. The RMA Program is a key player in the inventory and monitoring area and conducts research within all emphasis areas.

Key Outcomes and Program Accomplishments

The RMA Program has addressed a wide variety of important issues over the past five years that support the agency's mission. Specific outcomes, key research findings, and new tools are summarized on the following pages within the context of our three research problems areas.

Janelle Cossey

Problem 1 *- Provide essential information on the status and extent and characteristics of forest and rangeland in the Pacific region and their change over time.*

- The boreal forests of interior Alaska cover 15% of the nation's forested area, but have not been inventoried, so reliable information on status and trends is not available. Yet evidence suggests these forests and their substantial belowground carbon stores are changing faster in response to global warming than any other forests on Earth. We collaborated with NASA to develop and test an innovative design to efficiently inventory these remote forests with a combination of national FIA procedures and high-precision remote-sensing tools.
- We have consistently met congressionally-mandated reporting requirements while improving data quality, documentation, and analysis tools.
- We are responsible for two of FIA's national forest health indicators; lichen communities are efficient indicators of air quality, and vascular plant diversity and structure are indicators of threats to biodiversity, such as invasive species. We used these indicators to compile and publish novel baseline analyses of air quality, invasive plants, and native plant diversity for several regions across the U.S.
- Trees in urban areas provide substantial social and ecological services but are not being consistently evaluated. We led a Recovery Act Project that piloted an FIA inventory of urban areas in all Pacific states. We found that tree composition and abundance varies greatly within and among Pacific states, are associated with socio-economic status, and have direct implications for human health.

Janelle Cossey

Problem 2 *- Increase the efficiency and add value to inventory and monitoring efforts through the development of new tools, techniques, and methodology.*

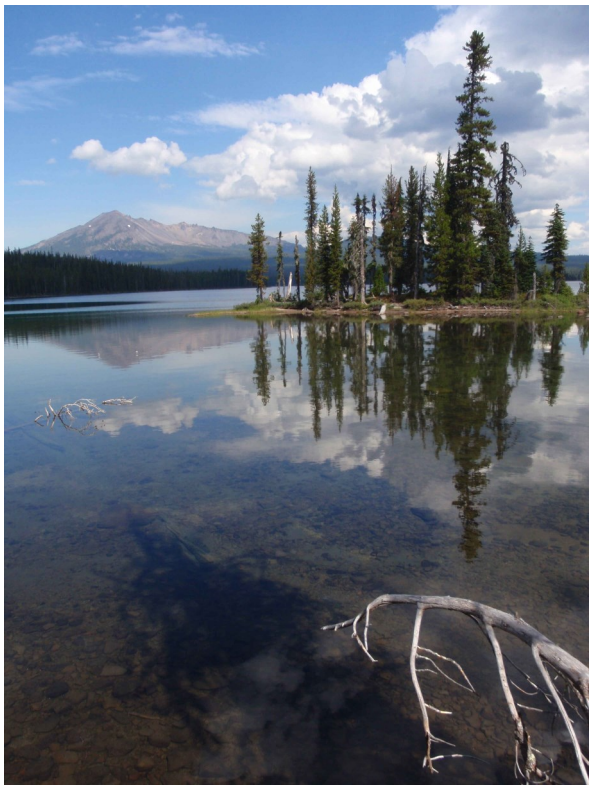
- The FIA grid provides robust estimates for areas of 100 thousand hectares or more, but can also be useful for estimating forest attributes for small areas (e.g., watersheds). We developed and tested several approaches that combine plot data with LiDAR and other remote sensing to provide estimates at a range of spatial scales.
- Nitrogen pollution from fossil fuels and agriculture can affect species composition, growth, and mortality in forests. We identified critical thresholds for nitrogen pollution using FIA lichen community surveys and chemical analyses.
- Ground-layer mosses and lichens provide habitat, essential forage, and store large amounts of carbon in boreal forest ecosystems. We developed new methods to efficiently and non-destructively estimate the diversity and mass of ground-layer mosses and lichens for future inventories in interior Alaska.
- Software tools, including the highly-popular FUSION package, were developed to efficiently produce GIS-ready spatial data products from raw airborne LiDAR data.
- Map-based and plot-based annual estimates of forest disturbance were developed across the conterminous U.S. from 1985-2012.
- Maps of forest composition and structure over the large regions within the Pacific states (WA, OR, CA) were developed using nearest-neighbor imputation approaches drawing from multiple data sources.
- Methods were developed to use high-density LiDAR for characterizing the effects of fire on forest structure in the western U.S.
- Techniques were developed to utilize airborne LiDAR and hyperspectral imaging as a sampling tool to support forest inventory in remote regions, such as interior Alaska.
- Ground-based LiDAR was used to inform the development of more accurate local tree volume equations.

Problem 3 *– Use inventory and monitoring data to understand the effects of human use, climate, and natural disturbances on the forest and rangeland condition.*

- Wildfires can cause significant damage and are expensive to control. Nevertheless, there is substantial disagreement whether different fuel treatments can reduce fire hazard and whether biomass use for energy can make treatments economical. We built the BioSum modeling tool and found that fire hazard reduction is possible in most southern Oregon and northern California forests without subsidy if some medium-sized trees are included in the harvest, but that use of harvest residues for bio-energy contribute only modestly to treatment feasibility.
- As forests store large amounts of carbon, understanding how much they store and whether they are losing or gaining carbon is crucial for developing options to reduce global warming. We found that Pacific Coast forests are accumulating carbon on federal lands outside of wilderness, primarily due to aging of intact forests. While the net effect of harvest and disturbance relative to growth is minor, urban development is a significant contributor to losses.
- Urban development is a significant cause of loss of forestland and can impact the function of remaining forests near developments. We found that the rate of urban development has slowed in Oregon compared to Washington, but new home construction in forested areas is similar among the two states and substantial.
- The Northwest Forest Plan was adopted in 1992 in part to maintain and promote the development of late-successional and old-growth forest. We found that late-successional forest has declined by 2.8% in the plan area, with forest maturation compensating for most losses due to harvest and disturbance. We created vegetation maps with a rich suite of vegetation attributes that enabled companion assessments of habitat change for northern spotted owls and marbled murrelets.
- Global warming is expected to affect the distribution and abundance of tree species, but efforts to detect change have used a variety of approaches and produced conflicting results. We developed an approach using design-based statistics (i.e., no model assumptions) with FIA data and found that significant shifts in the ranges of tree species have occurred in west coast forests and are associated with annual temperature.

RMA Vision for the Next Five Years

The RMA program leadership team has recently identified four cross-cutting research themes of high scientific and societal interest to provide further focus to the efforts of the program. It should be noted that these themes address one or more SPAs identified in the Forest Service R&D Strategic Plan, are directly related to FIA strategic priorities as specified in the 2014 Farm Bill, and encompass the three program problem areas. In addition, RMA will embrace advances in the emerging field of data science to more efficiently and effectively store, query, share and analyze the increasingly large data sets (FIA plot database, remote sensing) that provide the fundamental basis for much of the scientific work within the program.



Mark Gasser

Gerad Dean

Research Portfolio Themes

1. **Fire effects and management –** The role of wildfire in shaping the future landscape of the western U.S., and the potential impacts on western communities, are of tremendous concern. RMA scientists and collaborators will tie field plot measurements to remotely-sensed data to assess spatial variability of burn severity and relationships to pre-fire forest conditions across the landscape.

   Specific lines of research include:

   - Scientists within RMA are international leaders in detection and understanding of forest disturbance through the analysis of satellite image time series. Forest disturbance and recovery processes, often characterized by very subtle spectral trends, are notoriously difficult to accurately detect and attribute using remote sensing. Yet they are critically important drivers of ecological change across large swaths of the western U.S. Our scientists are using ensemble modeling–a complex machine learning technique--to integrate the output of maps from various complementary Landsat times with forest change algorithms, each of which is expected to have its own unique ability to capture part of the full spectrum of vegetation changes (***Problem 2***);

   - Airborne laser scanning can be used to generate structural signatures corresponding to various characteristic forest conditions, akin to the spectral signatures provided by multi-spectral remote sensing. Resource Monitoring and Assessment scientists, along with partners at University of Washington and USFS Region 5 in California, are using methods borrowed from spatial statistics and pattern analysis to develop a new "language" to describe the horizontal arrangement of forest clumps and gaps–as identified in airborne laser data--which can then be used to compare conditions between areas, e.g. a forest stand under consideration for management (harvest, thinning, prescribed burn, etc.) can be compared to an area that already exhibits the desired conditions, providing a valuable tool for evaluating the efficacy of various silvicultural options (***Problem 2***);

   - Wildfire impacts are often studied in selected areas and specific conditions, making it difficult to extrapolate results to the landscape and region. We will use the robust FIA sample grid to assess the full range of fire effects on combustion, mortality, and post-fire dynamics of snags, down wood, regeneration, and growth in forests of the Pacific coast states (***Problem 3***).

2. Interior Alaska – Ecological changes of tremendous consequence, including more frequent and severe fires, changes to the hydrology due to melting permafrost, etc., are occurring as a result of climate change in the boreal forests of Alaska. Our program is marshalling resources to establish the first forest inventory of this vast region in over 30 years. This work is key to understanding the early warning signs of climate change for an area that represents approximately one fifth of the forest land of the U.S. Although this opportunity presents tremendous challenges in terms of logistics, as virtually all FIA plots in interior Alaska will require a helicopter to access, RMA is ramping up capacity to accomplish this task.

Specific lines of research include:

- Statistically-reliable estimates of status and trends of Alaskan boreal forests, which appear to be significantly impacted by global warming, are not currently available. We will implement and compile the first comprehensive assessment of status and recent changes in Alaskan boreal forests using a combination of extensive ground plots and high-precision remote sensing (***Problem 1***);
- In understanding the complex ecological dynamics at play as heterogeneous boreal forests adjust to a changing climate, the past is indeed prologue. There is much to be gained by observing direct changes at multiple spatial scales over a multi-decadal period. Our scientists are working with collaborators at the National Aeronautics and Space Administration (NASA) to characterize patterns and processes of ecosystem responses to a warming climate in the forested landscapes of interior Alaska, including the encroachment of woody vegetation into drying wetlands, increased insect activity and damage, and changes to successional pathways due to more severe fires using a unique combination of multi-temporal (1982-2012) measurements from field plots, low-altitude aerial photos, and satellite remote sensing (***Problem 2***);
- Alaska's boreal forests appear to be changing in response to global warming, but research results disagree on whether tree growth is increasing or decreasing, and where or why. We will integrate new FIA field plot measurements, isotope and ring-width analyses of tree cores, and remote sensing change measurements to assess long-term growth and climate change effects on Alaska's boreal forest (***Problem 3***).

3. Carbon and biomass change – The fundamental role of our forests–and changes therein due to management and disturbance--in determining rates of greenhouse gas emission and carbon sequestration has highlighted the critical role of FIA data and RMA monitoring expertise in addressing this issue. Resource Monitoring and Assessment researchers and analysts will continue to provide scientific leadership to efforts, both domestic and international, aimed at providing baseline information on carbon change across the landscape.

Specific lines of research include:

- Inventory estimates rely extensively on a large number of allometric equations, for example, estimating cubic foot and board foot volume, biomass, and carbon from tree species, diameter, and height. Most of these equations were developed from small sample sizes in restricted geographic areas and their use could be introducing significant bias into our estimates. We plan to improve the accuracy and precision of inventory estimates, and inform forest growth and yield models with better equations of tree volume, biomass, growth, and mortality (***Problem 2***);

- The use of unmanned aerial vehicles (UAV) and developments in the fields of three-dimensional (3D) image-analysis and modeling have the potential to radically change how field crews collect information on forest attributes. Our researchers are working with collaborators at Washington State University to develop computationally-efficient techniques to extract highly-detailed, 3D forest structure information using stereo imagery acquired from UAV platforms and ground-based video cameras. Eventually, field crews may use this advanced technology to collect and store 3D models of tree and shrub stems, branches, and coarse woody debris instead of the conventional measurements such as diameter at breast height (DBH) and ocular cover. Potentially, this could lead to improved estimates of volume, biomass, and a richer understanding of carbon dynamics across diverse ecosystems of the western U.S. and Alaska (***Problem 2***);

- Substantial uncertainty remains in how much carbon is being accumulated in western forests and impact of management and disturbance on current and future carbon emissions. We will leverage the new comprehensive remeasurement of our states to produce novel assessments of recent changes in forest carbon and quantify the relative importance of disturbance, management, and land-use change on all ecosystem components (***Problem 3***).

4. **Land use and land cover change –** Assessing trends and patterns of land use change is crucial to understanding the potential impacts of these changes on critical ecosystem services. Forest Inventory and Analysis plot remeasurements, coupled with time-series analysis of remotely sensed data, provide a powerful basis for determining the type and extent of these changes across the landscape.

Specific lines of research include:

- Robust assessments of change in Pacific coast forests, based on remeasurement of ground plots on all ownerships with a consistent design, are not currently available. We will provide comprehensive assessments of the drivers of forest change (growth, removals, mortality, disturbance, and land-use change) in all of our PNW-FIA states while meeting congressional mandates to make information available and produce regular reports (***Problem 1***);
- Scientists within RMA will continue to provide leadership to regional-scale vegetation mapping efforts based on GNN imputation techniques, which is an intuitive and effective approach to mapping, often described as "painting the landscape with plots." Future research in this area will focus on developing the next generation of vegetation mapping algorithms through exploration of Bayesian hierarchical spatial modeling, machine learning algorithms, as well as assessing forest vegetation change through integration of GNN vegetation maps with multi-temporal remote sensing (LiDAR, Landsat) coverage and long-term tree measurements. This work will help us to understand the legacies of past timber harvest events on forest landscape dynamics during recent decades (***Problem 2***);
- Land managers need a consistent and comprehensive classification framework for vegetation communities to develop management guidelines and communicate issues and results. We will help develop a comprehensive National Vegetation Classification System informed by and applicable to FIA field data on tree and understory plant composition (***Problem 2***);
- Land use is a fundamental attribute of the landscape that has wide-ranging impact on forest abundance, condition, and use. Due to changing designs and definitions, inventory-based estimates of land use change have been difficult to generate. We will reconcile current and past inventories to determine trends in land use change for all west coast states and assess the impacts of development on remaining forest condition and management (***Problem 3***);
- Global warming may be affecting the frequency and severity of drought as well as insect and disease outbreaks globally. We will combine plot and remote-sensing measurements of change to assess these effects on tree mortality and growth and potential changes we might see in response to climate change (***Problem 3***).

Other Priorities – The RMA Program will continue important work outside of the four research portfolio themes outlined above, especially emphasizing urban issues.

Specific lines of research include:

- Trees in urban areas provide substantial social and ecological services but are not being consistently evaluated. We will implement nationally-consistent urban inventories in selected metropolitan areas and assess the ecosystem and social services provided by trees in urban landscapes (*Problem 1*);
- The majority of the people in the U.S. live in urban areas and may be exposed to a variety of environmental contaminants. However, monitoring those compounds is expensive and sample locations are few. We will develop efficient, cost-effective approaches to sample urban mosses and lichens to identify human exposure to environmental contaminants (*Problem 2*).

Our research goals support the PNW Strategic Framework Emphasis Areas (EAs) and the Forest Service Strategic Plan's Strategic Program Areas (SPAs) by:

- **Strengthening our ability to report on the core EA and SPA area of inventory and monitoring, by encompassing a broader range of topics, addressing change across all forestlands more comprehensively, and incorporating new remote-sensing technologies to improve the precision of our estimates and our ability to spatially represent forest change;**
- **Continuing to provide high-quality, timely information on resource management and use (SPA) and resource management and landscape resilience (EA);**
- **Providing new analyses of natural disturbances (EA) and wildland fire and fuel (SPA) that will improve our understanding of how these processes play out across the landscape and put disturbances and landscape changes in their proper spatial and temporal context;**
- **Evaluating the impact of variation in climate (EA) on forest growth and disturbance.**

The RMA Program expects to use research outcomes to support the agency's land management goals by developing and maintaining tools and applications that can inform natural resource managers, both public and private. Our long-term data sets and associated models improve our understanding of current and future vegetation types and distributions throughout the Pacific region, which has implications for wildlife habitat management and forest resources (economic, cultural, and ecological).

