CHAPTER 1
Introduction

Kevin M. Potter[1]

Forests cover a vast area of the United States, 304 million ha or approximately one-third of the Nation's land area (Smith and others 2009). These forests possess substantial ecological and socioeconomic importance. Both their ecological integrity and their continued capacity to provide goods and services are of concern in the face of a long list of threats, including insect and disease infestation, fragmentation, catastrophic fire, invasive species, and the effects of climate change.

Assessing and monitoring the health of these forests are critical and challenging tasks. While there is no universally accepted definition of forest health, the current understanding of ecosystem dynamics suggests that healthy ecosystems are those that are able to maintain their organization and autonomy over time while remaining resilient to stress (Costanza 1992), and that evaluations of forest health should emphasize factors that affect the inherent processes and resilience of forests (Kolb and others 1994, Raffa and others 2009). This national report, the 10th in an annual series produced by the Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture, attempts to quantify the status of, changes to, and trends in a wide variety of such indicators of forest health. These indicators encompass forest insect and disease activity, wildland fire occurrence, tree mortality, forest fragmentation, drought, standing dead tree resources, and forest soil critical acid loads.

This 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, as well as from other sources available at a wide extent. The chapters that present analyses at a national-scale, or multi-State regional scale, are divided between section 1 and section 2 of the report. Section 1 presents results from the analyses of forest health data that are available on an annual basis, allowing for the detection of trends over time and changes from one year to the next. Section 2 presents longer-term forest health trends, in addition to describing new techniques for analyzing forest health data at national or regional scales (the second objective of the report). While in-depth interpretation and analysis of specific geographic or ecological regions are beyond the scope of these parts of the report, the chapters in sections 1 and 2 present information that can be used to identify areas that may require investigation at a finer scale.

The second objective of the report is to present new techniques for analyzing forest health data as well as new applications of established techniques, presented in selected chapters of section 2. Examples in this report are chapter 6, which describes a newly developed drought index methodology that allows for the comparison of moisture conditions between geographical areas and across periods of time; and chapter 7, which is one of the first empirical assessments of the Nation's standing dead tree resources, using FIA phase 2 data.

[1]Research Assistant Professor, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27695.

The third objective of the report is to present results of recently completed Evaluation Monitoring (EM) projects funded through the national FHM program. These project summaries, presented in section 3, determine the extent, severity, and causes of forest health problems (FHM 2010), generally at a finer scale than that addressed by the analyses in sections 1 and 2. Each chapter in section 3 contains an overview of an EM project, key results, and contacts for more information.

Where appropriate throughout this report, authors use Bailey's revised ecoregions (Cleland and others 2007, Nowacki and Brock 1995) 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 are appropriate, authors use ecoregion sections or provinces 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 macro features (Bailey 1995). Provinces are further divided into sections, which may be thousands of square kilometers 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 Coast Forest (245)
- Upper Yukon Taiga (139)
- Yukon Intermontaine Taiga (131)

Conterminous States ecoregion provinces

- Adirondack-New England Mixed Forest - Coniferous Forest - Alpine Meadow (M211)
- 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)
- Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow (M221)
- Central Interior Broadleaf Forest (223)
- Chihuahuan Semi-Desert (321)
- Colorado Plateau Semi-Desert (313)
- Eastern Broadleaf Forest (221)
- Everglades (411)
- Great Plains - Palouse Dry Steppe (331)
- Great Plains Steppe (332)
- Intermountain Semi-Desert and Desert (341)
- Intermountain Semi-Desert (342)
- Laurentian Mixed Forest (212)
- Lower Mississippi Riverine Forest (234)
- Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow (M332)
- Midwest Broadleaf Forest (222)
- Nevada-Utah Mountains Semi-Desert - Coniferous Forest - Alpine Meadow (M341)
- Northeastern Mixed Forest (211)
- Northern Rocky Mountain Forest-Steppe - Coniferous Forest - Alpine Meadow (M333)
- Ouachita Mixed Forest-Meadow (M231)
- Outer Coastal Plain Mixed Forest (232)
- Ozark Broadleaf Forest (M223)
- Pacific Lowland Mixed Forest (242)
- Prairie Parkland (Subtropical) (255)
- Prairie Parkland (Temperate) (251)
- Sierran Steppe - Mixed Forest - Coniferous Forest - Alpine Meadow (M261)
- Southeastern Mixed Forest (231)
- Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow (M331)
- Southwest Plateau and Plains Dry Steppe and Shrub (315)

