Summary

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Evaluation Monitoring (EM) has become a vital component of the national Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture. From the inception of the EM component in 1998 until 2007, over 150 projects were funded to address some of the most critical forest health issues facing the Nation's forest ecosystems. The projects funded by the EM program from 1998 until 2007 covered a broad range of forest health issues. Of the EM projects discussed in this report, 34 percent evaluated tree disease problems, and 27 percent dealt with insect problems; the remainder addressed abiotic stresses and indicators (25 percent) and other biotic stresses and indicators (14 percent) (fig. 1). Nearly a third of EM projects were completed by specialists in the Forest Health Protection Program of the Forest Service, with 20 percent by university scientists, 20 percent by Forest Service Research and Development scientists, 19 percent by State agency investigators, and the rest by investigators from other Federal agencies and tribes (fig. 2). The geographic distribution of the EM projects funded from 1998 until 2007 is presented in figure 3, with 26 percent of the projects being located in the Interior West, 26 percent in the West Coast, 17 percent in the Southern, 16 percent in the Northeastern, and 15 percent in North Central FHM Regions.

The projects funded through the EM program have contributed significantly to our understanding of some of the major forest health issues in the United States. Key findings detailed in previous chapters include the following:

- Bark beetle outbreaks in ponderosa pine forests and pinon-juniper woodlands of the Southwest led to tree mortality near the lower elevational distribution of each pine species in stands with relatively high tree densities and in areas of poor site quality.
- Mountain pine beetle epidemics increase the probability of achieving larger fire sizes throughout the range of historic fire weather conditions in lodgepole pine forests.
- Daily Moderate Resolution Imaging Spectroradiometer (MODIS) data can be used to monitor insect defoliation for large patches in the upper Midwest.

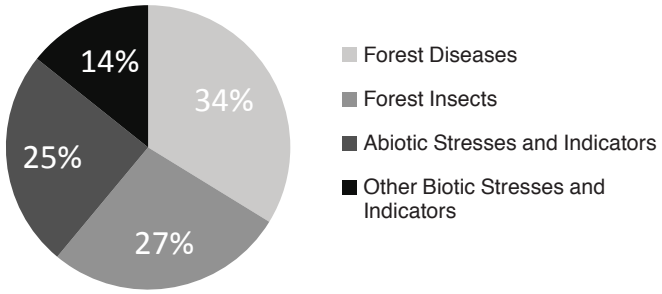

Figure 1—Proportion of evaluation monitoring projects by subject area.

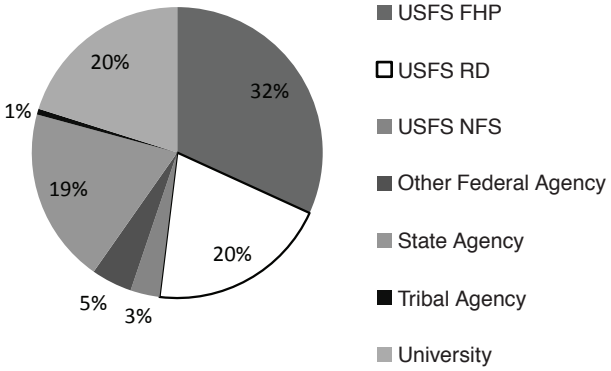

Figure 2—Proportion of evaluation monitoring projects by partner group. (USFS FHP = U.S. Forest Service Forest Health Protection; USFS RD = U.S. Forest Service Research and Development; USFA NFS = U.S. Forest Service National Forest System)

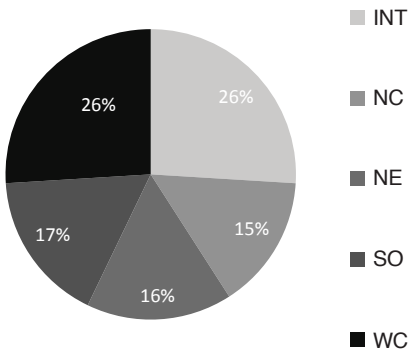

Figure 3—Proportion of evaluation monitoring projects by Forest Health Monitoring region. (INT = Interior West Region; NC = North Central Region; NE = Northeast Region; SO = South Region; WC = West Coast Region)