Program Delivery

Quality Assurance – Manuscript and Study Plan Review

Technical reviews are currently provided by team leaders as part of the PNW manuscript approval process. Policy reviews are carried out by the program manager (or deputy program manager), also as part of the manuscript approval process. Quality control and statistical procedures for development of inventory estimates from FIA data were established by statisticians and are well-documented and published. Most RMA research is based on analysis of FIA plot data. Given the importance of statistical rigor in much of the more innovative monitoring research carried out in RMA, the program maintains significant statistical expertise in-house (one research mathematical statistician, one mathematical statistician, and several scientists with biometrics and engineering backgrounds), and these experts are often consulted in the development of statistical analyses.

For research studies carried out with external cooperators, the study plan is often included in the Research Joint Venture Agreement. For research supported internally, study plans are typically developed by the project principal investigator (PI) and submitted to the team leader.

The Program is currently improving our review processes by developing a database for tracking publications and tracking the manuscript approval process (consistent with quality assurance guidance from the USDA and FS). Also, both the Vegetation Monitoring and Remote Sensing (VMaRS) and Vegetation Monitoring Science and Application (VeMSA) Teams will soon have a permanent full-time mathematical statistician on staff with multi-disciplinary knowledge needed to provide statistical reviews in a timely manner.

Quality Assurance – Data Security

The RMA Program has several mechanisms in place to manage and secure data, as well as document studies. Data collected and compiled for FIA Program operations are defined prior to data collection with relational database and variable specifications. Data are collected in the field with electronic data recorders (i.e., small computers) that have range and logic checks built in. Crews are required to “edit out” of the program (i.e., no errors or unaddressed warnings) prior to leaving the field plot. Data are electronically transmitted to Oracle databases housed by the CIO in Kansas City, and all subsequent edits and compilations are done in the Oracle environment. Compilation programs and algorithms using the National Information

Josh Feinberg

Management System (NIMS) are managed by the CIO and must pass a variety of checks before being implemented, including that all necessary calculations are specified prior to implementation. Variables and relationships in the publicly-available FIA data are documented and published.

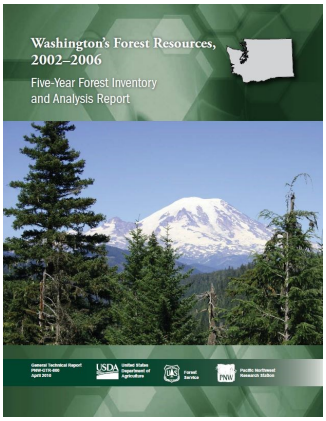
Forest Inventory and Analysis data include location and names of owners that are confidential and cannot be made available under the Food Security Act, and are kept secure behind the CIO firewall. Confidential data are sometimes shared with external collaborators, requiring a legally-binding agreement specifying the use and secure storage of the data and penalties for violating confidentiality.

Other datasets that are not part of the FIA business are individually managed by program employees, and stored on corporate network drives. Many scientists work with data stored locally (i.e., on individual computers) for ease and speed of access; in most cases these are copies of data already stored on corporate drives or databases. Scientists are responsible for maintaining all files associated with individual publications.

Studies involving a significant expenditure of funds and involvement of multiple people in the program are documented with study plans and analyses of options and decision points. Changes to the FIA Program, either data collection or compilation, require national change proposals vetted by all FIA functional groups ("bands", including data collection, information management, analysis, and techniques research) as well as the program managers for national changes, and regional change proposals vetted by all team leaders for regional changes.

Potential improvements to documentation include writing inventory compilation documentation so that all algorithms and equations used for PNW-FIA compilation are available in one place, and organizing the program electronic filing systems to make it easier to find publications, documentation, and ancillary datasets.

Steve Kraft



Outputs and Outcomes

Program publications consist of state reports, techniques documentation, and research papers on new monitoring methods, analysis tools, and results of specific policy-relevant investigations. We anticipate some changes in the modes of publication and science delivery in the next five years. We are assessing the utility of different types of reports to our clients and developing a strategy to produce more products in web-based, interactive formats that will allow us to reach a wider audience.

In addition to a base expectation of productivity from individual scientists, publication counts are greatly affected by the condition of the various datasets used and the success at obtaining funds and generating external collaborations. In recent years, little in the way of operating funds has been available to FIA-funded scientists, yet funding agencies and scientific reviewers seem to have the perception that FIA is sufficiently funded that they should be able to afford substantial research in addition to meeting production mandates. While a number of younger scientists are developing networks and programs and will no doubt increase their productivity, the recent and pending retirements of several highly-productive senior researchers will undoubtedly have an impact. As a result, we hope to somewhat increase or at least maintain our productivity.

Customer Satisfaction

The RMA Program makes a concerted effort to evaluate customer satisfaction, seeking feedback from clients and partners and tracking use of FIA data and related information. We hold annual client meetings that include formal feedback surveys and informal discussion sessions built into the meeting agendas. We track client interactions, and make requests for information or help, easily accessible on our program website. In addition, we participate in national FIA client meetings that provide valuable feedback on the overall FIA Program direction.

Recognition (e.g., awards) from users over the past five years include:

Robert McGaughey
PNW Research Station Excellence in Science Delivery Award - 2015

Warren Cohen
PNW Research Station Distinguished Scientist Award – 2015

Olaf Kuegler and Glenn Christensen
Climate Action Reserve Recognizing our Team Award - 2013

Another indicator of customer satisfaction is that our data are heavily used. Analysts within RMA fulfill approximately five to seven requests per week for data, information, or analytical support—some of which require substantial effort and expertise to answer correctly—and 12 to 15 database downloads from our program website per month. We also receive requests for data workshops, suggesting that external clients are interested in what our program produces.

Resource Monitoring and Assessment data are also accessed through the national online FIA database and analysis tools, which provided 186,175 data retrievals in 2014. Forest Inventory and Analysis data have been integral to building the national LANDFIRE application, to create tree cover layers for the inter-agency National Land Classification Dataset maps, provide estimates to the Environmental Protection Agency (EPA) National Greenhouse Gas Inventory for forestlands and associated international monitoring efforts, and provide base information for state assessments required by state and private forestry for state funding. Our staff are regularly approached by agencies, researchers, and the public for their expertise, and several RMA staff have particpated in Forest Service International Programs efforts to help developing countries establish forest carbon monitoring systems.

RMA is fundamentally a program that emphasizes partnerships. We actively seek partner contributions and build relationships that leverage existing expertise in our program, and successfully compete for external funding. Our statewide forest assessments and

RMA website interface

related summary information are frequently cited by resource managers, NGO's, policy-makers, and research scientists.

We serve the client base best when we are willing to leverage our resources by partnering with others that have abilities or infrastructure we lack and cannot afford to develop internally. Several examples of successful leveraging recently developed in RMA include:

- A partnership with USFS Region 5 to produce statewide maps of vegetation types, focusing on state needs for both fire readiness planning and statewide planning documents;
- A successful collaboration with NASA that has now extended to include the state of Alaska, University of Alaska Fairbanks, U.S. Fish and Wildlife and a number of other partners, all collaborating to achieve the inventory of interior Alaska;
- The recent participation of the Inventory Reporting and Mapping (IRAM) Team in the Forest Service initiative to use Esri as an outside partner to enhance program delivery;
- Assisting the California Air Resources Board in its use of FIA data and biomass calculation algorithms to establish baselines for carbon cap and trade across the country.
- Incorporating State of Oregon monitoring indicators into the FIA state report and assisting states with their use of FIA information in the State Assessments.

Customer satisfaction could be better tracked through more frequent client meetings that include facilitated discussion and feedback sessions. We are also exploring the potential of webinar technology to hold more frequent client meetings and workshops. Using technology may increase participation, which may decline in response to limited budgets and travel restrictions. There may also be ways to track data uses following workshops, client meetings, and website data downloads, and better use of website analytics (number of visits by topic, number of publication downloads).

Amy Jesswein

Josh Feinberg

Relevance

Below are five key components of RMA's past and current success (in no particular order), where our program's reputation continues to grow or remain stable:

- Providing high-quality inventory information in a timely manner;
- Development of techniques that link remotely sensed information with field plot data;
- Map- and plot-based estimates of changes in forest structure and composition, carbon storage, and land use at multiple temporal and spatial scales;
- National-scale forest health information using indicators of air quality and vascular plant diversity, providing baseline assessments of air quality, invasive plants, and native plant diversity;
- Refining and developing new tools, techniques, and methods that increase the efficiency and add value to inventory and monitoring efforts.

The program's key advocates and stakeholders are state agencies, NFS, NGO's, Air Resources Board (carbon cap & trade), and forest industry. These stakeholders advocate through funding, partnerships, and lobbying to Congress.

The breadth of research interests and professional and technical skills within RMA provide multiple opportunities to gain additional support (funding or in-kind). The NFS Urban Program, state and private forest assessments (including integration with Aerial Survey) may provide additional support. Interagency monitoring coordination (NASA, Natural Resources Conservation Service, National Park Service, U.S. Geological Survey), especially in remote areas with poor access (interior AK), and local urban monitoring efforts are being investigated. In addition, RMA staff are already pursuing involvement in NFS forest plan revisions.

Identifying Research Needs and Issues

The Resource Monitoring and Assessment Program uses a variety of strategies to identify and prioritize the research projects on which to focus our resources. A key to our success is frequent communication with clients, stakeholders, and potential partners. Our staff engage in frequent formal and informal client contact, participate in research conferences and professional society meetings, follow current events, note national priorities of our agency, and actively pursue partnerships with states, universities, regional forests, and other agencies. Program leadership interacts regularly with peers in other FIA programs and participates in national client meetings and FIA coordination meetings. Program leadership meets annually to review priorities and reassess which research lines should be continued, revised, or phased out. Our leadership team also meets twice monthly to evaluate progress on short- and long-term goals.

Delivery

The Resource Monitoring and Assessment Program has a history of innovation in program delivery, including development of software, applications, and interactive websites specific to our program's work. Our staff developed and maintains both a program-specific website and a regional FIA database application that greatly enhance our ability to deliver program products and information with user-friendly tools. Internal staff have the ability to make updates directly to the website, allowing for inclusion of more timely and relevant information. Bob McGaughey recently received the Station Award for Science Delivery for his LiDAR processing package, Fusion. Jeremy Fried, Glenn Christensen, and Larry Potts built the BioSum modeling system used by Oregon Department of Forestry, CalFire, and Rocky Mountain Research Station to examine the cost- and fire behavior- effectiveness of fuel reduction treatments and implications for carbon storage.

RMA analysts are participating in a national initiative to design and implement the Forest Service geo-platform. We are part of a USFS–Esri partnership to provide interactive online mapping tools that tell a more compelling story about our relevance, as well as provide easier access to our basic information and underlying data. We are actively working on new ways to communicate to modern audiences and a broader clientele, moving beyond delivering data to sharing information and knowledge using web technology.

The program contributes data and expertise to the national FIA tools and databases, and communicates results through Landfire and NVCS mapping efforts. Gradient nearest neighbor (GNN) maps and documentation are provided on the web, and our data are integral to the DecAID wildlife habitat model, which is also provided on the web.

The RMA Program has broad and varied communication needs which presents some challenges in science delivery to a full complement of customers. In addition to data delivery, we produce: statewide forest assessments, extensive documentation of methods and processes, information for landowners in multiple formats (brochures, flyers, websites) to improve field crew access to plots on all forest ownerships, interactive web-based information, maps for general public use, interactive web-based applications for downloading data (raw and summarized), and peer-reviewed journal articles. These tasks can be difficult to accomplish in a timely fashion when faced with technological restrictions from the CIO and Forest Service leadership, as well as limited resources within the station. Finding innovative solutions and ensuring that new technologies are incorporated into communication and technology transfer strategies at the station will help with these challenges in the future.

Janelle Cossey

Asset Management and Business Operations

Assets and Workforce Overview

One of the most important assets of the RMA Program is the extensive network of permanent plots that is installed on all lands, regardless of ownership and sampled every 10 years. These are installed in rugged territory, often with substantial investment of time - hours or even days—to reach the plots. Field work is coordinated by two Data Collection (DC) Teams, one based out of Anchorage, and one headquartered in Portland, with crews at duty stations across the west coast. The crews mitigate the substantial risk with extensive safety protocols. Measuring the plots requires strength to carry fifty pound packs and stamina to navigate a variety of ecosystems, from tropical islands to arctic tundra. Without our field crews, we would not be able to provide the substantial, ground validated information about forest change that we now produce. Thus, our most substantial and valuable asset is our field operations staff.

Data Collection Team based out of Anchorage, Alaska.

Data Collection Team based out of Portland, Oregon.

Our program installs the base FIA sample in Alaska, Washington, Oregon, California, Hawaii, and the U.S.-Affiliated Pacific Islands. Field work in Alaska is conducted primarily with helicopters and boats. Boats are also used extensively in the U.S.-Affiliated Pacific Islands.

The Norseman, field operations boat, and helicopter in southeast Alaska.

Field crews working in Alaska.

The organizational structure of RMA includes four teams in addition to the Data Collection Teams; they include Information Management (IM), Inventory Reporting and Mapping (IRAM), and our two research teams, Vegetation Monitoring Science and Application (VeMSA) and Vegetation Monitoring and Remote Sensing (VMaRS). The work of all these teams is intricately interwoven among field operations, data management, science, and reporting. The IM Team provides support to the field crews in programming the data recorders, preparation of field data files, hardware and software support. Our IM Team also provides support to analysis teams in subsequent post data processing, advanced programming of data compilations, posting data to the national FIA database, as well as supporting national FIA information technology systems. The IRAM Team provides quality control checks, analytical and statistical support, and the subsequent reporting and client meetings as required by the Farm Bill, and our research and remote sensing teams (VeMSA and VMaRS) revise field protocols, develop equations, improve efficiency with new techniques, and support the teams in mapping and data quality. The research and remote sensing teams also lead development of scientific findings and extract new knowledge from the permanent plot system and any associated supplemental information. This is accomplished in collaboration with a number of both internal and external partners. The program leadership team consists of six team leaders, the program manager, deputy program manager, a program analyst, program specialist, and program assistant.

Resource Monitoring and Assessment Leadership Team

Workforce—Staffing Strategies

We meet as a program leadership team annually to address concerns about our program's organization and establish priorities as well as determine changes required to meet those priorities. Form follows function—that is, we develop our science priorities first based on client and science information needs. We then create the workforce structure to meet those needs while still upholding nationally mandated requirements. We have evolved our structure to ensure we are an agile organization capable of meeting current science needs.

We recently engaged our leadership team with a facilitator in an exercise called Rapid Team Results to prioritize four portfolios of research toward better integration and within-program communication (see Vision and Strategy section). These four portfolios are regional and national priorities taken from strategic plans and client input, and envelop or recast much of the work we are currently doing toward improved coordination and communication. We are energizing our workforce by rallying around common themes and providing a more-honed focus for analysis and reporting. Working as part of a national program, we are continually evolving and responding to user and client group feedback to enhance our relevance.

Staffing Strategies to Respond to Change

The Resource Monitoring and Assessment Program uses a variety of staffing strategies to respond to changing issues. Approximately every five years, we reevaluate our science priority direction and look at ways to create flexible approaches to staff those priorities. We annually evaluate our workforce needs

and adapt our structure to fit. Our research teams evaluate staffing needs based on the priority research work we plan to accomplish. University partners are utilized to fulfill project needs, and permanent staff are chosen on the basis of long-term priority research lines. We are strengthening our mathematical and statistics resources by replacing vacancies with people that have updated skill sets.

We use a number of innovative strategies to flexibly fill positions, especially for field positions. Data Collection Teams have a well-rounded program that includes Student Conservation Association (SCA) internships, partnerships with NFS contractors, as well as state and university contractors. These contracting options are part of an overall strategy that includes continuing to use permanent staff for their knowledge base and dependability when other mechanisms fail.

But as a large program with a well-defined mandate for monitoring, the bulk of our work does not change in response to emerging issues. In fact, a greater concern for us is retaining experienced staff. A core of experienced, permanent field staff is crucial to maintain quality and efficiency and it typically takes two years of FIA experience before employees can function as competent, efficient crew leaders capable of managing all aspects of data collection at remote duty stations.