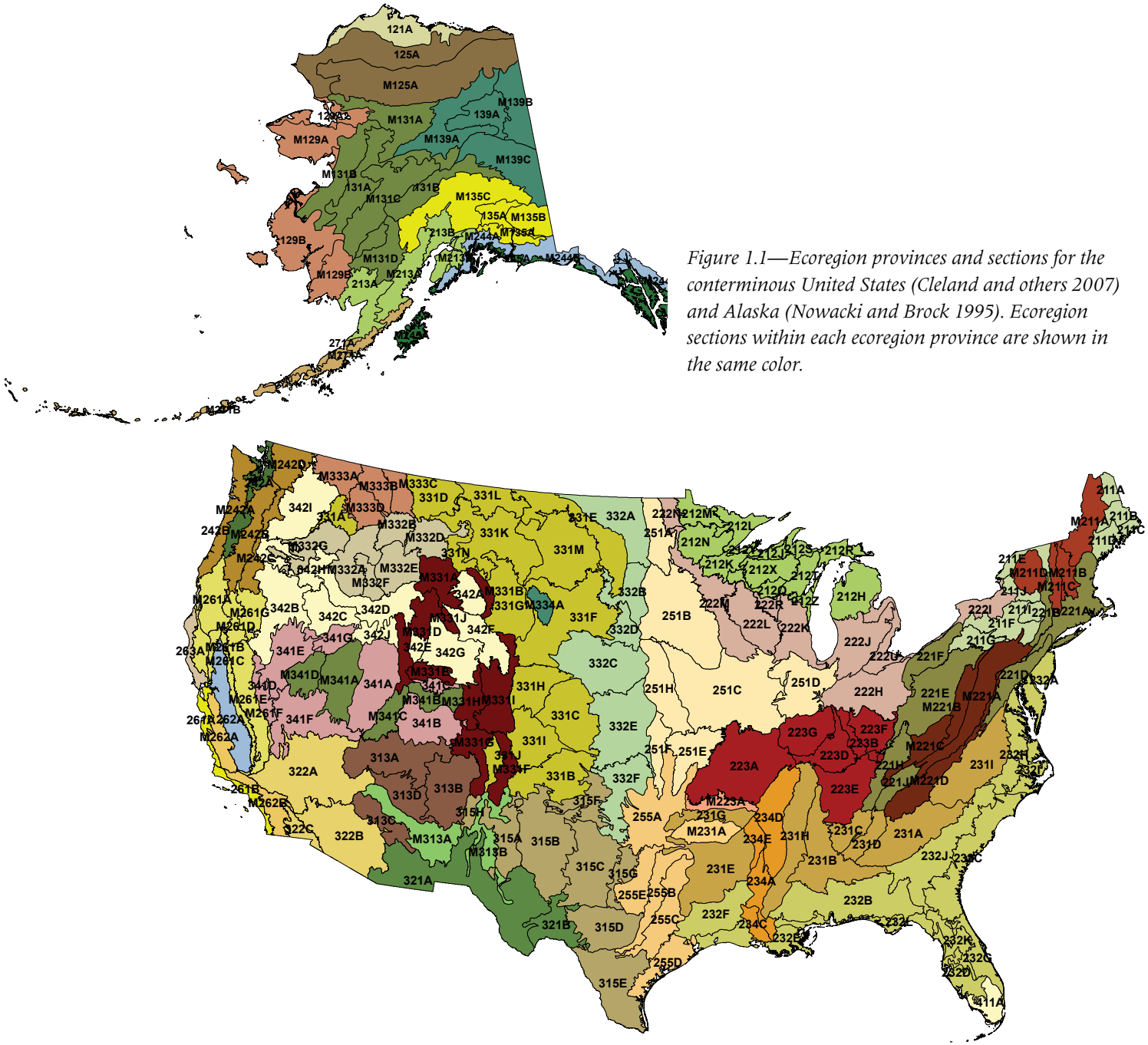

Figure 1.1—Ecoregion provinces and sections for the conterminous United States (Cleland and others 2007) and Alaska (Nowacki and Brock 1995). Ecoregion sections within each ecoregion province are shown in the same color.

DATA SOURCES

Forest Service data sources included in this edition of the FHM national report are FIA annualized phase 2 survey data (Bechtold and Patterson 2005), FHP national insect and disease detection survey forest mortality and defoliation data for 2009, Moderate Resolution Imaging Spectroradiometer (MODIS) Active Fire Detections for the United States database for 2009, and forest cover data developed from MODIS satellite imagery by the Forest Service Remote Sensing Applications Center. Other sources of data are daily weather station data from the National Climatic Data Center (NCDC) Parameter-elevation Regression on Independent Slopes (PRISM) climate mapping system data (PRISM Group 2009), and the 2001 National Land Cover Database (NLCD) map (Homer and others 2007).

