



Research on Monitoring Techniques

All aspects of the FHM Program are supported by a formal component to fund and conduct research on monitoring techniques (ROMT). This research is specifically directed to identify new indicators, improve current indicators, evaluate sampling designs, and improve analytical techniques.

Because the FHM Program was designed and implemented to function as a national program, it is no accident that the Program has a history of developing nationally standardized field and analytical techniques. This commitment to national standardization has succeeded to a degree that has rarely been matched by any other program, agency, or institution associated with the Forest Service. The ROMT aspect of FHM functions as an incubator where national protocols are developed with strict attention to input from the regions. Synthesizing national protocols from local input with follow-up pilot testing in several regions maximizes stakeholder buyoff. Once developed, some of these techniques are handed off to partners and collaborators for implementation; others are retained and managed directly by the FHM Program.

The RTP Research Team

Research on monitoring techniques may be conducted by any of the Program's collaborators, but FHM does maintain a formal connection with Forest Service Research and Development through the FHM Research Team located at Research Triangle Park (RTP), North Carolina. The staff at RTP includes four Southern Research Station (SRS) scientists and four North Carolina State University (NCSU) scientists. The NCSU scientists are attached to the Forest Service through Cooperative Agreements. The FHM Research Team is specifically tasked with the responsibility to improve existing monitoring systems and develop new sampling designs, measurement techniques, estimation methodology, and analytical procedures. The Team at RTP has participated in many of the ROMT activities undertaken by the Program.

As part of a major reorganization of the SRS implemented in 2006, the FHM Research Work Unit at RTP was combined with the Eastern Forest Evaluation and Threat Assessment Center (EFETAC) located in Asheville, NC. The former Research Work Unit now operates as a Research Team under EFETAC, with no major changes in research assignments anticipated. The collaborative relationship with NCSU will also be retained.

Indicator Development

Early ROMT activities focused on Indicator development--a concept resulting from collaboration with the EPA's Environmental Monitoring and Assessment (EMAP) Program. Indicators were selected on their ability to measure biological response, exposure to stressors, and habitat suitability. The Indicator development process was later tied to Montreal Process Criteria and Indicators when these received international approval in 1994. A formal Indicator development process was established to move Indicators from candidate to pilot to demonstration and finally to core status. Indicators were managed by "Indicator Leads" who were responsible for developing field manuals, QA procedures, data management structures, and analytical tools. The FHM Indicator development process resulted in several significant achievements, including the plot design later adopted by FIA, a national data storage and retrieval system, nationally consistent data recorder software, and nationally consistent processing engines based on peer-reviewed estimation procedures.

Collaborative efforts with FIA were formalized in 2000, when the FIA Program integrated the FHM plot network and associated Indicators into the Phase 3 portion of their national sampling frame. Indicator Leaders became Indicator Advisors under the integrated program, which transferred some of the workload required for Indicator delivery to FIA. Core Indicators now implemented by FIA include Crown Condition, Lichen Communities, Forest Soils, Vegetation Structure, Down Woody Material, and Ozone Bioindicators.

Data Quality Assurance and Quality Control

FHM was one of the first programs in the Forest Service to formalize data quality assurance (QA) and quality Control (QC) standards. This too was a product of early collaboration with the EPA. Quality Control measures included national pre-training sessions where regional trainers were trained, calibrated, tested, certified, and supplied with regional training plans; regional training sessions where production crews were trained and certified; hot checks where trainers visited field crews shortly after training to check crew performance; and debriefing sessions to improve protocols for the next year.

Quality Assurance methods featured reference plots, where experts established a single plot that was measured by many crews; cold checks, where plots completed by production crews were remeasured by regional experts; and national comparability measurements, where a team of Indicator Leaders performed hot and cold checks across all regions. Most of the QA/QC concepts and procedures implemented by the FHM Program were transferred to FIA when the two Programs merged.

Urban Monitoring

As systems to measure and evaluate forest ecosystems mature, increasing attention is being focused on vegetation in nonforest systems. Because only limited tree data are available from urban areas, two pilot programs have been implemented to test the feasibility of urban forest health monitoring methods: 1) extension of FIA sampling protocols into urban areas, and 2) street-tree surveys.

FIA has not traditionally sampled any vegetation in areas defined as a nonforest land use. Urban areas (whether tree covered or not) are by definition a nonforest land use. Approximately 11,735 FIA plots are located in areas defined as urban (based on the 1990 Bureau of Census definition). For urban forest health monitoring, FIA would extend forest-plot data collection protocols to plots defined as urban. Since 2001, pilot tests have been conducted in Indiana, Wisconsin, New Jersey, Colorado, and Tennessee.

Street-tree monitoring applies only to trees in public rights-of-way along highways, streets, and roads, and only in Census-defined urban areas. Street-tree plots consist of linear samples similar in size to FIA plots. Pilots have been conducted in Maryland, Wisconsin, and Massachusetts.

The urban forest health monitoring program is being designed to achieve two goals: 1) to produce annual state-level reports on the status and condition of urban forests and street trees, and 2) to assist urban forest managers by supplying them with the tools necessary to conduct their own local assessments.

Range Monitoring – Bridger-Teton Pilot

Rangelands comprise a significant percentage of National Forest System lands. Currently, we do not know the status and trends of many of our nation's rangelands, and nationally consistent protocols for sampling, estimating and describing indicators of rangeland health do not exist. FHM sampling protocols for all vegetation (including grasses, forbs, shrubs and trees) are being pilot tested through several efforts.