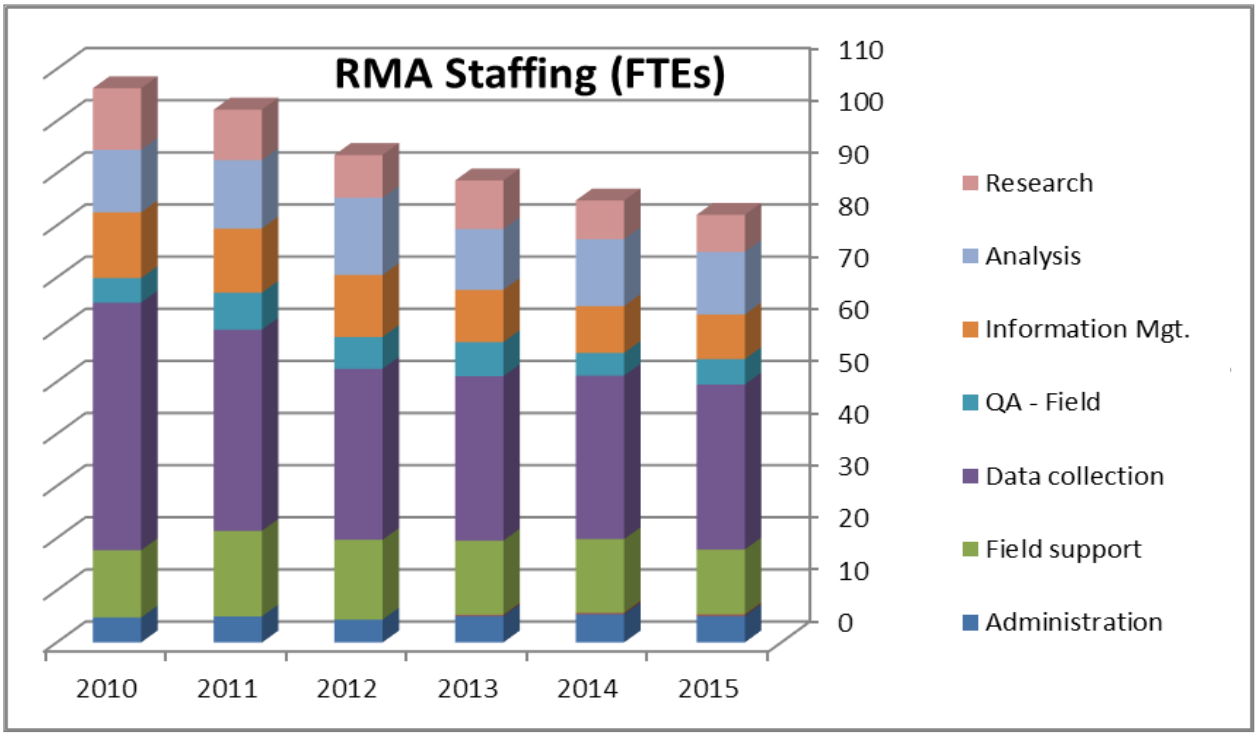
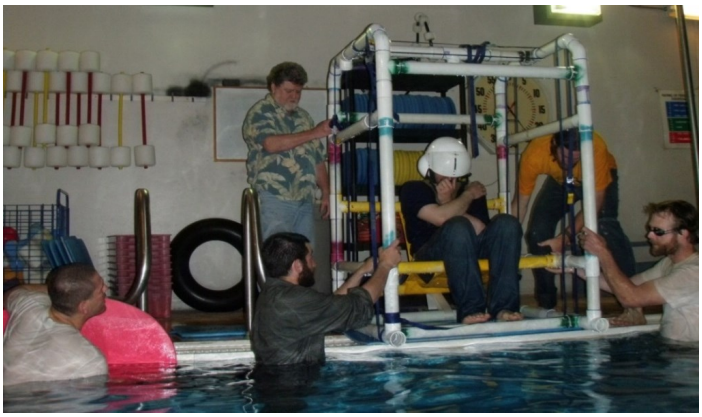


Figure 1—Changes in staffing levels since 2010 in response to budget reductions.

All the teams have unique workforce management opportunities and challenges, including:

- Our commitment to maintain training and developmental opportunities for the large, talented pool of entry level and higher field operations staff. We are interested in providing encouragement and opportunity for our staff to explore career paths in other parts of the Forest Service. We also aim to retain a certain percentage of core staff with long term knowledge. We need to provide adequate enrichment and training to keep them current with their skills and be challenged by their positions.
- We understand that our team leaders are being mired in administrative work. We reactivated a program analyst position to help organize science reporting and administrative needs.
- We plan to fill a recent vacancy from our IM staff with a program level project manager; several teams have recently hired or trained professional or technical staff in project management principles. As a large program with a complex set of goals and mandates, RMA realizes the value of using project management techniques.
- Remote sensing needs to continue and strengthen its position as a combined station and RMA program and replace retiring staff who have built large and beneficial programs for the station.
- The IM Team is responsible for managing a large amount of data with limited staff that must be skilled in Oracle database administration as well as forestry or natural resource management. They must fully understand how to manipulate, check, and present the information in a reliable, usable, maintainable, and flexible format for internal and external clients.
- We also identified the need for two positions to provide hands-on IM/IT support to the DC Teams for computers and software needs. These recurring duties had previously been covered intermittently by a position at a much higher grade.
- The IRAM Team needs to recruit and train staff to meet the vision they have set for themselves to be leaders in advanced web-GIS analysis and interactive communication and outreach venues.
- We reevaluated and reorganized our GIS structure to consolidate resources and assignments primarily in one team to facilitate communication and flexibility in devoting resources to priority projects and increase our responsiveness to client requests.
- Although Data Collection in Alaska will always have formidable challenges in having adequate coverage of helicopter managers, both in obtaining training and in the time it takes to build competency, we have made great gains the past couple years. We now have a number of enthusiastic employees who are receiving training and are being mentored to become helicopter managers.
- Difficulty obtaining underwater helicopter exit training led the Alaska team to get an employee into the 'train the trainer' course, who is now qualified to provide this training annually to their team and other units in Alaska.



Data Collection Alaska Team conducts underwater helicopter exit training in Anchorage.

Increasing Diversity

The RMA program engages in many hiring actions and we take many steps to recruit diverse applicants and retain under-represented groups. We work with the station to hire and recruit a diverse workforce given the constraints of Merit versus Demo candidate pools. We have done a good job outreaching to veteran's groups and to organizations assisting persons with disabilities. We have found that the Forest Service outreach database is ineffective and that we need to send to public distribution mailing lists to nnreceive any type of response. Also, we have concerns about the advice that if we nadvertise positions via Demo, we need to hire 80% of our candidates from that list. This has resulted in advertising via primarily Merit, and passing the same internal diversity pool from agency to agency. We are reshuffling the diversity deck, but not opening up our ranks to new talent with new perspectives and backgrounds. The flexibility to choose the best candidate, regardless of an arbitrary list, has been lost.

We have been satisfied with outreach using special emphasis program managers and the cultural transformation and partnership specialist (CT&P) when positions are broadly circulated. Both mechanisms have successfully expanded our outreach campaigns. We understand the CT&P position has transitioned, but the tradeoff in value against ever-increasing overhead is a discussion that is needed.

The Program uses the Student Conservation Association (SCA) to provide staff for FIA field operations. Additionally, we contract via the NFS Regions to meet data collection needs. Summer seasonal and temporary staff help fulfill our needs for data collection if human resources staff are available to process requests submitted in November and December. We utilize a number of different hiring authorities to fill our vacancies including Public Land Corps, Schedule A, Pathways, Presidential Management Fellows and the 1890 Scholar Program. We also ensure that we obtain the most diverse candidate pool possible by attending outreach opportunities such as the National Hispanic Environmental Council Conference.

Succession Planning

We plan for succession for retiring or resigning employees whenever possible. We are using existing vacancies to hire expected vacancies to provide crucial overlap in areas with steep learning curves (e.g., Wanek/Brown, Reid/Johnson, Campbell/Potts, Hubbard/Mueller, Cohen/Vice). We have used retired employees to assist in work continuity as well (e.g., Winterberger, Waddell, Koleser).

We do experience high turnover rates among field crew, primarily because of the strenuous nature of the work that requires a great deal of travel, and skilled staff often find full-time opportunities elsewhere. Succession planning for field crews can be particularly challenging because it is difficult to predict resignations (retirements are rare among field staff) and vacancies are often filled by existing RMA staff (which simply creates another vacancy).

We are attempting to create overlap in priority research by creating mentoring relationships where funding allows. Using our new portfolio priorities, we hope to create an nentire cadre of partners in our focal areas that can maintain the overall work priorities. By working across teams and involving several scientists in the overall portfolio of work, we hope to enhance continuity. We have also kept important research lines alive across retirements by hiring individuals with experience in the types of analysis and research we are preserving. For example, we hired an RMA scientist with experience in GNN analyses and quantitative ecology to replace a retiring individual. Position descriptions and evaluation criteria are written to attempt to hire individuals who will continue priority research lines.

Gerad Dean

Fortuna crew in Humboldt County, California.

Workforce Management and Morale

Workforce management and morale are a major concern for our program. Exit interviews are conducted when requested by employees. It is solely the option of the departing individual. Exit interviews are handled by Albuquerque Service Center (ASC) using an electronic system. We have not had access to the official results. Supervisors do discuss reasons for employee departures with the employee where appropriate. If issues of job satisfaction are raised, we address them as a leadership team in a broader context.

Employees have left the program in recent years primarily owing to retirements and field-going people finding full-time or less strenuous work. Some field staff and information management staff have left to pursue careers in other areas, agencies, or owing to promotions. A handful of employees have left out of dissatisfaction with the rapid pace of change and inability or unwillingness to adapt. We encourage our staff to develop their careers and extend their skill sets so they can better contribute within our organization and beyond in future positions. Toward that end, we have revised and adapted many of our positions to be career ladder positions. There are some barriers to our ability to develop, enhance, and maintain critical skills. The rapid pace of technological change and the available workforce to pursue the necessary skillset to remain competitive and productive stand out as key challenges for our staff.

New employee onboarding follows the standard checklists, augmented by lists and processes led by Jane Terzibashian in our Data Collection Team to ensure we go beyond standard onboarding. There are problems with getting people into computer systems, assigned to the correct staff areas, or simply entered into the payroll system to get paid. The process is slow and not well integrated across the agency. We often use mentoring as on-the-job training. For supervisors, we have a mentoring system in place that makes use of initial AgLearn training and partnering with senior leadership.

We offer flexible work schedules, good benefits, wellness programs, a safe and respectful work environment, and opportunities for advancement, training, and career development to help retain productive people. We also emphasize the importance of their work for the larger success of the program. We are working toward improving productivity of all employees by better communicating expectations, project requirements, timelines, and feedback systems. We are initiating program-wide project management to assist in these efforts and provide feedback and reporting for projects at more regular intervals. We also are taking steps to strengthen our leadership team and inspire a shared vision among all staff within the program.

Josh Feinberg

We ensure employees are being properly rewarded by following station guidelines for performance awards, including cash, non-monetary, and time-off awards. We celebrate our successes with pizza (annual data loads), cake and coffee (retirements), and a variety of other jobs well done. We provide Spot and Extra Effort Awards, non-monetary awards, and other general awards to say "good work." As a leadership team, we try to let employees know we value their work by simply saying "thank you."

We encourage employees to participate in wellness activities, such as the Station's Wellness Program that provides compensation for time and exercise program fees. We compete annually in the PNW Research Station Wellness Challenge. Leadership models wellness in our lifestyles, and in safety discussions we emphasize wellness. We ensure employees have access to ergonomic workstations and equipment to make their jobs easier and more comfortable.

One of our program's strengths is ensuring employees are properly trained for current duties. Our field crew training is a model of success in quality assurance that has paid great dividends in data quality and safety. We provide ongoing training for information management, analysis, science, and administrative staffs. We use individual development plans (IDP) to identify needs and provide training solutions. We work to ensure employees are provided opportunities for future positions and career advancement, including regular participation in Forest Service leadership development training opportunities. Our program also has an excellent track record or receiving Civil Rights Advisory Group scholarships that fund 50% of the total training amount requested by applicants.

Janelle Cossey

Advanced Technology

We use advanced technology at all stages in our research, from data collection and data management, to analysis and publication of results. Examples include: custom programmed electronic data recorders and tablets, laser rangefinders/clinometers, high-precision GPS (sub meter accuracy), GPS post-processing, NAIP photography for land cover/use change detection, Delorme InReach two-way communication devices, Android smartphones for online check out/in and real-time ArcGis Online fire safety applications, G-LiHT remote sensing, LiDAR, LandTrendr Landsat change analysis, BioSum biomass modeling, advanced data storage and retrieval systems (NIMS, FIADB, FIDO, PNW-FIADB, custom RMA web), Visual Structure from Motion (VSfM), and reporting systems to better convey spatial storytelling (web-GIS, ESRI/Cognos, Tableau, Forest Atlas of the U.S.). We also support other FIA work units to continually test new and emerging technology in the fields of database design and field crew data collection devices.

Our program also develops advanced technology to meet regional and national needs. The RMA program maintains a number of important tools including FUSION, BioSum, NOMS and PNW-FIADB. We actively support research with LandTrendr, TimeSync, Visual Structure from Motion, and other research products and processes. Advances in remote sensing and web-GIS technologies will likely be most useful to our program.

Josh Feinberg

Barriers to Using Advanced Technology

We rely heavily on advanced technology to accomplish our objectives, but some formidable barriers limit our ability to use technology. For example, the technical approval process is cumbersome. Researchers wanting to test Android-based data collection systems found the process unworkable. Regulations regarding drones led to abandonment of one line of remote sensing work. The difficulty of serving data and products outside of the Forest Service has limited our communication abilities (SharePoint, web-GIS, database systems, and retrieval systems). The national FIA Program is working with the CIO on solutions to cross the Forest Service firewall. Our program as well as the station's Communications and Applications Publishing (CAP) Team lack expertise in new communication media

incorporating spatial storytelling, although we currently are training personnel in advanced systems to implement spatial storytelling. Tight network security, LincPass requirements, and difficulty sharing data with contractors and outside collaborators have been challenging issues we're still working to resolve.

One change that will be required in the near future is the ability to test new field data collection devices as we work toward replacement of aging devices and technology. The CIO has pressured our data collection staff to cease testing and to rely on an enterprise team to evaluate field hardware and software. The most difficult part of the testing is the field component where we rely heavily on our veteran field staff for technical and ruggedness requirements, and the usability of a device in all environments. An enterprise team cannot provide adequate field testing for our complex protocol given the significant investment. Also, shifting this task away from experienced RMA staff will not help with employee morale and retention.

Jennifer Carson

Steve Kraft

Sound Financial Management

Fiscal Responsibility

RMA's largest asset includes over 40,000 permanent, long-term ecological monitoring plots for research across five states and six Pacific Island groups. The resulting ecological database serves as the basis for program, station, national, and partner research covering a broad spectrum of questions and variables through time.

Over the last few years, we have been very successful in balancing expenditures to allocation. We have very good working relationships with our partners in budget at the station. Over the last year, we were limited in having little to no program administrative support and still managed to be within one half of one percent of our net allocation. Now that we have hired a program specialist, program analyst, and program assistant, we expect scientists and staff will be able focus more on their primary job responsibilities. We are very pleased with the assistance and oversight that the station budget office (SBO) has provided for the program. Phillip Won and the field budget analysts have been an exceptional resource in helping our new administrative staff understand research finances, follow station budget guidelines, and feel comfortable asking questions pertaining to budget issues. They often refer our staff to important references, communicate changes in budget operations, and follow up on complicated and detailed processes.