A major source of data for FHM analyses 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 125,000 permanent forested ground plots across the conterminous United States and southeastern Alaska, with a sampling intensity of approximately one plot per 2 428.11 ha. The FIA program's phase 2 encompasses the annualized inventory measured on plots at regular intervals, with each plot surveyed every 5 to 7 years in 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 radius of 58.9 feet (approximately one-fourth acre) that originates at the center of each subplot (Woudenberg and others 2010).

FIA phase 3 plots represent a subset of these phase 2 plots, with one phase 3 plot for every 16 standard FIA 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, soil condition, and vegetation structure and diversity. Additionally, data on ozone bioindicator plants are collected on a separate grid of plots. Most of these additional forest health indicators were measured as part of the FHM Detection Monitoring ground plot system prior to 2000[2] (Palmer and others 1991).

[2]USDA 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 Rd., Research Triangle Park, NC 27709.

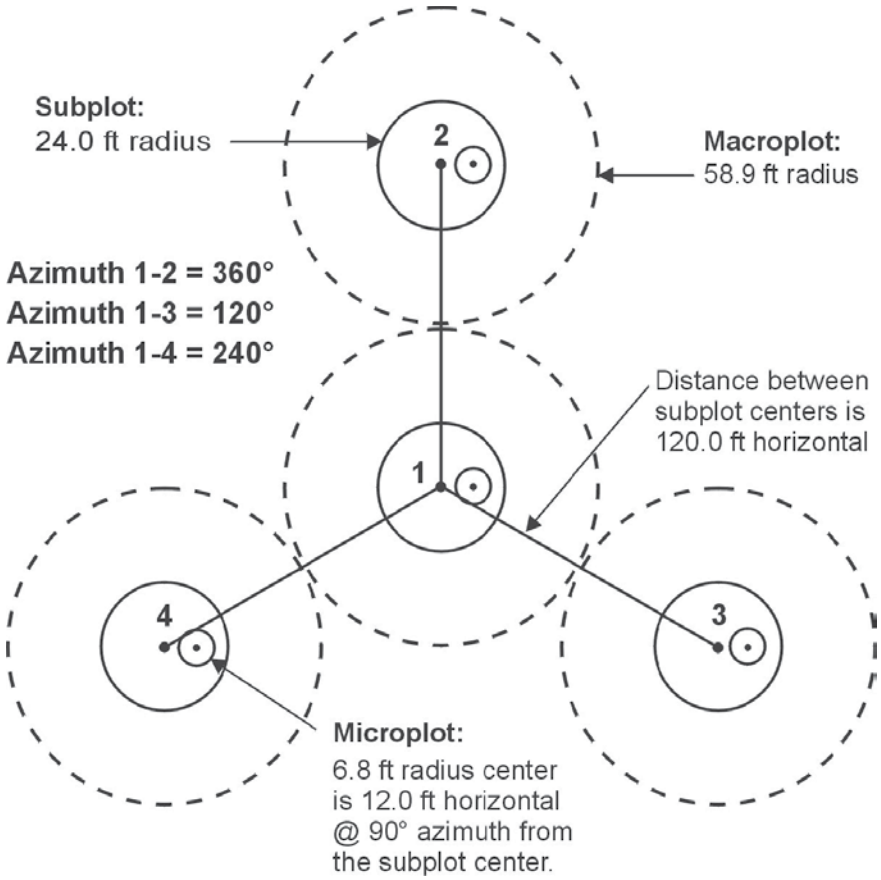

Figure 1.2—The Forest Inventory and Analysis mapped plot design. Subplot 1 is the center of the cluster with subplots 2, 3, and 4 located 120 feet away at azimuths of 360°, 120°, and 240°, respectively. (Source: Woudenberg and others 2010)

THE FOREST HEALTH MONITORING PROGRAM

The FHM program is a national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis, and covers all forested lands through a partnership encompassing the Forest Service, State foresters, and other State and Federal agencies and academic groups (FHM 2010). 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 encompasses five major activities (fig. 1.3):

- Detection Monitoring—nationally standardized aerial and ground surveys to evaluate status and change in condition of forest ecosystems (sections 1 and 2 of this report).
- Evaluation Monitoring—projects to determine extent, severity, and causes of undesirable changes in forest health identified through Detection Monitoring (section 3 of this report).
- Intensive Site Monitoring—projects to enhance understanding of cause-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 (section 3 of this report).
- Research on Monitoring Techniques—work 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 (section 2 of this report).