The use of rangeland health indicators to determine rangeland health and function has been demonstrated at the National Forest scale. Health and function of rangelands can be monitored using protocols initially developed by FHM and implemented using the FIA sampling design. Extension of this work to a national strategy for national assessments of rangelands is currently being evaluated through a multi-agency pilot test on the Bridger-Teton National Forest involving BLM, NRI, FIA and FHM.

Riparian Monitoring

Currently, there is no nationally consistent method to inventory and characterize riparian areas. It is generally understood that FIA does not adequately sample linear, sparse, or widely dispersed resources, which results in underestimation and poor characterization of riparian resources across the landscape. The FHM Program is involved in two efforts currently underway to address this problem.

FHM, FIA, the EPA, and the Oregon Department of Environmental Quality are collaborating on the development of field protocols to sample riparian ecosystems. Two different linear plot designs to sample trees and understory vegetation have been tested in Oregon's John Day Basin. When compared to population estimates from the FIA plot grid, population estimates from the pilot studies indicate that species richness is much greater in the riparian plots, and that human impacts (particularly roads) are more severe. These findings support the argument that specialized sampling procedures are needed in riparian areas.

Another collaborative effort among FHM, FIA, and RSAC is underway in Wyoming to assess riparian resources with a focus on nationally available remote imagery. This project is testing the use of Nested Area Frame Sampling to answer the 'big' questions while minimizing the need for costly field data collection. The objective is to produce tabular estimates of riparian area biophysical attributes at the state level, much like FIA does for forest lands.

SOD Detection Protocols

Besides the monitoring systems designed to detect general forest health problems, the ROMT component of FHM includes the capability to address specialized needs. When potentially dangerous invasive species are identified, a risk-based sampling approach is applied that incorporates knowledge of pest biology, susceptible hosts and likely pathways of introduction to monitor high-risk areas for invasions.

Phytophthora ramorum, a pathogen that causes sudden oak death (SOD), is already a severe threat

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to oak forests in California and Oregon, where areas with known infestations have been quarantined. This pathogen has the potential to devastate oak-dominated ecosystems in the Eastern U.S. There are dozens of alternate host species, including ornamentals that have the potential for wide distribution through commercial nurseries.

In 2003 it was discovered that nurseries in California and Oregon had shipped thousands of infected plants to more than 30 states. As a result, more than 21 States have confirmed infections in nursery stock. In an effort to identify infected areas and initiate early eradication measures, the FHM Program produced a national map based on risk factors that include:

- Locations of nurseries receiving infected plants
- Presence of known host species
- Locations within the rainfall and temperature parameters required to sustain the fungus.

Targeted sampling efforts in high risk areas were then implemented to survey the perimeters of nurseries to determine if the pathogen had escaped into nearby forests.

Recently it has been discovered that this pathogen is waterborne, and more effective stream-baiting sampling protocols have been developed to monitor streams in high risk areas. After six years of sampling we have been able to conclude that:

- *Phytophthora ramorum* is not native to the U.S.
- It has been widely distributed to nurseries throughout the U.S.
- It has been detected in ornamental species in urban settings in CA, OR, GA, and SC
- It has spread into natural forest ecosystems only in CA and OR.

Eradication efforts in CA and OR offer hope that early detection and eradication can prevent this pathogen from spreading to areas where it does not yet occur.

Risk Rating Methodology

Collaboration between the FHM and FHP Programs has led to the construction of the 2006 National Insect and Disease Risk Map (NIDRM). The primary goal of this effort is to provide Congress, USDA officials, and land managers with a periodic strategic assessment of tree mortality risk from major insects and diseases.

Of more significance than the map itself, is the framework that was developed to produce it. Utilized by all nine Forest Service regions and 49 states, this framework provides a consistent, repeatable, transparent process through which interactive spatial and temporal risk assessments can be conducted at

various levels. The national framework consists of a five step process designed to be highly iterative, utilizing input from a variety of sources to:

1. Identify agents of concern and target host species;
2. Identify, rank, and weight criteria that determine the susceptibility and vulnerability to each agent;
3. Standardize criteria values and combine the resultant maps using a series of weighted overlays;
4. Convert modeled values for each agent to predicted Basal Area (BA) loss over a 15-year period, and
5. Identify regions at risk of encountering a 25% or greater loss of total BA in the next 15 years.

The NIDRM project resulted in the integration of 190 insect and disease models individually run and assembled into a national map on a central server maintained by the Forest Health Technology Enterprise Team (FHTET) in Fort Collins, CO. The national framework in which the models were constructed permits local information to easily and quickly be entered into large-scale risk assessments.

Analytical Techniques and Tools

As Indicators reach core status and data collection and processing procedures stabilize, more attention is being focused on analytical tools. These techniques include methods to adjust indicators for normal occurrences such as drought and natural senescence. Multivariate analytical techniques have been used in recent national reports to yield an integrated look at forest health indicators. Methods used to detect patterns in human epidemiology are being adapted to analyze forest health problems. The Research Team at RTP has conducted pioneering research in the use of satellite imagery to measure and track patterns of forest fragmentation. The Indicator Advisors recently hosted a workshop to transfer the latest analytical tools and software to FIA analysts. Plans are currently underway to incorporate this technology into FIA's National Information Management System (NIMS).

ROMT Theme

One major theme associated with the monitoring products discussed above is the FHM Program's ability to deliver and promote standardized national protocols. This is possible because most of these techniques were developed with regional input and/or synthesized from existing regional efforts. The Program's commitment to collaboration has not only facilitated the development of nationally accepted monitoring techniques, it has seeded many of these concepts into other Programs and Agencies.

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