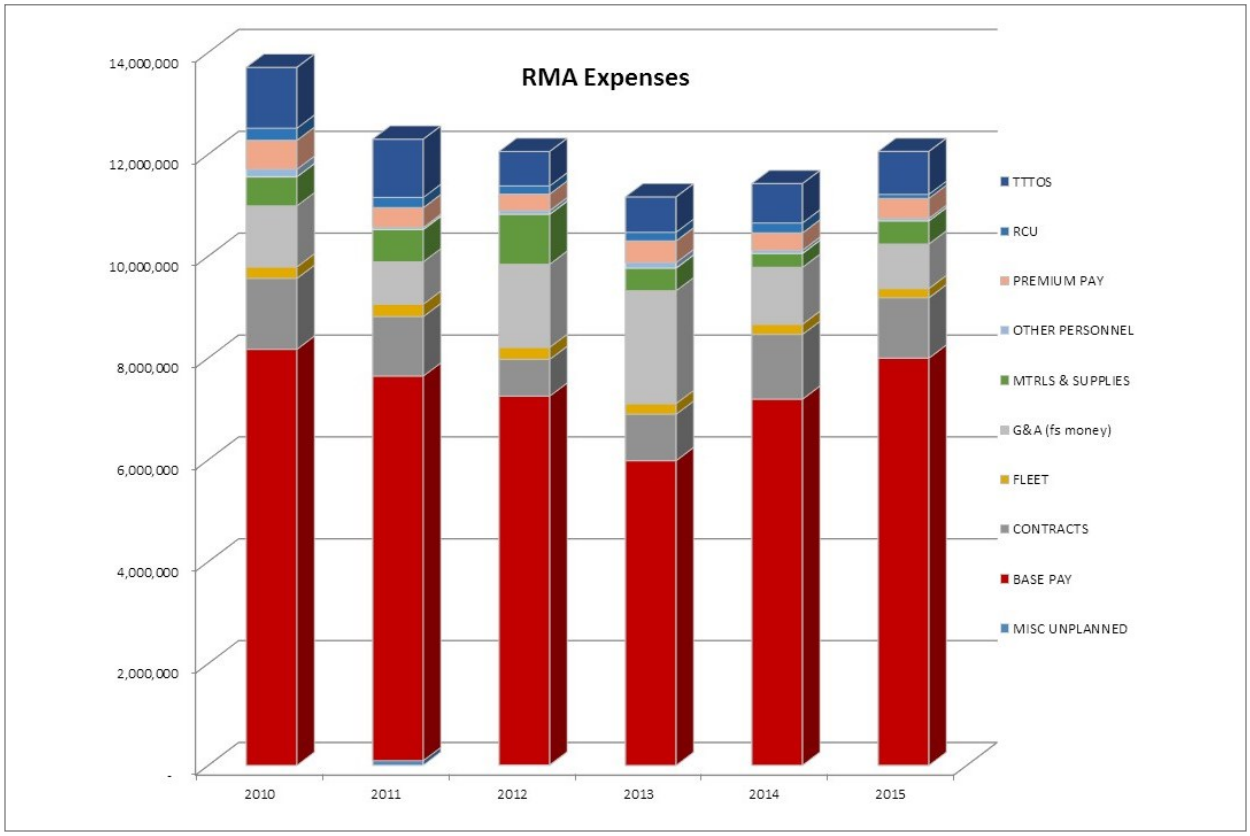


Figure 2—Resource Monitoring and Assessment Program budget since 2010.

In our 100+ person staff, with operations across 11 states and island groups, RMA employs a program specialist to assist tracking of allocations and expenditures. Our program specialist is responsible for alerting leadership to deficits and surpluses throughout the year, in addition to providing the financial data for station accomplishment reporting, CRIS/RITS reporting, and the FIA Annual Business Report.

The Data Collection Team covering Washington, Oregon, and California has done an excellent job of enhancing efficiencies, decreasing costs by approximately one fifth of their annual budget over the last five years. This was accomplished by reducing some data collection protocols, implementing field-generated efficiencies in many procedures, and using interns on staff. The resulting annual savings of $1M has helped defray increasing costs for general inflation of about $250k per year.

Soft Funding

Soft funding typically provides about 19 percent of the total RMA budget. There is high variability in outside funding over time given the sporadic nature of projects. Major contributors include NASA, Oregon State University, ARRA Urban funds, Joint Fire Science, and Nation Forest Inventory and Monitoring (NFIM). We ensure that soft funds support agency needs by reviewing all grants and agreements for relevance toward mission.

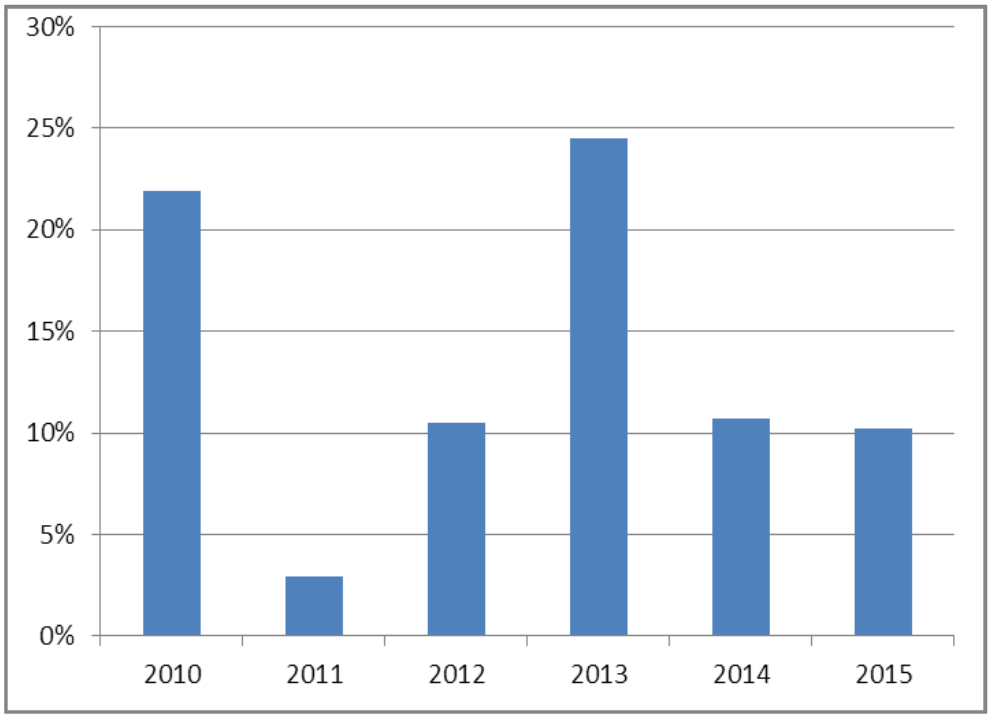


Figure 3—Percent of the RMA budget coming from G&As, ISAs, and partner BFMs. Partner contributions average approximately 19 percent of the total RMA budget over the last six years.

Leveraging Outside Support

The Resource Monitoring and Assessment Program is very creative in how we buy technology, expertise, science or staff support from others. Within FIA, we obtain national resources for technology and IT expertise via the Forest Service National Information Resources Direction Board (IRDB). While cumbersome, the arrangement works. At the local level, we use grants and agreements to supplement our expertise via university partnerships. This has generally been successful when identified resources are procured and maintained for the life of a project. We have not been successful obtaining information technology or management expertise through individual contracts owing to the very steep learning curve involved in our data and data systems. The reporting team, on the other hand, successfully used in-service authorizations to bring in professional or technical staff from other programs or enterprise teams into RMA to support analysis and publication preparation.

Recent funding trends do influence our research productivity. During the Great Recession, incoming funds from partners to perform work were limited. Allocations were lower and we were not able to partner with outside universities and other entities as we had in the past. Research operating funds were severely restricted, meaning travel to present at conferences and funds for analysis, analysis supplies, or equipment were not available, resulting in decreased ability to produce research and resulting publications (see charts below). This decreased ability will show some lag time in terms of products. Year to year variability in incoming agreements is high owing to different emphases in research partnerships.

One area for improvement would be in the timeliness of contracting and changing guidance. Boat and helicopter operations in Alaska are handled through Region 10, and despite imposing deadlines of June 30, it continually runs up against the fiscal year end. For a million dollar plus contract, this is an unacceptable risk. Changing guidance on our ability to pay ahead into contracts makes it challenging for us to plan for complex operations and achieve sound financial management.

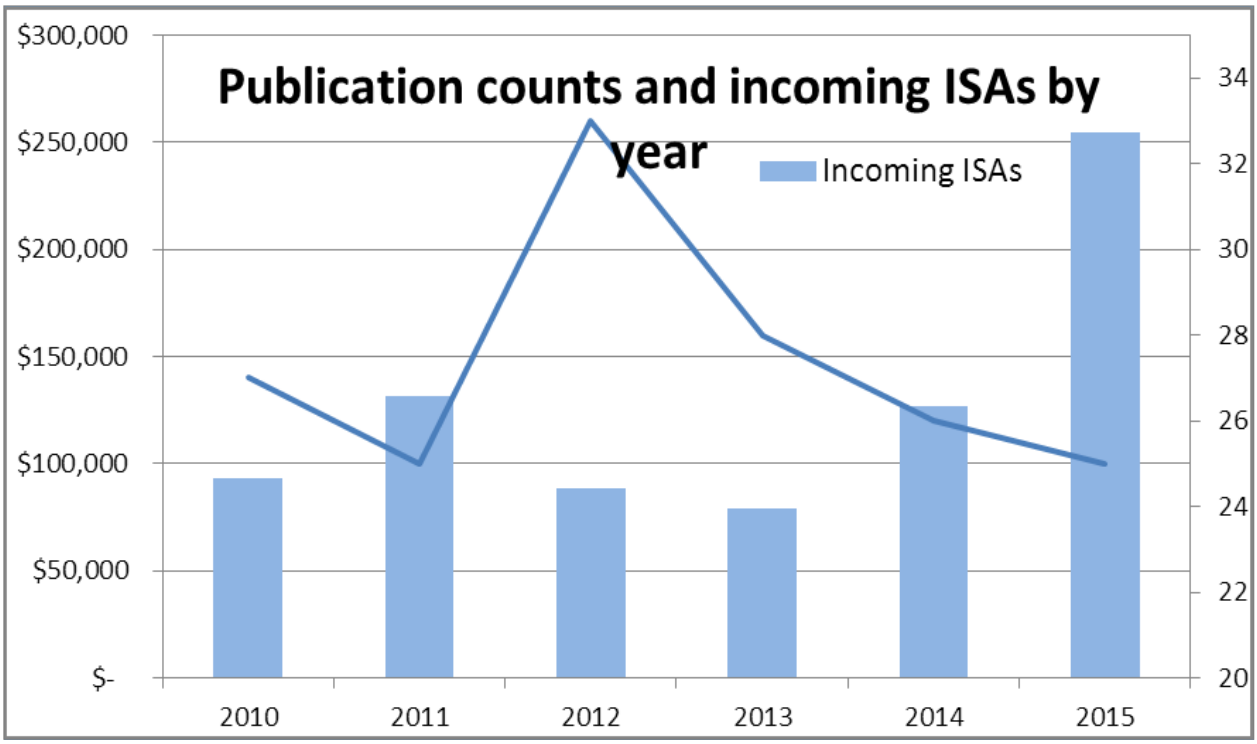


Figure 4—Relationship between number of publications and dollars of in-service agreements from 2010 through 2015.

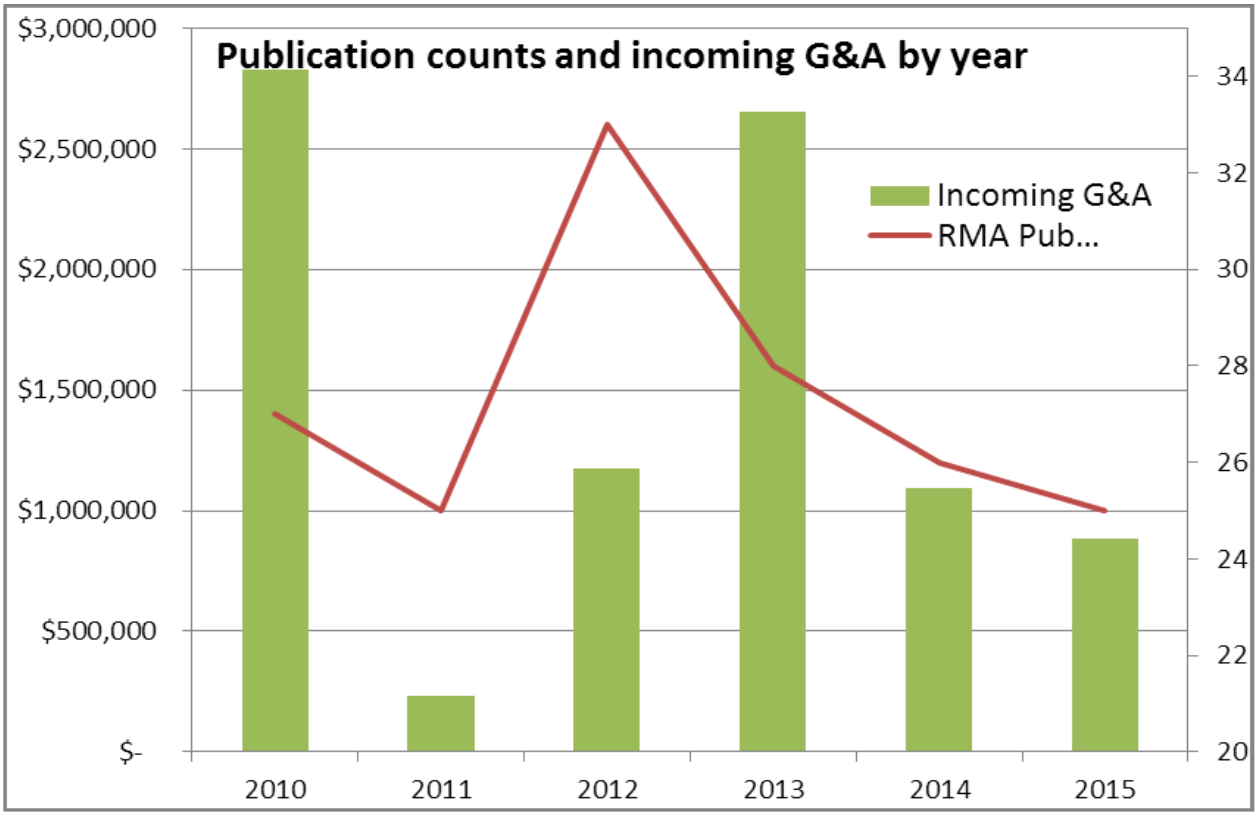


Figure 5—Relationship between number of publications and dollars of grants and agreements from 2010 through 2015.

Safety

The Resource Monitoring and Assessment Program continues its commitment to a culture of safety and wellness to improve the lives of employees while strengthening our program of work. Empowered and engaged employees provide valuable input to refine our existing safety systems using annual RMA safety surveys, improved near-miss reporting, and referring to the Safety Program Evaluation Checklist (SPEC) Review. Ideas shared by team members have led to creative work improvement projects and our dedicated RMA Safety Committee members (which includes members from every team in the program, including management) also bring ideas to fruition using analysis and action. In addition, our wellness program has been expanded to include seasonal employees while in non-pay to maintain fitness levels while not working in the field.

We actively review and revise job hazard analyses (JHAs) and communication plans. In 2015, a collaborative effort was made to author a new JHA for river crossings and working in stream beds, using an innovative risk assessment matrix developed by one of our field crew leaders. We consistently use personal protective equipment (PPE), and continuously review its effectiveness, while searching for new technology to fit our changing needs.

Our communication plan for field-going staff is fluid and evolving. It took a new turn this year as we confronted widespread fire activity. We piloted a new two-way field communication device and a web-based check-out and -in system to replace a faulty telephone check-out and -in service.

Our program is proactive in orienting new employees to relevant safety issues and procedures. Supervisors have a checklist of safety issues to review with new staff, and team leaders include safety and wellness in all team meeting agendas. Field staff have the opportunity before accepting a position to review the "FIA rewards and challenges" document that describes the on-the-ground reality of the job that may not be detailed in the position description. This innovative document was developed as a collaborative team effort to better educate new data collection employees.

Our group has a full scope of safety training, but several courses have been added permanently or piloted in response to employees' requests for additional training. Along with first aid and cardiopulmonary resuscitation (CPR) courses, hands-on defensive-driving training is now incorporated into our intern orientation, and wilderness survival training was offered as a pilot for some of our employees. Since our field crew duty stations span the west coast, we require each crew to lead their own tailgate safety session every pay period to address not only regional differences in safety issues but seasonal safety issues as well. Field crews in Alaska have at least one certified Wilderness Emergency Medical Technician per crew. This sets a precedent for additional employees to be trained in advanced medical response, and staff in northern Washington participated in Forest

Service sponsored safety training related to riding and handling stock animals as some of our plots in remote areas require stock assistance for efficiency.

The majority of safety incidents or near misses in our program occur in the field. Near misses are reviewed regularly by the Safety Committee and state field crew coordinators. New incidents are potentially prevented by taking a proactive approach. For example, the progressive handling of safety in the face of an unprecedented fire season in 2015. We realized that fire behavior was far different than the past, and that current safety procedures may not be adequate for the current circumstances. Data collection leadership called a safety stand down, and during the stand down the team drafted a new set of procedures that incorporated fuel moisture readings, smoke forecasts, and flammability indexes. The results led them to move all staff out of areas hazardous for either risk of rapid spread of new ignitions or unhealthy levels of smoke. In addition, they developed a new system for accounting for locations of staff.

C Braden

Challenges and Opportunities

As a large, innovative program, we do face challenges to achieving our vision, but these challenges also present us with multiple opportunities to improve and adapt. Some of the most obvious challenges our program faces are related to funding—years of operating within a flat or declining budget—in conjunction with increasing costs and few reductions in expectations or congressional mandates. Limited resources often reduce creativity as focus tends to shift from longer term strategies to short-term activities (reactions to a crisis or taking on the path of least resistance), but RMA staff are finding ways to prioritize our workload and continue to meet client needs within the limitations.

The needs of our clients and the important issues we face change more quickly than our ten-year FIA remeasurement cycle, requiring us to anticipate and adapt while also maintaining a core of basic resource information that can be compared across large spatial and temporal scales. The RMA Program benefits from its large and diverse workforce and a history of cross-team collaborations that take a strategic approach to integrating production and research portions of our program. We are starting to reach the collective potential of our breadth of knowledge, skills, and experience, as demonstrated by our initiative to focus and prioritize our research products around four key themes that are likely to remain relevant for the next decade.

A less obvious challenge to RMA is the increasing difficulty of accessing plots, both public and private. Plots on federal lands in the Pacific Northwest are increasingly more difficult to access as road and trail networks deteriorate and disappear. This results from the travel maintenance plans enacted by each Forest in an attempt to cope with diminishing management budgets as fire suppression budgets increase. Obtaining permission from private landowners continues to be an issue because of strained relationships with the federal government in our region. If fewer plots are measured, there is greater potential for bias in our data. We are mitigating these access issues by reaching out to landowners in different ways and having more resources available to answer any questions they may have about our program. We are also trying new approaches to accessing plots such as incorporating aerial and terrestrial transportation assistance through helicopters and pack animals.

Janelle Cossey

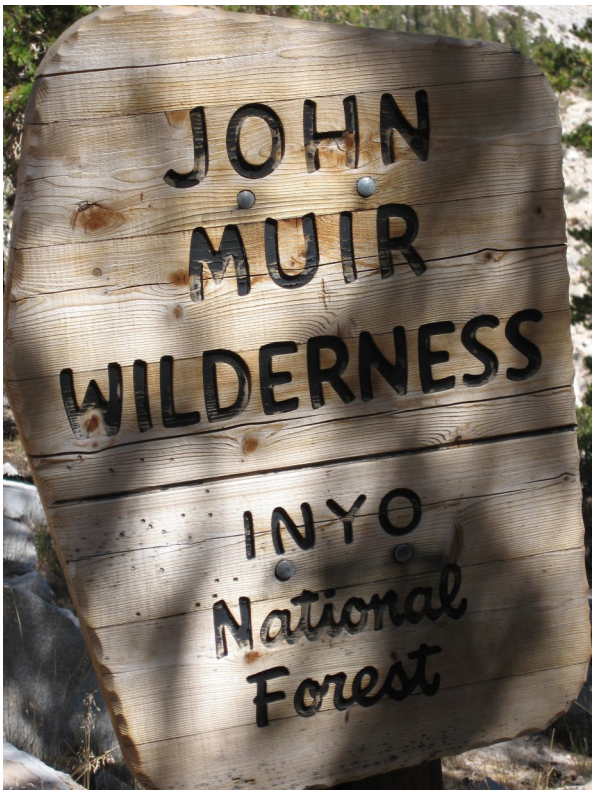
Potential Station/ RMA Partnerships

In Alaska, we have access issues in USFS Wilderness areas. The only way to access these areas is by helicopter, and the region will not allow access to these areas. This is a problem on many levels, from the absence of plots in very large forest areas, to the impact on sampling in other wilderness areas. This is a difficulty we may need station support to address.

Despite the challenges of developing more extensive partnerships, the RMA Program is committed to expanding its capacity by increasing its mutually beneficial relations with outside units. We are interested in expanding our relationships with states and NFS, who are already natural partners. To do this, we have discussed working proactively with the Interior West Region to form regional coalitions. We will hold a joint meeting with the Interior West FIA unit this fall to explore the benefit of communicating with the entire western audience. This effort could be expanded to a station level as well.

With the expected launch of ICESAT-2 satellite LiDAR (2017) and the Global Ecosystem Dynamics Investigation (GEDI) LiDAR on the international space station (2018) we will soon have nearly comprehensive, higher-quality LiDAR-derived forest structure information over most of the globe. These measurements will provide unprecedented information on the spatial distribution of aboveground carbon and biomass throughout the U.S. and beyond. Our program plans on increasing our scientific expertise and capacity for the analysis and application of spaceborne LiDAR to support forest inventory. We intend to fill a vacant station position in our remote sensing team with a scientist who will specialize in use and dissemination of this information when funds become available. A station/RMA partnership could capitalize on the strong relationship with NASA (perhaps even partnering with RMRS) to build and strengthen our leadership in remote sensing.

Two areas that would benefit from more PWN Station / RMA collaboration are urban monitoring and tribal partnerships. National FIA is expanding the sample base into urban areas. When the funding is available in the West to implement urban FIA, this seems like a natural area for a Station/FIA partnership.



Josh Feinberg

Tribes represent a relatively large ownership in the west, yet we have not established a consistent mechanism to build a good relationship with them. This is also an area that may benefit from a joint effort with the station.

RMA is looking for creative approaches that allow us to anticipate change so that we can adapt and continue to be leaders and innovators in inventory and monitoring science. The Station Management Team can help our program achieve its vision and goals by continuing to provide funding opportunities; introducing our scientists to potential partnerships; supporting process improvements within human resources and the CIO; and technology and staffing support in the publications group to help us deliver our science in a more timely and compelling manner.

Innovations

The RMA Program demonstrates a high degree of innovation, from operations to science delivery, and many of these innovations have already been shared across the station and with other research stations. We made multiple changes over the last five years to implement efficiencies in field operations, safety, retention of a productive and experienced workforce, and making our products more widely available.

Gerad Dean

Recent Program innovations:

- We developed a program website using a topical approach that is more intuitive for modern internet users. We provide simple and direct downloads of databases from our website, updating the data annually. Our program also participates in the newly formed partnership between USFS and ESRI to pursue innovative, interactive, web-based tools that allow us to tell our stories and share knowledge in a more accessible format than published articles.

- We are at the forefront of implementing the USFS Digital Strategy Framework, working with the CIO to move our data and information beyond the Forest Service firewall and demonstrate the value of our multi-million dollar program to the general public.

- We developed a quality assurance/quality control process that improves the data coming in from the field and implements formalized checks on compiled variables which has greatly improved efficiency and our ability to make data publicly available on time. These efforts have led to similar efforts in other FIA units.

- We have been involved in refinement of field protocol and compilation algorithms to improve consistency across FIA units, efficiency of information management and analysis, and transparency of results.

- We developed new and efficient inventory designs for remote areas (i.e., interior Alaska) that integrate cutting-edge remote-sensing technology with field protocols that meet specific regional needs, address critical national issues (climate change and carbon accounting), and do it within the national FIA framework.

- We are continually developing innovative applications of emerging geospatial techniques and technologies (LiDAR, hyperspectral imaging, graphics/visualization, machine learning, satellite image time series analysis) to improve our ability to detect and monitor important vegetation characteristics across multiple scales.

- We are expanding the application of inventory and monitoring information beyond traditional timber assessments with peer-reviewed science on invasive species, wildlife habitat, tree species migration, fuel hazard reduction, air pollution effects, role of urban forests, and the effects of land use change.

- Several innovative tools and techniques developed by RMA scientists, such as FUSION LiDAR processing software, TimeSync/LandTrendr Landsat time series analysis tools, and more are now widely-used throughout the station and agency.

- RMA scientists are using novel approaches to combine information from field and remote sensing data to monitor carbon stocks in support of REDD+/MRV and national greenhouse reporting programs.

Appendices

RMA Charter — p. 45
FIA net appropriated funds and partner support funds — p. 65
State and National Forest System contributions to FIA — p. 67
University grants to PNW-FIA (2000-2015) — p. 69
PNW-FIA Income and Expenses (2000-2014) — p.71

The following supporting documents are available on the RMA website News & Events page (http://www.fs.fed.us/pnw/rma):

- RMA Organizational Charts (2010 and 2016)
- RMA Science Accomplishments
- RMA Publications 2010-2015
- RMA Project Priority Portfolio Plans
- PNW Research Station Strategic Framework
- FIA Strategic Plan
- USFS R&D Quality Assurance Plan
- Electronic File Storage for PNWRS RMA
- FIA Business Report 2014
- FIA Rewards and Challenges Field Crew Document
- FIA Brochure—2014 Farm Bill
- FIA Brochure—Carbon
- FIA Brochure– Investment
- FIA Brochure—Tribal Partnerships
- FIA Brochure—Urban Inventory

RESOURCE MONITORING AND ASSESSMENT PROGRAM CHARTER

Pacific Northwest Research Station

Review and Approval

Signature	Title	Recommendation		Date
		Qualified	Unqualified	
/s/ Edward J. DePuit Recommended	Program Manager			August 6, 2009
Recommended	Water, Air, Soil Strategic Program Area Lead #1	✓		9/17/09
Recommended	Forest Hlth Sci Staff Director #1	✓		9/23/09
Recommended	Strategic Program Area Lead #2	✓		9/18/09
Recommended	Staff Director #2	✓		24 Sep 09
/s/ Boy B. Eav Approved	Station Director			August 6, 2009
David G. Cleaves Concurred	Deputy Chief for Research			9/29/09

(Adapted from FSM-4000-1)

Qualification: The Charter does not contain the specificity needed by the Washington Office to provide the national oversight referred in the Forest Service Manual, planning, cross station and agency coordination, and responses to Congressional or Administration queries. Submission of a business plan that identifies staffing, resource needs, and planned accomplishments would likely provide the needed information to redeem national responsibilities.

(Adapted from FSM-4000-1)

CHARTER
RESOURCE MONITORING AND ASSESSMENT PROGRAM

Pacific Northwest Research Station

Executive Summary

Forests and rangelands in the Pacific region are among the most diverse and productive in the world. They are also in a constant state of change due to natural and anthropogenic impacts. Management of these forests is dynamic owing to changes in land management policies, increasing human populations and their growing demands on forest resources, new and emerging markets for natural resources, competing values among those with a stake in these forests, and a growing understanding of fundamental ecosystem processes. Basic knowledge of the current status, past trends, and future projections of the forest and rangeland ecosystems is critical to policymakers, land managers, and the public.

The mission of this program is to improve forest and range ecosystems by developing and applying inventory and monitoring methodology to maintain current comprehensive inventories and conduct multiscale assessments of the status, trends, and prospective futures of the region's ecosystems.

The program has three major problem areas that cover the existing Forest Inventory Analysis Program responsibilities as well as provide flexibility to expand the focus of the inventory as well as the development of techniques and application of inventory and monitoring information to current and emerging issues.

Problem 1: How can we provide essential information on the status, extent, and characteristics of forest and rangeland in the Pacific region and their change over time to decisionmakers?

Problem 2: How can we increase the efficiency and add value to inventory and monitoring efforts through the development of new tools, techniques, and methodology?

Problem 3: How can inventory and monitoring data be used to understand the effects of human use, climate, and natural disturbances on the forest and rangeland condition?

People and natural resources are intimately tied together by complex environmental relationships. The state of today's forests, range, air, and water reflects our past choices and a continuously changing trend in resource conditions. Providing credible, reliable, timely information is essential to making informed management decisions and policies. Research results and information will be of particular interest to land managers, policymakers, nongovernmental organizations, and the public.

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R&D PROGRAM NUMBER

TBD

STATION

Pacific Northwest Research Station

R&D PROGRAM LOCATIONS

Anchorage, Alaska; Portland, Oregon; Corvallis, Oregon (depending on final composition of program this could change)

R&D PROGRAM TITLE

Resource Monitoring and Assessment (RMA) Program

PROGRAM MANAGER

Charles E. Peterson

AREA OF APPLICABILITY

Research and development activities within this program have broad application to regional, national, and international issues. The Forest Inventory and Analysis portion of this program has responsibility for the inventory of all forest land in the states of Alaska, California, Hawaii, Oregon, Washington, and six Pacific Island groups.

ESTIMATED DURATION

The RMA Program is chartered for 10 years (2010–2020) with a mid-term review and potential charter revision after 5 years (in 2015). Amendments will be made to the charter as needed to address emerging issues.

MISSION

Improve forest and range ecosystems by developing and applying inventory and monitoring methodology to maintain current comprehensive inventories and conduct multiscale assessments of the status, trends, and prospective futures of the region's ecosystems.

JUSTIFICATION AND PROBLEM SELECTION

Program Justification

Forests and rangelands in the Pacific region are among the most diverse and productive in the world. They are also in a constant state of change owing to natural and anthropogenic impacts. Management of these forests is dynamic owing to changes in land management policies, increasing human populations and their growing demands on forest resources, new and emerging markets for natural resources, competing values among those with a stake in these forests, and a growing understanding of fundamental ecosystem processes. Basic knowledge of the current status, past trends, and future projections of the forest and rangeland ecosystems is critical to policymakers, land managers, and the public.

Purpose

The primary purpose of this program is to provide inventory, assessment, quantitative analysis, and technique development services to help inform policy development and land management decisions. The Forest Inventory and Analysis (FIA) Program responsibilities will be a major component of the Resource Monitoring and Assessment (RMA) Program. Providing an annual inventory of forested lands as well as periodic assessments of the status and trends of forests are key products of the program that are in high demand by state and federal land managers, nongovernment organizations (NGOs), financial investors, and private landowners. Statistical methods and techniques development is essential for researchers and planners to design and maintain efficient and effective inventories and monitoring efforts for a variety of management and policy needs. Incorporating new technologies such as remote sensing data into the data collection and analysis phases of inventory and monitoring projects presents opportunities to enhance the spatial and temporal resolution of forest assessments. Ultimately, innovative analysis of systematically sampled inventory data enhances our understanding of the relationships between disturbance and ecosystem condition.

Focus

The Pacific Northwest (PNW) Research Station is responsible for the inventory of approximately 570 million acres (Alaska, California, Hawaii, Oregon, Washington, and six Pacific Island groups), with about 38 percent (220 million acres) in forest land. Two-thirds of the forest land is in public ownership (federal, state, and local), with approximately one-fourth of all forest land administered by the National Forest System. Overall, the forests in this region contain over 249 billion cubic feet of wood volume. They grow about 4.7 billion cubic feet of tree volume each year, but mortality offsets about 29 percent of that growth. Harvest of timber for traditional wood products continues to be a large, or the largest, component of the economies of many counties in Oregon, Washington, and California. At the same time, interest in new uses of forest land--for bioenergy production, carbon sequestration, and other nontraditional uses is building quickly.