- Analysis and Reporting—synthesis of information from various data sources within and external to the Forest Service to produce issue-driven reports on status and change in forest health at national, regional, and State levels (sections 1, 2, and 3 of this report).

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 representing a variety of analyses on disturbance and forest conditions (Steinman 2004), urban monitoring methods (Lake and others 2006), health conditions in national forests (Morin and others 2006), urban forest health monitoring (Cumming and others 2006, 2007), crown conditions (Randolph 2010, Randolph and Moser 2009), and ozone monitoring (Rose and Coulston 2009). Reports in the Forest Health Highlights series are annually produced for each State to profile current conditions, and are available on the FHM Web site at www.fs.fed.us/foresthealth/fhm. These highlights are produced by the FHM regions in cooperation with their respective State partners. FHM and its partners also produce reports and journal articles on monitoring techniques and analytical methods, including analyzing forest health data (Smith and Conkling 2004), soils as an indicator of

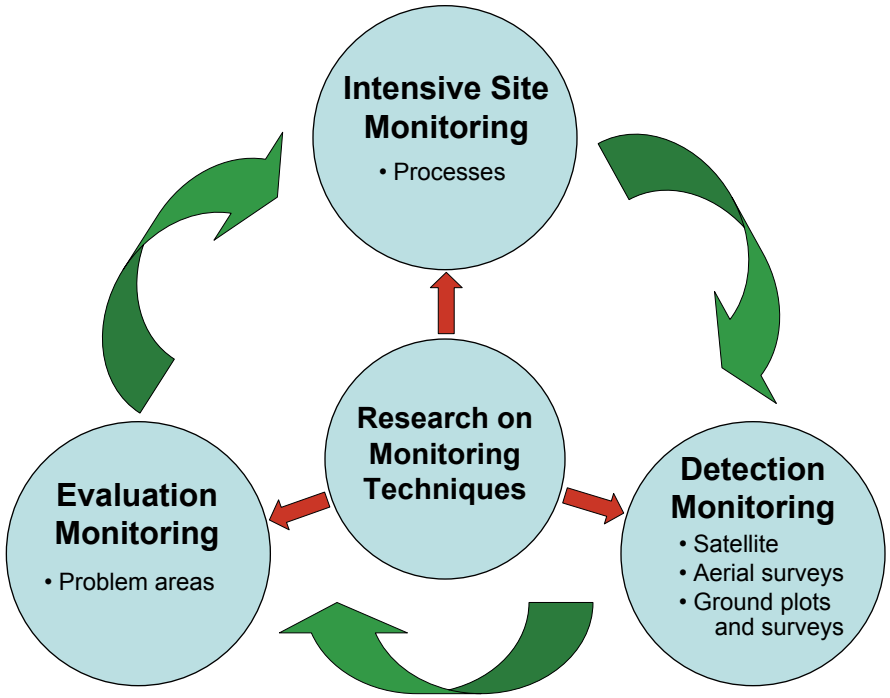

Figure 1.3—The design of the Forest Health Monitoring (FHM) Program (FHM 2003). A fifth component, Analysis and Reporting of Results, draws from the four FHM components shown here and provides information to help support land management policies and decisions.

forest health (O'Neill and others 2005), crown-condition classification (Schomaker and others 2007), sampling and estimation procedures for vegetation diversity and structure (Schulz and others 2009), and the overall forest health indicator program (Woodall and others 2010).

For more information about efforts to determine the status, changes, and trends in indicators of the condition of U.S. forests, visit the FHM Web site at www.fs.fed.us/foresthealth/fhm. This FHM national report is produced by national forest health monitoring researchers at the Eastern Forest Environmental Threat Assessment Center, which was established under the Healthy Forest Restoration Act to generate knowledge and tools needed to anticipate and respond to environmental threats. For more information about the research team, and about threats to U.S. forests, please visit www.forestthreats.org/about.

LITERATURE CITED

Bailey, R.G. 1995. Descriptions of the ecoregions of the United States. 2[d] ed. Misc. Publ. No. 1391. Washington, DC: U.S. Department of Agriculture Forest Service. 108 p. Map scale 1:7,500,000.

Bechtold, W.A.; Patterson, P.L., eds. 2005. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 85 p.