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- Incidence of white pine blister rust is greatest in the northern and western portions of the central Rocky Mountains where the disease has been present for decades. New locations were discovered in southern Colorado, including the first report on bristlecone pine.
- Recent and rapid mortality of aspen was greatest in the Southwest with more moderate losses further north.
- Surveys of butternut canker distribution and severity in Vermont projected that 85 percent of all butternut trees there would by dead by 2011.
- Drought was a major determinant of oak decline and mortality in the Southeast.
- The red oak borer outbreak of 1999-2005 in the Ozark Mountains exceeded all historical records in terms of area affected and attacks per tree.
- Early surveys for sudden oak death (2001) determined that (1) the pathogen *Phytophthora ramorum* was not confined to coastal California but had established in Curry County, OR, and (2) 10 percent of the land area in California coastal forests was infested within a few years of the pathogen's discovery.
- Fire suppression activities that disturb the ground increased the risk of invasive plant spread.
- Invasive plants respond to fires more quickly than native plants.
- An introduced insect pest, *Thrips calcaratus*, was found to be a major cause of basswood decline in the Lake States.
- Altered hydrology, which increased saltwater intrusion into forested wetlands, was a major factor leading to decline of oak-gum-cypress bottomland forests in southern Louisiana.
- Fire behavior and stand growth models may be combined with FIA inventory data on down woody material to inform landscape-scale fire hazard mitigation/management efforts.
- Snow-pack depth was consistently associated with onset of, and recovery from, dieback in northern hardwoods.
- Decreasing snow-pack depth was also associated with decline of yellow cedar in southeast Alaska.
- Nitric acid (HNO_3) was found to degrade lichen communities in the Los Angeles Basin.
- Ozone concentrations in the San Bernardino Mountains, although currently lower than in the 1960s and 1970s, are still some of the highest in the United States.
- Siliciclastic landscapes in Shenandoah National Park are especially sensitive to loss of base cations, due to atmospheric chemical deposition, which poses particular concerns for forest and aquatic health in these areas.
- Forest floor mercury was highest in the northeast and northern Rocky Mountains. Ecoprovince and latitude were significant predictors of Hg concentrations in the forest floor.
- Carbon content in the forest floor may be roughly estimated from simple measurements of forest floor thickness and ancillary geospatial data.

The results of EM projects have been used by land managers and forest health practitioners in a variety of ways. The following are some examples highlighted in the previous chapters:

- Impacts of bark beetles were considered in Forest Plan revisions and project-level environmental analyses in Wyoming.
- Information on relationships between bark beetle outbreaks and fuel loading was integrated into fire behavior models (FARSITE and FlamMap).
- The spread of hemlock woolly adelgid was predicted in the Northeast.
- Forest stands have been prioritized for treatment utilizing the hazard rating system for balsam woolly adelgid.
- A genetic conservation strategy is being developed and implemented for five-needle pines threatened by white pine blister rust.
- The Ouachita, Ozark-St.Francis, and Mark Twain National Forests prioritized control and salvage efforts in stands affected by the red oak borer in the Ozarks.
- The first detections of *P. ramorum* in Oregon triggered quarantines for the affected area and led to the development of an eradication effort.
- The evaluation of lichen communities downwind from two coal-fired power plants in Colorado was used in the assessment of Air Quality Related Values in Federal Clean Air Act Class I wilderness areas.
- The HNO_3 critical loads established for lichens were used by the Environmental Protection Agency in setting a secondary air quality standard for nitrogen oxides.
- A conservation and management strategy for yellow-cedar is currently being implemented at locations in coastal Alaska focusing regeneration efforts in areas with sufficient protective snow cover.
- The Carbon Online Estimator was developed to allow any user to produce carbon and dead wood estimates based on FIA Program annualized data. It has been named as an official U.S. carbon estimation tool for forests by the Department of Energy.
- Ten of the 14 species tested for ozone sensitivity are now on the FIA supplemental list of bioindicator species and are used to identify areas where ozone injury occurs.

While the results of completed EM projects have been impressive and useful, there are many unanswered questions that should be investigated in the future. The subject matter specialists who synthesized the preceding chapters suggested new lines of inquiry for the EM program, including the following:

- Long-term effects of bark beetle outbreaks should be evaluated through permanent plots remeasured at 5-year intervals for the next 20-25 years.

- Fire spread models should be further developed for various bark beetle affected landscapes.
- White pine blister rust resistance mechanisms and adaptive traits in high elevation white pine species of the Rocky Mountains should be evaluated.
- A better understanding of the genetic diversity remaining among populations of butternut will guide future germplasm collection.
- Developing a broad network of intensive oak monitoring sites will enhance understanding of insect, disease, and climate interactions.
- Compiling data on biotic and abiotic stressors over longer time periods will help elucidate natural variation in stressors and in the responses of forests to those stressors.
- There is a need for more investigation into fire severity associated mortality and damage relationships.
- Critical loads for lichen communities need to be determined for regions beside the well-studied Pacific Northwest.
- The usefulness of the Lichen Communities Indicator for monitoring climate change has largely been ignored in favor of air quality applications.
- The effects of short-term versus long-term exposure to ozone need further investigation.

Several chapter authors identified the need to target more evaluations on under-utilized indicators, including lichens, ozone, down woody material, and soils. Increased coverage and repeated measures will facilitate more detailed evaluations of these indicators in the near future. There is also a need for more evaluation of the extent and impact of invasive plant species as more data are collected on the phase 2 and phase 3 plots of the Forest Inventory and Analysis Program of the Forest Service. The FHM program should continue to encourage the use of additional sources of information, including aerial and ground detection surveys and other ancillary data in conducting EM projects.

In conclusion, EM is a vibrant component of the FHM program that has significantly enhanced our understanding of some of the most critical forest health issues facing the Nation's forests. Over the period from 1998 through 2007, the EM projects effectively addressed the second and third objectives of the FHM program—to verify and define the extent of deterioration in forest ecosystems and to understand the processes that cause forest health problems so that strategies can be developed for problem mitigation and prevention. Through the EM projects, the FHM program successfully engaged a broad spectrum of partners and collaborators in conducting forest health evaluations on a wide range of topics spanning forested ecosystem throughout the country. The EM approach of focused evaluations of current forest health concerns is effective in providing timely solutions to land managers as they are managed for sustainable, resilient forest ecosystems.

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