This tremendous forest resource also provides important economic, social, and aesthetic benefits to the over 47 million people who live in the region. Population density ranges from 1.1 persons/square mile in Alaska to over 200 persons/square mile in California. Impacts on, and uses of, forest land differ substantially across the region. The demand for increased goods and services from the land (water, recreation, solitude, open space, wood products, etc) is on the rise.

For the FIA portion of the program, there is a legislative mandate to maintain a comprehensive inventory of the Nation's forest lands, including analysis and reporting. The PNW-FIA Program has legislatively assigned responsibility, through the Renewable Resources Planning Act of 1974, the National Forest Management Act of 1976, the Renewable Resources Research Act of 1978, the Forest Ecosystems and Atmospheric Pollution Act of 1988, Section 253(c) of the Agricultural Research, Extension, and Education Reform Act of 1998 and administrative direction from the FIA Blueprint for the 1990s and Vision for the Future for maintaining current assessments of the forest resource supply and demand situation in the Pacific region. The Research Title to the Agricultural Research, Extension, and Education Reform Act of 1998 now requires that an inventory of forests in each state be conducted each year, an analytical report be produced every 5 years for each state including trend information, all forested lands regardless of ownership be included, and national standards and definitions be applied.

Needs and Benefits

People and natural resources are intimately tied together by complex environmental relationships. The state of today's forests, range, air, and water reflects our past choices and a continuously changing trend in resource conditions. The conversion of "wild" landscapes to wildland-urban interface has significant impacts on the management and use of the forest resource. Impacts of natural disturbances including climate change and management response will have significant impact on the conditions and future of the forests. Land ownership patterns are also shifting dramatically with changes in the traditional forest industry infrastructure and continued development of land in and near the forest ecosystems. Resource management continues to be contentious and challenging. Providing credible, reliable, timely information is essential to making informed management decisions and policies.

Information/Technology Transfer

Transfer of scientific, technical, and general information from the RMA Program is a critical component of the overall research cycle. Outputs from this program will include baseline inventory information, technical summaries, new techniques, advancement of new theory, and response to client requests. The target audiences include other researchers, land managers and other decisionmakers, other federal and state agencies, NGOs, private industry, investment bankers, and the public. Technology transfer delivery methods will include peer-reviewed journal articles, station publications, workshops and client meetings, direct consultations, Web sites and Web-based tools for accessing and using information, databases, maps, tools, and models. The FIA responsibilities include annual posting of inventory data, 5-year reports for each state, participation in the 5-year national Resources Planning Act publications, and annual reporting of business information to Congress.

Relationships to National Strategies and Goals

The RMA Program's work is related to many of the Agency strategic plan goals and the R&D Strategic Program Areas. The RMA Program contributes to four of the Agency goals as defined in the *USDA Forest Service Strategic Plan 2007-2012*:

> **Goal 1: Restore, Sustain, and Enhance the Nation's Forest and Grasslands** (including fire, wildlife, invasive species, landscape ecology, global change, and range research)
>
> **Goal 2: Provide, Sustain, and Enhance Benefits to the American People** (including ecosystem services research)
>
> **Goal 4: Maintain a Full Range of Basic Management Capabilities of the Forest Service** (including development/transfer of synthesized information, tools and technologies)
>
> **Goal 7: Improve Scientific Basis for Sustainable Natural Resources Management** (including high-quality research responsive to current/future priorities, and facilitation of increased use of research-derived information, tools, and applications.

In addressing the above goals, the RMA Program will also support the national mission of USFS R&D as stated in its *USDA Forest Service Research & Development Strategic Plan, 2008-2012* to "*develop and deliver knowledge and innovative technology to improve the health and use of the Nation's forests and rangelands–both public and private*. The associated vision is that "*we are recognized as a world leader in providing innovative science for sustaining global forest resources for future generations*." The program's work includes research in five of the seven USFS R&D national Strategic Program Areas:

1. Water, Air and Soil	(RMA Problems 1, 3)
2. Resource Management and Use	(RMA Problems 1, 3)
3. Wildland Fire	(RMA Problems 1, 3)
4. Invasive Species	(RMA Problems 1, 3)
5. Inventory and Monitoring	(RMA Problems 1, 2, 3)

Relationships to Station Strategies and Other Programs

The program's work is directly related and integral to the research directions established in the PNW Research Station's 2008 Strategic Business Plan, which included the definition of five foundational themes for station research over the next 10 years. The RMA Program directly corresponds to the forest resources monitoring and assessment foundational theme in the plan and the intent of the program was broadened to recognize the potential to conduct work in areas broader than just forests. The RMA Program will work jointly with all other PNW Station programs on issues that we have defined as

crosscutting and on specific projects where the problems cross one or more programs. Program-to-program relationships are summarized in appendix B.

The RMA Program also has close ties to the Rocky Mountain, Northern, and Southern Research Stations, all of which have units responsible for regional implementation of the national FIA Program. This program has a special relationship with the PSW Research Station because of our inventory responsibilities in California, Hawaii, and the Pacific Island groups.

PROGRAM PROBLEMS

Activities of the RMA Program will focus on three broad Problem areas considered of key importance to providing essential information on the status, trends, and futures of the region's ecosystems.

Problem 1. How can we provide essential information on the status and extent and characteristics of forest and rangeland in the Pacific region and their change over time to decisionmakers?

This problem encompasses the primary function of the national FIA Program for the Pacific region (five states and six Pacific Islands). The vision for the national FIA Program is to deliver current, consistent, and credible information about the status, condition, and trends of America's forests. It includes the data collection, processing, analysis, and delivery of the annual inventory of forest land, the 5-year reports for each state, and the general analysis of forest status, extent, and condition.

Problem 1 Elements

1.1 Conduct the annual inventory of all forest land within the states of Alaska, California, Hawaii, Oregon, Washington, and the six Pacific Islands

This element focuses on delivering the current FIA Program on forested lands in the Pacific region. Work will also include participating in the development and implementation of national methods and standards for the comprehensive inventory, delivering data within 6 months of the end of the field season, producing a report every 5 years for each state, and participating in Forest and Rangeland Renewable Resources Planning Act and other national assessment efforts. This element also includes continuing the inventory of forest health indicators such as understory vegetation, down woody material, lichens, ozone, and more. Monitoring invasive plant species will be part of the data collection protocols.

1.2 Monitor the Timber Product Output component of the national FIA Program

Information will be collected on the composition, size, and location of the primary processing facilities within the region. Information on timber flows, mill capacities, wood use, and product output will be used to do regular assessments of the status, condition,

and economic health of the forest industry. We will also provide information to the national Timber Product Output Web site and to the RPA assessment.

1.3 Participate in the annual National Woodland Owner Survey
This work characterizes the owners of private woodlands for their ownership objectives, management practices, future intentions, and demographics. An annual survey of woodland owners provides information both nationally and regionally that will be used to develop an understanding of family forest owners and evaluate policy alternatives to encourage and facilitate sustainable family forest stewardship.

1.4 Conduct an annual inventory of rangeland within the Pacific region
The national Rangeland Sustainable Roundtable has raised concerns about the lack of a comprehensive inventory of rangeland. The national FIA Program has been working with partners in the range community to pilot test methods for purposes of tracking health, productivity, and sustainability of rangelands at the strategic level. It is possible within the next 10 years that the program could be expanded to include all land classified as nonforest by cover and nonurban and nonagriculture by use.

1.5 Conduct an annual inventory of forested urban areas
A systematic approach to collecting and reporting data on status and trends of trees and forests in urban settings would provide valuable information on an area currently not inventoried nationally. The FIA sampling frame could be expanded to urban settings, maintaining the strategic scale while providing a platform for others to intensify to the individual city level. Urban trees and forests have significant implications for urban energy budgets, air quality, and quality of life of urban populations, which includes some 80 percent of the U.S. population.

1.6 Reporting and monitoring of coarse-scale indicators of conditions and trends
Similar to the Criteria and Indicators of Sustainability developed through the Montreal Process, sets of indicators have been developed by local entities such as the Oregon Department of Forestry. Work would be done to estimate these indicators and track trends temporally, refine indicators based on new information or expanded coverage of ecosystems over time.

Problem Importance

People served and issues addressed: The work in this Problem is valuable to a wide range of partners and clientele including, but not limited to, State Foresters, the forest products industry, financial investors, State and Private Forestry, National Forest Systems, researchers, NGOs, other agencies, universities, and private landowners. Specific needs include understanding the status and trend of forest land, its health and condition, its economic potential, ownership patterns and sustainability of working forests, its ability to support habitat, the risk of wildfire, and the impact of land development on forest condition.

Potential clientele, societal and scientific benefits: In the short term, the outcomes of this Problem will be to provide decisionmakers with the information they need to make effective land management decisions, guide economic development of new and

innovative uses of forest resources, and identify emerging problems with the forest resources. As the role and area of the inventory expands, similar information needs will be provided for rangeland and urban forests. In the longer term, the results will be to provide information at a variety of temporal and spatial scales that will be useful for an array of questions on impacts of climate change, increased population, dwindling resources, increased pollution, a changing forest land base, and increasing demand for ecosystem services.

Likelihood of Success in Problem Work

Work under this Problem will build on a significant base of inventory and monitoring work that has been underway since the 1930s. The first three elements are tied directly to the national FIA Program and have received significant support from the Forest Service, State Foresters, Forest Industry, NGOs, and private landowners. Methods and techniques development (Problem 2) will be needed to keep the inventory efficient and effective. Currently, the funding is only available for California, Oregon, Washington, and coastal Alaska. Additional funding or new techniques will be needed to expand the forest inventory to interior Alaska and Hawaii. Additional support is also needed to expand the work to rangeland or urban forests. The likelihood of success for the existing area of the inventory is very high. The likelihood of success for new and expanded responsibility is moderate in the short term, and may be higher in the longer term.

Approach to Problem Solution

The general approach to this Problem includes conducting the annual inventory of forest land following agreed-upon national protocols and additional regional protocols as defined by the regional issues and partner needs. A "needs assessment" will be performed on a 10-year cycle, concurrent with the length of the inventory cycle, to ensure that the information collected is adequate, necessary, and useful to address current and projected future questions. Following the needs assessment a review of protocols, technology, and application of results will be conducted to identify the most efficient and effective methods for data collection, processing, analysis, and delivery. Annually the data will be delivered via the Web to the public, and through other databases directly to partners. On a 5-year interval, summary reports on a state basis will be provided. Use of coarse-scale criteria and indicators of conditions and trends will be done through these periodic reports. General summary reports at different scales and direct client support will be done on an ongoing basis.

Problem 2. How can we increase the efficiency and add value to inventory and monitoring efforts through the development of new tools, techniques, and methodology?

To stay relevant and improve the inventory we need new techniques and methods that capitalize on new technology and generate new knowledge. Funding for FIA has been stable for the last 5 years so efficiencies are required to maintain the inventory, and creativity and innovation are required to extend the inventory to interior Alaska and Hawaii. Expansion of inventory and monitoring work to focus on land areas and features

beyond traditional forest land will require the development of new sampling designs and protocols. Work in this area has the potential to fundamentally change the way that systematic inventory and monitoring work is done, address the problems with temporal and spatial scaling of information, and explore opportunities for evidence-based assessment of risk and prediction of outcomes of treatments.

Advances in technology for airborne and satellite sensors are rapidly changing the potential for ancillary data to be applied to inventory and monitoring questions. Issues of the viability of new remote sensing technology, its applicability and cost effectiveness, and its potential for temporal and spatial scaling all need to be explored.

Emphasis under this problem will also include developing metrics and protocols for monitoring to address changes in condition of aquatic, riparian, and terrestrial ecosystems affected by management. In this way, the effects of management and restoration activities that are propagated throughout these systems can be better assessed. These efforts will require improved measurement techniques, database designs, and analysis and models enhanced with visualization tools.

Problem 2 Elements

2.1 Improve estimation techniques to increase precision and accuracy of estimates for inventory and monitoring

Understanding the impacts of measurement error estimation, missing data, and small area estimation are also examples of the type of statistical based research that could vastly improve the overall estimates, and the applicability of monitoring information to address questions at different scales. Significant resources are invested in sampling field plots based on current estimates of variance. A more thorough investigation into the different available methods for estimation of variance for simple random samples versus systematic samples is one example of an improved technique that may result in refined estimates of variance and improved efficiency.

2.2 Incorporating ancillary information to increase precision and accuracy of estimates for inventory and monitoring

One primary use of remotely sensed data is to provide stratification for two-phase sampling. Ancillary information, including remote sensing or geographic data, can also be combined with plot data to improve the precision of the estimators, and to improve the estimates for small areas. Use of remotely sensed ancillary data has the potential to reduce costs and provide valuable information especially in remote areas that are difficult to access. Use of mathematical programming to optimize the combined use of different sources of data is another area of exploration.

2.3 Inventory and monitoring methods for additional resources need to be developed and tested

There is a need both regionally and nationally to have strategic-level information available for forests and other natural resources. In the recent past, critical issues were timber availability, timber uses, and market demands. Current issues include forest health, carbon sequestration, riparian area monitoring, and wildlife habitat conditions.

The research and development would include work on definitions, sample design, protocols, compilation procedures, and models for a variety of natural resources and ecosystems beyond forests.

2.4 Develop approaches to use a combination of remote sensing and plot data to generate spatial products with known properties

Improved modeling and analytical approaches are needed for combining site-specific field plot data with remotely sensed data to develop spatial layers that depict geographically continuous models of forest attributes. Development of techniques and procedures for spatially estimating forest attributes and improving detection and assessment of disturbance is essential for a better understanding of trends. This would include evaluating tools such as imputation and interpolation to develop "wall to wall" comprehensive models with estimates of error.

2.5 Improve methods, models and tools to project long-term and large-scale trends in terrestrial and aquatic ecosystems in response to natural processes, disturbance and environmental change

Managers need information about changing forest conditions. Enhanced capability to project long-term trends in terrestrial and aquatic ecosystems and ecological services provides information to managers that can be used to guide investment strategies and management options. Approaches must be developed that integrate different data sources to enable a comprehensive understanding of long-term trends. Thus, research under this problem element will integrate plot-derived and remotely sensed data, other spatial databases, both empirical and process-based modeling, and other analytical approaches. Further, this research will integrate different methodological approaches used for different spatial scales. This element will focus on development of such improved methodologies, with particular emphasis on improving our ability to determine past and project future long-term and large-scale ecological trends in response to biophysical drivers of change. Decision-support systems, risk assessment methods, simulation models, statistical techniques, and linkages between the forest inventory and existing prediction tools are areas for future research and development.

2.6: Develop metrics, monitoring protocols, and statistical methods to address the effects of management and restoration activities on terrestrial, aquatic, and riparian ecosystems and processes.

Monitoring has been inherently present in the traditional FIA Program that tracks status and trends of forest and rangeland. However, research scientists have been increasingly asked over the past 10 to 15 years to assist in assessing the effectiveness of management actions, especially for selected fish and wildlife species. Research under this element would place the emphasis on the effects of management and restoration activities at a range of spatial scales. Development of scientifically-defensible approaches to evaluation of management and restoration effects is highly complex. Land use history of an area is rarely simple, and is commonly unknown. Methods for monitoring status, trends, and ecosystem responses to management will be confounded by variable natural disturbances. The research will establish protocols for conducting monitoring programs at each scale of interest and aggregating the information from small to large scales.

Additionally, it will provide the understanding for appropriate interpretation of results at each scale. Because land managers will never have the resources minimally necessary to monitor every species or process, the challenge under this research effort is to assure that the research is conducted over a reasonable range of conditions such that the methods and tools can be extrapolated to provide risk management scenarios in other areas.

Problem Importance

People served and issues addressed: The primary audience for the research in this Problem is the developers and implementers of inventory and monitoring projects, such as the national FIA Program, National Park Service, and U.S. Geological Survey (USGS) Organizations like Food and Agriculture Organization (FAO) who are concerned about international trends would benefit from having improved estimates of accuracy and precision to improve their efficient and wise use of resources to collect data and analyze trends. University partners and National Aeronautics and Space Administration (NASA) would collaborate to develop better uses of remotely sensed imagery as a tool for data collection as well as additional information for use in conjunction with field data. The biometrics community will be able to use the more efficient methods of forest estimation for improving growth and yield models, vegetation simulators, and natural resource inventories.