Cleland, D.T.; Avers, P.E.; McNab, W.H. [and others]. 1997. National hierarchical framework of ecological units. In: Boyce, M.S.; Haney, A., eds. Ecosystem management applications for sustainable forest and wildlife resources. New Haven, CT: Yale University Press: 181-200.

Cleland, D.T.; Freeouf, J.A., Keys, J.E., Jr. [and others]. 2007. Ecological Subregions: Sections and subsections for the conterminous United States. Sloan, A.M. tech. ed. Gen. Tech. Report WO-76. Washington, DC: U.S. Department of Agriculture Forest Service. Map, presentation scale 1:3,500,000; Albers equal area projection; colored. Also as a GIS coverage in ArcINFO format on CD-ROM or at http://fsgeodata.fs.fed.us/other_resources/ecosubregions.html. [Date accessed: March 18, 2011].

Costanza, R. 1992. Toward an operational definition of ecosystem health. In: Costanza, R.; Norton, B.G.; Haskell, B.D., eds. Ecosystem health: New goals for environmental management. Washington, DC: Island Press: 239-256.

Cumming, A.B.; Twardus, D.B.; Smith, W.D. 2006. National Forest Health Monitoring Program, Maryland and Massachusetts Street Tree Monitoring Pilot Projects. NA-FR-01-06. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Area, State and Private Forestry. 23 p.

Cumming, A.B.; Nowak, D.J.; Twardus, D.B. [and others]. 2007. Urban forests of Wisconsin: pilot monitoring project 2002. NA-FR-05-07. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Area State and Private Forestry. 33 p. Low resolution: http://www.na.fs.fed.us/pubs/fhm/pilot/pilot_study_wisconsin_02_lr.pdf. High resolution: http://www.na.fs.fed.us/pubs/fhm/pilot/pilot_study_wisconsin2_02_hr.pdf. [Date accessed: October 19, 2007].

Forest Health Monitoring (FHM). 2003. Forest Health Monitoring: A National Strategic Plan. http://fhm.fs.fed.us/annc/strategic_plan03.pdf. [Date accessed: August 24, 2011].

FHM. 2010. Program description. Forest Health Monitoring Fact Sheet Series. http://www.fhm.fs.fed.us/fact/. [Date accessed: October 22, 2010].

Homer, C.; Dewitz, J.; Fry, J. [and others]. 2007. Completion of the 2001 National Land Cover Database for the conterminous United States. Photogrammetric Engineering and Remote Sensing. 73: 337-341.

Kolb, T.E.; Wagner, M.R.; Covington, W.W. 1994. Concepts of forest health: Utilitarian and ecosystem perspectives. Journal of Forestry. 92: 10-15.

Lake, M.; Marshall, P.; Mielke, M. [and others]. 2006. National Forest Health Monitoring program monitoring urban forests in Indiana: pilot study 2002, Part 1. Analysis of field methods and data collection. Gen. Tech Rep. NA FR-06-06. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Area. http://www.fhm.fs.fed.us/pubs/ufhm/indianaforests02/indianaforests02.html. [Date accessed: November 6, 2007].

Morin, R.S.; Liebhold, A.M.; Gottschalk, K.W. [and others]. 2006. Analysis of Forest Health Monitoring surveys on the Allegheny National Forest (1998-2001). Gen. Tech. Rep. NE-339. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 102 p. http://www.fs.fed.us/ne/newtown_square/publications. [Date accessed: November 6, 2007].

Nowacki, G.; Brock, T. 1995. Ecoregions and Subregions of Alaska, EcoMap Version 2.0. Juneau, AK: U.S. Department of Agriculture Forest Service, Alaska Region. Map, presentation scale 1:5,000,000; colored.

O'Neill, K.P.; Amacher, M.C.; Perry, C.H. 2005. Soils as an indicator of forest health: a guide to the collection, analysis, and interpretation of soil indicator data in the Forest Inventory and Analysis Program. Gen. Tech. Rep. NC-258. St. Paul, MN: U.S. Department of Agriculture Forest Service, North Central Research Station. 53 p.

Palmer, C.J.; Riitters, K.H.; Strickland, T. [and others]. 1991. Monitoring and research strategy for Forests—Environmental Monitoring and Assessment Program (EMAP). EPA/600/4-91/012. Washington, DC: U.S. Environmental Protection Agency. 189 p.

PRISM Group. 2009. 2.5-arcmin (4 km) gridded monthly climate data. ftp://prism.oregonstate.edu//pub/prism/us/grids. [Date accessed: April 6, 2009].

Raffa, K.F.; