

Forests cover a vast area of the United States, 303.1 million ha (749 million acres) or approximately one-third of the Nation's land area (Smith and others 2004). These forests are of substantial ecological, economic, and social importance. Both their ecological integrity and their capacity to provide goods and services are of considerable concern in the face of a long list of threats, including insect and disease infestation, fragmentation, catastrophic fire, invasive species, and the effects of global climate change.

Assessing and monitoring the health of these forests is, therefore, a critical and challenging task. While there is no universally accepted definition of forest health, a healthy forest ecosystem is likely to possess four characteristics (Kolb and others 1994):

- The physical environment, biotic resources, and energy consumption networks to support productive forests during at least some successional stages
- Resistance to catastrophic change and/or the ability to recover from catastrophic change at the landscape level

- A functional equilibrium between supply and demand of essential resources (water, nutrients, light, growing space) for major portions of the vegetation
- A diversity of seral stages and stand structures that provide habitat for many native species and all essential ecosystem processes

The national Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture, produces this annual national technical report on the health of U.S. forests, using the Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 2007) as an organizing framework.

The FHM national technical report has three specific objectives. The first is to present information about forest health from a national perspective, or from a multi-State regional perspective when appropriate, using data collected by the Forest Health Protection (FHP) and Forest Inventory and Analysis (FIA) programs of the Forest Service, in addition to data from other sources. The chapters in the first

Chapter 1. Introduction

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section of the report achieve this objective, in chapters organized according to the Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 2007). These results stem from the ongoing national scale detection monitoring efforts from FHM and its cooperators, using a wide variety of regional-scale data and analysis techniques. While in-depth interpretation and analysis of specific geographic or ecological regions are beyond the scope of this report, the report presents information for the identification of areas that may require investigation at a finer scale.

The second objective of the report, also covered in section 1, is to present new techniques and new applications of established techniques for analyzing forest health data. Examples in this report are chapter 2, which presents a new set of statistical techniques for quantifying evolutionary variation among tree communities; chapter 3, which describes new tools that allow for the fine-scale display of national land cover mosaic maps; chapter 4, which introduces a newly developed drought index methodology that allows for the comparison of moisture conditions between geographical areas and across periods of time;

and chapters 5 and 6, which use a Geographical Information System hotspot analysis to, respectively, detect significant clusters of forest mortality and defoliation and detect significant clusters of forest fire occurrences.

The third objective of the national technical report, addressed in its second section, is to present results of recently completed evaluation monitoring (EM) projects that have been funded through the FHM national program. These projects are funded by FHM to determine the extent, severity, and/or causes of forest health problems (Forest Health Monitoring 2009), generally at a finer scale than that addressed in the first section of the report. Each chapter in the second section of the report contains an overview of the EM project, key results, and contacts for more information. This objective is new to the national technical report, and these EM project summaries are included for the first time.

Organization of the Report

The Forest Service has adopted the Santiago Declaration and accompanying Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 2007) as

a forest sustainability assessment framework (Smith and others 2001, U.S. Department of Agriculture Forest Service 2004). It is appropriate, therefore, to note which criterion is addressed by each of the chapters in the first section of this FHM national technical report. The seven criteria are:

Criterion 1—conservation of biological diversity

Criterion 2—maintenance of productive capacity of forest ecosystems

Criterion 3—maintenance of forest ecosystem health and vitality

Criterion 4—conservation and maintenance of soil and water resources

Criterion 5—maintenance of forest contribution to global carbon cycles

Criterion 6—maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies

Criterion 7—legal, institutional, and economic framework for forest conservation and sustainable management

While a complete evaluation of all the sustainability criteria is not appropriate in this report, it contains chapters associated with four criteria: criterion 1 (chapters 2 and 3); criterion 3 (chapters 4, 5, 6, 7, and 8); criterion 4 (chapter 9); and criterion 5 (chapter 10).

When appropriate throughout this report, authors used Bailey's revised ecoregion provinces and sections (Cleland and others 2007) as a common ecologically based spatial framework for their forest health assessments (fig. 1.1). Specifically, when the spatial scale of the data and the expectation of an identifiable pattern in the data were appropriate, authors used ecoregion sections as assessment units for their analyses. In Bailey's hierarchical system, the two broadest ecoregion scales, domains and divisions, are based on large ecological climate zones, while each division is broken into provinces based on vegetation macrofeatures (Bailey 1995). Provinces are further divided into sections, which may be thousands of square miles in extent and are expected to encompass regions similar in their geology, climate, soils, potential natural vegetation, and potential natural communities (Cleland and others 1997).