Improved measurement techniques, models, analysis, and visualization tools, and database designs will benefit scientists and others by producing tools they can use to better characterize, analyze, summarize, and display data from their projects. Scientists will use visualization tools to more broadly understand and communicate information from their studies.

Potential clientele, societal and scientific benefits: Potential clientele include a broader array of scientists within and outside of the station who are interested in the development of sampling designs and protocols for a range of inventory needs beyond traditional forest inventory. Increased desire for information to be spatially represented and available has created need to invest in the development of more mapped-based products while also ensuring the quality and validity of the products are understood.

Likelihood of Success in Problem Work

The development of new techniques and methods to conduct the forest inventory has been a long-standing focus of the PNW Research Station. Regional variables of interest such as understory vegetation and down woody debris have been adopted into new national standards. Doing more research into the statistical properties of our estimation and evaluating new methods and techniques will continue to be an area with a moderate to high likelihood of success, with substantial benefits. Increased understanding of the potential for a variety of remotely sensed data will be critical to improving the efficiency of the inventory and the effectiveness of applying the inventory information to address current and emerging issues. Use of ancillary data has a high likelihood of improving estimates and increasing the efficiency of inventory methods over the next 10 years. In addition, there is real promise in using new technologies to add value to traditional inventory measurements (roads, structures, downed wood, riparian areas, etc.)

Approach to Problem Solution

The approach to this problem will include statistical research on estimation techniques and methods for inventory and monitoring. Investigation into existing techniques used in other disciplines will be conducted as well as refinement and development of new techniques. Theoretical statistical work and mathematical modeling will be done to join field plot data with remotely sensed data to improve the precision of the estimators and to improve the estimates of small areas or domains. Imputation, interpolation, and other modeling techniques will be researched and evaluated for use in developing geospatial products with known error estimates.

Research under specific elements of this Problem relates to specific elements and Problems in other PNW programs. The Ecological Process and Function Program, Land and Watershed Management Program, and the Threat Characterization Program all have problems or elements that address developing detection methods; techniques for measuring, modeling, and predicting characteristics of ecosystems at multiple scales; or characterizing, addressing, and communicating error and uncertainty.

Problem 3. How can inventory and monitoring data be used to understand the effects of human use, climate, and natural disturbances on the forest and rangeland condition?

Because inventory and monitoring data are designed to provide a systematic probabilistic sample across ecosystems of interest, they allow assessment of condition and trend over temporal and spatial scales. The broad-scale inventories provide context and validation for what we learn from fine-scale studies addressing a range of forest and rangeland issues. Inventory and monitoring findings have improved our understanding of the effectiveness of regulation in managing land use change; patterns and trends in fire hazard and potential fire effects; and the consequences of land development for active forest management, carbon sequestration, climate change, and expansion in the area of impervious surfaces.

Problem 3 Elements

3.1 What are the ecosystem services and resource product potential of forest and rangeland ecosystems over temporal and spatial scales?

Strategic-level inventories provide critical information about broad-scale status and trends of forest and range attributes, including a wide range of ecosystem services and products. Land managers and decisionmakers need to know the context for their decisions and the broad-scale impacts of management actions. Inventory and monitoring projects provide assessments of the potential for ecosystems to support wood products, carbon sequestration, biomass/bioenergy, wildlife habitats, air quality, and more.

3.2 What is the impact of disturbance on forest and range extent, condition, and use?

Broad-scale disturbance has long been an influential component of ecological processes in the Pacific region. Disturbances such as fire, wind, invasive plant species, and insects and disease have all grown in importance as human populations have expanded and become more diverse in their expectations for the goods and services to be delivered by forest and range ecosystems. Understanding the impact, severity, and rate of change of disturbance is an area of increasing interest and research effort. There is a unique role for inventory and monitoring data to provide field data of known quality as part of the evaluation of disturbance over time.

3.3 Providing projections of future scenarios of change and management with regard to human needs and uses of the ecosystems will provide decisionmakers with valuable insights

Understanding the past and expected magnitudes and causes of changes in species distribution, tree mortality, disturbance frequency, and forest productivity will equip land managers with the information they need to develop and implement strategies to adapt and mitigate the deleterious effects of climate change. It will provide them the basis for understanding the impacts of regulations and the consequences of land development on future natural resources.

3.4 Developing tools that transform inventory and monitoring data into answers that land managers need.

In conjunction with developing an understanding of the status, trend, and prospective futures of the forest and range ecosystems, researchers in this program will also be developing a variety of tools to be used by managers and other scientists to evaluate management questions. Current examples include products like "BioSum," which was developed to evaluate the economic potential and impact on fire hazard of fuel reduction treatments at a landscape level. Collaboration will be a key element of this work as models and tools are developed to address questions around wildlife habitat, nutrient availability, fire recovery, and more.

Problem Importance

People served and issues addressed: Forests are at an increased risk of insect attack and fire owing to overstocked conditions; growing urban populations in the West have increased use pressure on many forests; recent shifts in public policy have reduced timber harvest levels from historical highs of 20 years ago, and potential impacts from climate change may also have profound impacts. Research and development in this Problem is focused on providing interpretation of inventory and monitoring data as it relates to specific questions of interest. This Problem has the broadest array of people served and issues addressed for this program. Traditional partners and clients including State Forestry Organizations, National Forest System, Bureau of Land Management, Forest Industry, and State and Private Forestry have an interest in understanding the effectiveness of regulation on land use change, the consequences of land development on forest management and fire risk, the opportunities for fuel treatments and reduction of fire risk at a landscape level, and in monitoring the recovery of forests after major fire events especially with changes in climate. Other client groups include NGOs like the Heinz Center for Sustainability and FAO who are interested in the broad prospective of the sustainability and health of the all natural resources nationally and internationally.

These groups are interested in understanding the role of forestry and land use change in carbon accounting and assessing benchmarks for state-level greenhouse gas emissions. University partners who work cooperatively with us are invested in increasing knowledge about the changing environment and helping to define strategies to maintain the vitality of the natural resources in the future.

Potential clientele, societal and scientific benefits: Short-term benefits of the work in the Problem will be to develop stronger working relations and partnerships with existing clients and partners as they see new and innovative uses of the traditional inventory and monitoring information. Already we have seen collaborations with efforts like Landfire, USGS Multiresolution Land Characteristics consortium land cover mapping, and NASA explorations of use of technology to assess cover, biomass, and trends increase. As more results become available relating to fire risk assessments, contribution of forests to carbon markets, validation opportunities for fire and climate models, and tools for managers we anticipate creating a new set of partnerships. Already Native Corporations in Alaska along with the National Park Service and USGS are working together to strategize for opportunities to monitor water quality, permafrost condition, biomass and bioenergy for interior Alaska. Pacific Northwest Research Station scientists are also becoming more engaged in cross-program efforts with the RMA scientists. Finally, we see opportunities for the research to result in better understanding of ecosystem response at multiple scales to climate change for use by land managers to develop adaptation and mitigation strategies.

Likelihood of Success in Problem Work

Work in the Problem has been underway for several years with some real successes and some amount of frustration. Evaluating and understanding trends over time requires a base of information that is consistent and reliable over time. The foundational data available through the FIA Program is truly unique and provides a substantial source of information on the region's forests. However, changes to inventory and monitoring protocols, definitions, and sampling design that have been made with the best of intentions all create inconsistencies across time. Collecting data with one intent in mind and then finding out that the original question has changed substantially, or been superseded creates its own set of problems. Finding or creating data sets that are consistent over time will be the biggest difficulty with this Problem. Research into new techniques and approaches and testing evidence-based analysis techniques will certainly add to the complexity of the work, as will dealing with spatial- and temporal-scale questions. Overall, this Problem has a moderate to high likelihood of success. Results will be highly sought after and scrutinized, and when done well, have the potential to be authoritative.

Approach to Problem Solution

The approach to address this problem will ultimately be defined by the individual questions being researched. Research will be done using existing inventory and monitoring data sets in combination with information from other agencies or studies specific to a line of inquiry such as fire risk maps, fire effects models, ambient ozone monitoring, census data, price trends, temperature and precipitation layers. On occasion, additional data will be collected as a separate research study. The ability to look

backwards one to many decades and assess real change from changes in methods will require significant investment in understanding the historical data and the development and application of new and robust analysis techniques. Researchers will rely on a variety of foundational research from other disciplines (fire science, geo-statistics, social sciences, ecology, silviculture) in the other PNW Research Station programs to develop hypothesis to test that can be addressed at the landscape, state, or ecoregion scale. Research may require the development of tools and techniques to analyze the relations between ecological processes and management actions at the landscape scale. Identification of key relationships with the inventory and monitoring data using evidence-based analysis will be one of the techniques pursued.

This Problem is similar to Problem 2 in that it has the potential to be highly collaborative with other PNW programs. Each of the other programs has identified areas where there is strong overlap with the RMA Program. Issues such as long-term and large-scale projections; evaluation of disturbances over time; measuring, modeling, and predicting characteristics of ecosystems at multiple scales; understanding the effects of population and land use trends on forest fragmentation and open space; and projecting supply of natural resources and products will be integrated projects across multiple programs.

ENVIRONMENTAL CONSIDERATIONS

Proposed research activities in this program will likely be limited in context and intensity and are not expected to have a significant effect on the environment. However, the environmental effects of specific actions will be considered during the development of study plans.

STAFFING/ORGANIZATIONAL PLAN and COST ESTIMATES

Current staffing for the RMA Program includes 12 scientists including 9 research foresters, 2 ecologists, and 1 mathematical statistician. Of the nine research foresters, three have remote sensing emphasis, one has an engineering emphasis, and one has a focus on visualization techniques development.

Staffing and funding 2010-2014. Staffing shown in scientist years (SY) and funding is in thousands of dollars

Resource Monitoring & Assessment Program Problems & Elements	FY 10		FY 11		FY 12		FY 13		FY 14	
	SY	$	SY		SY		SY		SY	
Problem 1: Status and extent…….	**1.7**	**10,175**	**1.9**	**10,675**	**2.0**	**12675**	**2.0**	**12,675**	**2.0**	**12,675**
Problem 2: Tools and 5echniques development	**5.7**	**1,500**	**5.7**	**1,500**	**6.0**	**1,800**	**6.0**	**1,800**	**6.0**	**1,800**
Problem 3: Using inventory and monitoring……	**4.5**	**1,700**	**4.3**	**1,700**	**5.0**	**2,100**	**5.0**	**2,100**	**5.0**	**2,100**

APPENDIX: RELATIONSHIP TO OTHER PROGRAMS AT THE PNW RESEARCH STATION

Resource Monitoring & Assessment Program Problems & Elements	Other PNW Foundational Programs and Program Problem Number																	
	Threat Characterization & Management					Land & Watershed Management				Goods, Services, & Values					Ecological Process & Function			
	1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4
Problem 1: Status and extent…….																		
1.1 Forest land	x	x		x					x		x		x	x				x
1.2 Timber product											x			x				
1.3 Natl. Woodland Owner Survey											x		x					
1.4 Rangeland	x			x														x
1.5 Urban	x			x									x					x
1.6 Indicators					x													
Problem 2: Tools and Techniques development																		
2.1 Estimation techniques	x				x			x	x		x							
2.2 Ancillary information	x				x			x	x		x							x
2.3 Nonforest inventory								x	x		x							
2.4 Spatially explicit estimates	x				x			x	x		x							x
2.5 Predicting trends																		
2.5 Effects of mgmt. activities																		
Problem 3: Using Inventory and Monitoring……																		
3.1 Ecosystem services	x			x	x						x			x	x	x	x	x
3.2 Disturbance impacts					x						x			x	x	x		x
3.3 Projections of future	x	x	x	x	x						x	x	x	x	x	x	x	x
3.4 Management tools			x		x			x	x		x	x	x	x				

FIA net appropriated funds and partner support funds

Unit	Year	Unit base appropriated funding	Average National Responsibility	Unit net available base appropriation	Change from previous year	Total partner contributions	Cumulative partner contributions
NRS	2005	16,343,000	1,408,000	14,935,000		4,044,867	
NRS	2006	16,238,500	1,320,000	14,918,500	-0.1%	4,691,188	8,736,055
NRS	2007	16,167,000	1,344,000	14,823,000	-0.6%	4,500,730	13,236,785
NRS	2008	16,167,000	1,717,000	14,450,000	-2.5%	2,537,878	15,774,663
NRS	2009	16,214,000	1,442,000	14,772,000	2.2%	3,140,862	18,915,525
NRS	2010	17,224,000	992,000	16,232,000	9.9%	4,195,076	23,110,601
NRS	2011	17,160,000	990,000	16,170,000	-0.4%	3,943,934	27,054,535
NRS	2012	16,683,000	990,000	15,693,000	-2.9%	4,018,704	31,073,239
NRS	2013	15,168,000	1,010,000	14,158,000	-9.8%	3,316,421	34,389,660
NRS*	2014	15,528,000	610,000	14,918,000	5.4%	3,315,959	37,705,619
SRS	2005	14,865,000	444,000	14,421,000		1,300,643	
SRS	2006	14,647,700	439,000	14,208,700	-1.5%	1,334,085	2,634,728
SRS	2007	14,597,000	360,000	14,237,000	0.2%	1,887,946	4,522,674
SRS	2008	15,095,000	291,000	14,804,000	4.0%	1,668,798	6,191,472
SRS	2009	15,285,000	347,000	14,938,000	0.9%	2,483,317	8,674,789
SRS	2010	16,284,000	299,000	15,985,000	7.0%	2,148,291	10,823,080
SRS	2011	16,440,000	298,000	16,142,000	1.0%	1,988,637	12,811,717
SRS	2012	15,701,000	338,000	15,363,000	-4.8%	2,032,777	14,844,494
SRS	2013	14,629,000	313,000	14,316,000	-6.8%	1,812,621	16,657,115
SRS	2014	14,253,000	313,000	13,940,000	-2.6%	2,416,365	19,073,480

FIA net appropriated funds and partner support funds (continued)

Unit	Year	Unit base appropriated funding	Average National Responsibility	Unit net available base appropriation	Change from previous year	Total partner contributions	Cumulative partner contributions
IW	2005	11,791,000	360,000	11,431,000		421,658	
IW	2006	11,644,500	213,000	11,431,500	0.0%	531,528	953,186
IW	2007	11,699,000	394,000	11,305,000	-1.1%	399,151	1,352,337
IW	2008	12,151,000	335,000	11,816,000	4.5%	657,444	2,009,781
IW	2009	12,486,000	394,000	12,092,000	2.3%	737,124	2,746,905
IW	2010	14,768,000	394,000	14,374,000	18.9%	805,962	3,552,867
IW	2011	14,730,000	394,000	14,336,000	-0.3%	3,106,442	6,659,309
IW	2012	14,228,000	434,000	13,794,000	-3.8%	2,958,770	9,618,079
IW	2013	13,152,000	310,000	12,842,000	-6.9%	1,560,745	11,178,824
IW	2014	13,142,000	310,000	12,832,000	-0.1%	1,070,497	12,249,321
PNW	2005	13,542,000	228,000	13,314,000		242,000	
PNW	2006	13,424,100	102,000	13,322,100	0.1%	115,000	357,000
PNW	2007	13,479,000	154,000	13,325,000	0.0%	346,000	703,000
PNW	2008	13,540,000	215,000	13,325,000	0.0%	1,691,438	2,394,438
PNW	2009	13,595,000	164,000	13,431,000	0.8%	132,200	2,526,638
PNW	2010	14,965,000	164,000	14,801,000	10.2%	366,906	2,893,544
PNW	2011	14,895,000	165,000	14,730,000	-0.5%	169,850	3,063,394
PNW	2012	14,013,000	165,000	13,848,000	-6.0%	1,118,379	4,181,773
PNW	2013	13,107,000	167,000	12,940,000	-6.6%	977,698	5,159,471
PNW	2014	13,107,000	167,000	12,940,000	0.0%	1,030,508	6,189,979