Alaska ecoregion provinces

	Alaska Mixed Forest (213)
	Alaska Range Taiga (135)
	Aleutian Meadow (271)
	Arctic Tundra (121)
	Bering Sea Tundra (129)
	Brooks Range Tundra (125)
	Pacific Coastal Icefields (244)
	Pacific Gulf Coastal Forest (245)
	Upper Yukon Taiga (139)
	Yukon Intermontaine Taiga (131)

Eastern ecoregion provinces

	Adirondack—New England Mixed Forest—Coniferous Forest—Alpine Meadow (M211)
	Central Appalachian Broadleaf Forest—Coniferous Forest—Meadow (M221)
	Central Interior Broadleaf Forest (223)
	Eastern Broadleaf Forest (221)
	Everglades (411)
	Laurentian Mixed Forest (212)
	Lower Mississippi Riverine Forest (234)
	Midwest Broadleaf Forest (222)
	Northeastern Mixed Forest (211)
	Ouachita Mixed Forest—Meadow (M231)
	Outer Coastal Plain Mixed Forest (232)
	Ozark Broadleaf Forest (M223)
	Prairie Parkland (Subtropical) (255)
	Prairie Parkland (Temperate) (251)
	Southeastern Mixed Forest (231)

Western ecoregion provinces

	American Semi-Desert and Desert (322)
	Arizona—New Mexico Mountains Semi-Desert—Open Woodland—Coniferous Forest—Alpine Meadow (M313)
	Black Hills Coniferous Forest (M334)
	California Coastal Chaparral Forest and Shrub (261)
	California Coastal Range Open Woodland—Shrub—Coniferous Forest—Meadow (M262)
	California Coastal Steppe—Mixed Forest—Redwood Forest (263)
	California Dry Steppe (262)
	Cascade Mixed Forest—Coniferous Forest—Alpine Meadow (M242)
	Chihuahuan Semi-Desert (321)
	Colorado Plateau Semi-Desert (313)
	Great Plains—Palouse Dry Steppe (331)
	Great Plains Steppe (332)
	Intermountain Semi-Desert (342)
	Intermountain Semi-Desert and Desert (341)
	Middle Rocky Mountain Steppe—Coniferous Forest—Alpine Meadow (M332)
	Nevada—Utah Mountains Semi-Desert—Coniferous Forest—Alpine Meadow (M341)
	Northern Rocky Mountains Forest—Steppe—Coniferous Forest—Alpine Meadow (M333)
	Pacific Lowland Mixed Forest (242)
	Sierran Steppe—Mixed Forest—Coniferous Forest—Alpine Meadow (M261)
	Southern Rocky Mountains Steppe—Open Woodland—Coniferous Forest—Alpine Meadow (M331)
	Southwest Plateau and Plains Dry Steppe and Shrub (315)

Data Sources

A major source of data in FHM national technical reports has been the FIA program, which collects forest inventory information across all forest land ownerships in the United States. FIA maintains a network of more than 100,000 permanent ground plots across the conterminous United States, with a sampling intensity of approximately 1 plot per 2428.11 ha (6,000 acres). The FIA Program's phase 2 encompasses the annualized inventory measured on plots at regular intervals, with each plot surveyed every 5 years in most Eastern States, but with plots in the Rocky Mountain and Pacific Northwest regions surveyed once every 10 years (Reams and others 2005). The standard one-sixth-acre plot (fig. 1.2) consists of four 24-foot-radius subplots (approximately 0.0415 or 1/24 acre), on which field crews measure trees at least 5 inches in diameter. Within each of these subplots is nested a 6.8-foot-radius microplot (approximately 1/300th acre), on which crews measure trees smaller than 5 inches in diameter. A core-optional variant of the standard design includes four "macroplots," each with a radius of

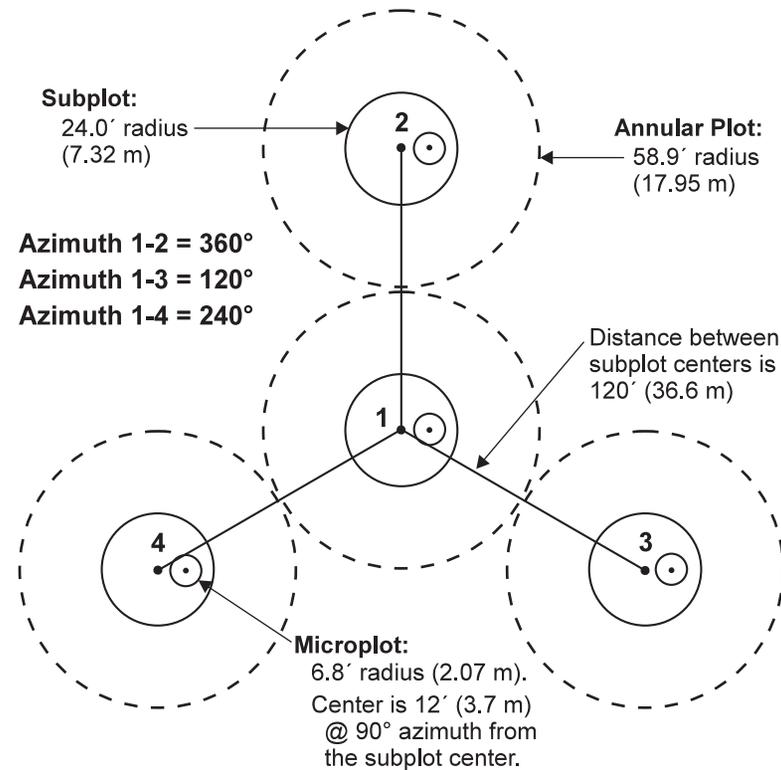


Figure 1.2—The FIA mapped plot design. Subplot 1 is the center of the cluster with subplots 2, 3, and 4 located 120 feet away at azimuths of 360°, 120°, and 240°, respectively (Forest Inventory and Analysis 2009).

58.9 feet (approximately one-fourth acre), that originate at the center of each subplot (Forest Inventory and Analysis 2009).

FIA phase 3 plots are a subset of the phase 2 plots, with 1 phase 3 plot for every 16 standard phase 2 plots. In addition to traditional forest inventory measurements, data for a variety of important ecological indicators are collected from phase 3 plots, including tree crown condition, lichen communities, down woody material (DWM), soil condition, and vegetation structure and diversity. Additionally, data on ozone bioindicator plants are collected on a separate grid of plots. Prior to 2000¹, these additional forest health indicators were measured as part of the FHM detection monitoring ground plot system (Palmer and others 1991).

Forest Service data sources in this edition of the FHM national technical report include: FIA annualized phase 2 survey data, FIA phase 3

DWM data (2001–06), FIA phase 3 soil quality data (2001–05), FHP low-altitude aerial survey forest mortality and defoliation data (2006), Moderate Resolution Imaging Spectroradiometer (MODIS) active fire detections for the U.S. database (2005–07), and forest cover data developed from MODIS satellite imagery by the Forest Service, Remote Sensing Applications Center. Other sources of data were: the 2001 high-resolution National Land Cover Database map (Homer and others 2007), the Parameter-Elevation Regression on Independent Slopes climate mapping system data (PRISM Group 2008), the NCSU-APHIS Plant Pest Forecasting System climatic and environmental variable data for pest and pathogen geographical distribution modeling (Magarey and others 2007), the Biota of North America county-level plant species distribution data (Kartesz 2008), and the wildland-urban interface data (Radeloff and others 2005).

¹ U.S. Department of Agriculture Forest Service. 1998. Forest health monitoring 1998 field methods guide. Research Triangle Park, NC: U.S. Department of Agriculture Forest Service, National Forest Health Monitoring Program. 473 p. On file with: Forest Health Monitoring Program, 3041 Cornwallis Road, Research Triangle Park, NC 27709.

The Forest Health Monitoring Program

Forest Health Monitoring is a national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. The program covers all forested lands through a partnership encompassing the Forest Service, State foresters, and other State and Federal Agencies and academic groups (Forest Health Monitoring 2008). The FHM program utilizes data from a wide variety of data sources, both inside and outside the Forest Service, and develops analytical approaches for addressing forest health issues that affect the sustainability of forest ecosystems. It has five major activities (fig. 1.3):

- Detection monitoring—nationally standardized aerial and ground surveys to evaluate status and change in condition of forest ecosystems
- Evaluation monitoring—projects to determine extent, severity, and causes of undesirable changes in forest health identified through detection monitoring

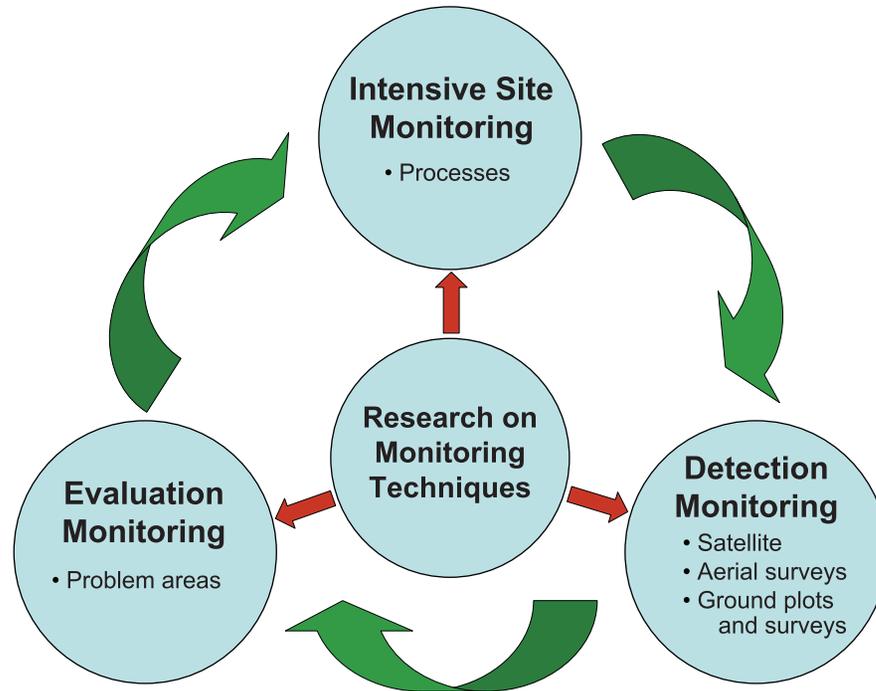


Figure 1.3—The design of the FHM Program (Forest Health Monitoring 2003). A fifth component, analysis and reporting of results, draws from the four FHM components shown here and provides timely information to help support land management policies and decisions.

- Intensive site monitoring—to enhance understanding of cause and effect relationships by linking detection monitoring to ecosystem process studies and to assess specific issues, such as calcium depletion and carbon sequestration, at multiple spatial scales
- Research on monitoring techniques—to develop or improve indicators, monitoring systems, and analytical techniques, such as urban and riparian forest health monitoring, early detection of invasive species, multivariate analyses of forest health indicators, and spatial scan statistics
- Analysis and reporting—synthesis of information from various data sources within and external to the Forest Service to produce issue-driven reports on the status of and change in forest health at national, regional, and State levels

In addition to its national reporting efforts, FHM generates regional and State reports. These reports may be produced with FHM partners, both within the Forest Service and in State forestry and agricultural departments. Some examples are Keyes and others (2003), Laustsen

and others (2003), Neitlich and others (2003), Steinman (2004), Lake and others (2006), Morin and others (2006), and Cumming and others (2006, 2007). The Forest Health Highlights series, available on the FHM Web site at www.fs.fed.us/foresthealth/fhm/, is produced by the FHM regions in cooperation with their respective State partners. FHM and its partners also produce reports on monitoring techniques and analytical methods, such as Smith and Conkling (2004) and O'Neill and others (2005).

For more information about efforts to determine the status, changes, and trends in indicators of the condition of U.S. forests, please visit the FHM Web site at www.fs.fed.us/foresthealth/fhm/. This FHM national technical report is produced by the National Forest Health Monitoring Research Team, which is a part of the Eastern Forest Environmental Threat Assessment Center established under the Healthy Forest Restoration Act as part of a nationwide network of early warning activities about threats to forest health. For more information about the research team, and about threats to U.S. forests, please visit www.forestthreats.org/about.

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