Source: FIA Annual Reports and Budget allocation documents

** Increase not quite real due to working thru how to handle IRDB to UNLV previously a NRS pass thru charge.*

State plus NFS Contributions to support FIA *(Dollars)*

Region	5-Year	2010	2011	2012	2013	2014
NORTH						
WI	6,530,448	929,814	1,690,147	1,495,847	1,448,610	966,030
MN	2,730,377	600,956	482,612	586,969	513,075	546,765
ME	2,227,754	423,287	440,118	483,314	362,311	518,724
MI	201,000	40,200	40,200	40,200	40,200	40,200
IN	863,035	221,952	224,449	236,900	120,715	59,019
PA	384,153	43,000	182,008	50,574	60,536	48,035
MO	453,540	149,603	67,492	70,406	98,547	67,492
NY	99,450	19,890	19,890	19,890	19,890	19,890
KS	202,715	62,963	34,938	34,938	34,938	34,938
WV	246,500	49,300	49,300	49,300	49,300	49,300
IL	116,795	23,359	23,359	23,359	23,359	23,359
SD	94,173	11,092	19,652	22,752	21,851	18,826
DE	74,793	18,275	20,489	20,489	7,770	7,770
IA	89,260	18,680	17,645	17,645	17,645	17,645
NH	102,000	20,400	20,400	20,400	20,400	20,400
OH	56,725	11,345	11,345	11,345	11,345	11,345
MD	61,500	12,300	12,300	12,300	12,300	12,300
NE	29,265	5,853	5,853	5,853	5,853	5,853
ND	37,595	8,795	7,200	7,200	7,200	7,200
MA	56,000	8,200	8,200	8,200	8,200	23,200
VT	43,000	8,600	8,600	8,600	8,600	8,600
RI	24,465	12,189	3,069	3,069	3,069	3,069
NJ	11,335	667	1,667	1,667	3,667	3,667
CN	2,500	500	500	500	500	500
TOTAL	**14,738,377**	**2,701,220**	**3,391,432**	**3,231,717**	**2,899,881**	**2,514,127**
Avg/St/Yr	**122,820**					

State plus NFS Contributions to support FIA *(Dollars) continued*

Region	5-Year	2010	2011	2012	2013	2014
SOUTH						
TX	1,836,751	343,503	524,300	194,113	309,409	465,426
KY	1,354,485	344,103	289,625	501,472	131,418	87,867
GA	940,448	191,160	180,519	205,658	201,042	162,069
AR	732,964	140,240	107,016	107,016	144,077	234,615
AL	526,423	172,704	53,405	53,405	76,796	170,113
TN	486,119	168,166	127,269	162,744	27,940	
SC	604,901	163,068	80,948	106,526	124,000	130,359
FL	625,800	137,037	163,930	145,673	59,388	119,772
VA	688,845	139,248	154,339	154,339	123,514	117,405
MS	604,931	130,527	126,625	126,625	92,263	128,891
OK	446,719	10,124	41,993	57,804	199,608	137,190
LA	-					
NC	221,262	17,160	31,850	117,402	14,850	40,000
TOTAL	**9,069,647**	**1,957,040**	**1,881,819**	**1,932,777**	**1,504,304**	**1,793,707**
Avg/St/Yr	**139,533**					
INTERIOR WEST						
NM	3,839,131	411,000	1,857,844	1,126,187	444,100	
CO	1,143,377	231,649	237,450	231,522	247,246	195,510
ID	103,600			103,600		
UT	472,809	12,926	102,191	330,562		27,130
MT	437,180	68,940	171,040		123,400	73,800
NV	120,819	1,200	300	2,974	116,345	
AZ	-					
WY	-					
TOTAL	**6,116,916**	**725,715**	**2,368,825**	**1,794,845**	**931,091**	**296,440**
Avg/St/Yr	**152,923**					
PACIFIC NORTHWEST						
OR	390,858	115,600		118,250	157,008	
CA	184,267	95,300		29,400	29,427	30,140
AK	528,706	88,506		140,000	160,200	140,000
WA	121,361	20,000			55,520	45,841
HI						
TOTAL	**1,225,192**	**319,406**	**-**	**287,650**	**402,155**	**215,981**
Avg/St/Yr	**49,008**					
US TOTAL						
TOTAL	**31,150,132**	**5,703,381**	**7,642,076**	**7,246,989**	**5,737,431**	**4,820,255**
Avg/St/Yr	**124,601**					

$8 MILLION IN UNIVERSITY GRANTS (2000—2015)	
Oregon State University	**3,494,045**
Adjunct Inventory and Monitoring Program/Flora and Fauna	84,950
Alpine plant communities using permanent plot systems and predictive mapping	85,000
Carbon Content of Dead Wood	119,000
Carbon monitoring systems integrating field and remote sensing data	56,000
Characterization of Forest Canopy Structure and Wildlife Habitat in Western OR from Regional Inventory Data	37,096
Decay Reduction Factors For Standing Dead Trees	50,000
Decline in CA using FIA data	4,167
Developing climate and air quality gradient for lichen communities in California	285,239
Down woody material/carbon research	40,000
Ecological drivers and potential responses to climate change of tree species distribution in pacific coastal states	83,500
Evaluating the Potential of Remote Sensing Technologies	76,000
FIA Biomass Study	355,998
Identification and Documentation of Vascular Plants on Inventory Plots in the Pacific Northwest	25,000
Imputation and modeling methods to estimate productivity of Pacific Northwest forests	172,774
Lichen and bryophyte indicators and roles in forests	132,360
Linking forest canopy measurements to wildlife habitat models.	65,949
Modeling changes in subalpine forests/alpine plant communities using permanent plots and predictive mapping	14,471
National Imputed Database: Building a Project Plan in Cooperation with a National Team	23,965
Pacific Coast Forest Disturbance, Regrowth, and Biomass Dynamics	55,000
Quantification of carbon sequestration in the west coast states	57,140
Regional and national lichen analysis and QA/QC coordination	257,595
Regional carbon models from linking field measurements and satellite change detection	110,926
Regional patterns of forest wildlife habitat: scaling from plots to landscapes	134,500
Regional patterns of forest wildlife habitat: scaling from plots to landscapes	17,204
Spatial and Ecological Analysis of Red Fir Decline in California using FIA Data	34,775
Spatial monitoring of forest conditions over regional landscapes	178,597
Status and Trends of Whitebark Pine Distribution and Health in CA, OR, WA	17,000
Support for the landscape change monitoring system	333,390
Using Airborne Lidar to improve the cccuracy of mapped FIA variables	50,000
Using Ancillary Information and Forest Inventory Data Improvement	283,874
Using high-density airborne LIDAR to improve the accuracy of mapped forest inventory variables	60,000
Using imputation to estimate change and status of forest attributes from paneled inventory data	133,519
Vegetation indicator advisor	34,000
Land Trender for PNW NASA CMS project, land cover monitoring	25,056
Portland State University	**176,507**
Modeling forest resilience, biomass and carbon management potential	43,994
Bio-Monitoring urban forests	36,000
Modeling forest resilience, biomass and carbon management potential from FIA data	96,513
University of Alaska	**736,924**
Biomass and Carbon in Boreal Forests of Alaska Using L-Band	40,000
Experimental Forests- Bonanza Creek	337,000
Growth, mortaility, and climatic impacts via tree ring analysis	19,964
Projection of forest growth and yield in coastal Alaska	56,294
Tests of repeatability of field techniques	15,000
Vegetation Database development (AKEPIC)	5,000
Pilot Project of Tanana Valley FIA, Alaska	149,751
Growth, mortality, and climatic impacts via tree ring analysis on FIA plots	113,915

$8 MILLION IN UNIVERSITY GRANTS	
University of British Columbia	**63,000**
Fire effects and ecosytem recovery after forest wildfire on FIA plots	63,000
University of California	**104,935**
Experimental Forests- Hubbard Brook Climate Effects	104,935
University of California, Berkeley	**129,936**
Development of a Geo-Referenced Database for the Circa 1919 Vegetation Type Map/Weislander Inventory Plots	102,354
Identification and Documentation of Vascular Plants on Inventory Plots in the Pacific Northwest	27,582
University of California, Davis	**36,083**
Digitizing 1930's Era Wieslander Vegetation Type Maps for CA	36,083
University of Guam	**441,729**
Guam's forest inventory and analysis (FIA) program and Micronesia Challenge's terrestrial monitoring program's forest inventory	175,617
Implementation of annual FIA	266,112
University of Hawaii	**1,143,510**
Experimental Forests- Hawaii Experimental Forest	932,832
FVS-OPCOST: user-friendly FVS simulator to estimate costs of all types of forest fuels management	176,521
Developing statewide report on non-timber forest product use	34,157
University of Leeds	**546,453**
Biodiversity analysis of Southeast Alaska	546,453
University of Montana	**405,442**
Forest Market Census and Analysis of CA and OR	405,442
University of Washington	**661,672**
Carbon monitoring systems integrating field and remote sensing data	18,000
Characterizing forest structure using airborne lidar	79,890
FIA Plot Climate Analysis (W/RMRS Forest and Woodlands Ecosystems program)	144,516
Invasive plants in pacific coast forestlands: creation of a priority list and identification and management aids	30,000
Land Cover Change Assessment for Western Washington for the Past 20 Years	150,000
Use of high-resolution LIDAR and multispectral data collection for forest inventory	13,440
Data processing and field sample design for Lane County	30,000
LIDAR and remote sensing to inform landscape analysis and forest management	70,000
Carbon monitoring spatial optimization of sampling for Interior Alaska	42,500
Carbon monitoring development	83,326
Washington State University	**59,982**
Evaluation of visual structure from motion technology for forest inventory field operations	59,982
Grand Total	**8,000,218**

Gerad Dean

PNW income and expense 2000-2014															
Item	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
INCOME															
00-Pre-yr adjustments	265,000	72,000	1,503,914	1,837,191	1,632,000	801,000	240,820	76,000	331,000	982,150	700,000	206,600	(210,200)	395,465	11,460
01-Research appropriation	5,327,000	5,830,000	6,830,000	8,674,000	12,051,000	12,727,000	12,749,000	12,749,000	12,749,000	12,775,000	14,215,000	13,890,000	13,052,000	12,280,000	13,107,000
02-S&PF appropriation	44,000	1,278,077	968,000	981,200	935,000	815,000	675,100	730,000	791,000	820,000	750,000	1,005,000	961,000	827,000	-
03-NFS appropriation	1,587,000	2,787,000	2,787,000	2,769,000				-	-		-	-	-	-	-
04-Other federal funds	290,000	275,340	1,677,914	1,837,191	1,632,000	801,000	240,820	76,000	331,000	-			-	-	173,000
TOTAL FEDERAL	7,513,000	10,242,417	13,766,828	16,098,582	16,250,000	15,144,000	13,905,740	13,631,000	14,202,000	14,577,150	15,665,000	15,101,600	13,802,800	13,502,465	13,291,460
05-Partner base funds	70,000	70,000	198,342		85,000	85,000	85,000	85,000	85,000	85,000	182,500	45,000	141,648	76,869	670,000
06-Partner value-added funds		502,000	1,377,937	2,622,488	145,546	157,000	30,000	261,000	1,606,438	47,200	184,406	124,850	976,731	900,829	360,508
TOTAL PARTNER	70,000	572,000	1,576,279	2,622,488	230,546	242,000	115,000	346,000	1,691,438	132,200	366,906	169,850	1,118,379	977,698	1,030,508
TOTAL AVAILABLE	7,583,000	10,814,417	15,343,107	18,721,070	16,480,546	15,386,000	14,020,740	13,977,000	15,893,438	14,709,350	16,031,906	15,271,450	14,921,179	14,480,163	14,321,968
EXPENSES															
10-Administration expense	355,000	369,200	253,624	687,000	761,407	328,343	360,681	492,513	427,055	484,172	434,147	629,999	451,973	532,498	555,220
11-Office travel expense	97,000	148,500	350,974	151,000	209,656	169,362	165,829	136,668	93,723	145,393	98,644	91,552	72,576	75,523	111,548
12-Imagery expense	60,664	128,251	33,131	57,000	81,890	216,401	9,445	3,912	3,748	74,827	8,364	-	13,500	-	-
21-Image analysis expense	274,332	338,899	44,000	143,000	-	-	-	-	-	-	-	1,458	-	16,356	16,758
30-Field supervision expense	392,668	589,238	458,231	536,300	689,250	716,820	957,911	914,334	1,040,002	666,640	1,142,758	1,365,458	1,327,858	1,254,426	1,112,189
31-Field crew expense	584,475	992,757	2,758,877	2,158,400	2,142,030	3,011,426	2,358,880	2,246,033	2,218,812	3,243,142	3,190,146	2,706,391	2,261,249	2,196,979	1,893,056
32-Fieldwork Grants	2,000	22,840	152,169	1,725,600	266,112		126,000	17,425	655,921	-		1,186,844	772,161	1,206,466	1,542,617
33-QA Crew expense	168,605	164,385	487,791	242,300	255,506	333,612	349,136	414,247	426,779	439,252	385,936	587,031	495,623	516,299	352,446
34-Field/QA travel expense	358,158	735,625	1,144,432	850,500	1,108,722	1,238,714	1,925,526	1,871,396	1,422,955	1,484,415	1,827,612	701,144	516,617	523,419	471,985
35-Vehicle expense	254,830	785,740	432,449	546,000	242,570	230,698	223,739	223,616	220,353	230,758	223,483	237,612	227,052	211,556	208,731
36-Field Equipment expense	226,755	244,426	218,496	257,300	73,664	72,056	37,897	64,869	100,205	88,578	170,836	-	194,515		
TOTAL FIELD COST	1,987,491	3,535,011	5,652,445	6,316,400	4,777,854	5,603,326	5,979,089	5,751,920	6,085,027	6,152,785	6,940,771	6,784,479	5,795,074	5,909,146	5,581,024
Alaska Boat/Helicopter Contract				1,650,000								907,560	484,327	504,216	1,287,187
40-Information Mgmt expense	695,825	734,901	738,613	799,800	1,238,301	1,439,701	1,459,289	1,472,391	1,163,952	1,132,220	1,467,009	1,388,658	1,270,328	1,143,406	1,011,917
41-Information Grants	25,000	24,300		67,083	141,000	500,000		34,000	38,635	50,000	50,000	25,000	-	3,965	-
42-Publication expense	18,000	25,000	30,000	35,000	38,168	27,174	10,533	30,613	16,623	41,125	16,099	36,979	44,341	2,574	2,253
43-Computer/Telecomm. Expense	404,234	492,300	222,619	208,400	313,680	114,632	94,592	123,320	78,200	146,877	100,151	16,366	92,633	117,588	141,468
50-Analysis expense	827,690	974,567	833,722	870,000	955,561	1,077,321	951,244	988,150	919,293	1,030,827	1,059,422	1,092,464	1,312,016	1,064,798	1,245,810
60-Techniques Research expense	369,010	478,032	525,065	845,500	805,270	813,323	628,426	668,891	612,553	728,449	708,273	675,308	628,086	775,069	577,498
61-Research Grants	399,000	511,779	252,321	247,105	955,287	337,100	401,957	524,628	130,765	524,182	705,970	167,297	658,926	633,274	660,506
70-Miscellaneous/other expense	318,754	341,620	84,228	1,232,700	1,145,038	1,470,649	2,454,915	1,416,318	1,536,651	1,487,155	1,729,703	1,912,808	1,649,424	1,383,767	1,394,704
80-INDIRECT EXPENSES	1,344,000	1,838,457	1,404,981	2,236,403	1,947,000	1,940,000	1,148,920	1,786,000	1,787,000	1,793,151	1,976,705	2,181,750	1,682,723	1,833,333	1,871,478
81-Fire Transfer	-	-	1,252,525	-	-	-	-	-	977,775				-		-
90-EOY Balance	72,000	229,600	584,666	365,000	1,101,243	305,668	-	125,676	-	785,987	369,742	97,483	131,200	(100,716)	(12,663)
TOTAL EXPENSES	7,248,000	10,170,417	12,262,914	15,911,391	14,471,355	14,343,000	13,664,920	13,555,000	13,871,000	14,577,150	15,665,000	16,009,160	14,287,127	13,894,798	14,444,708
Forest base+QA plots	1,598	1,846	2,117	2,159	2,355	2,231	2,445	2,558	1,833	1,925	1,748	1,953	1,760	1,603	2,303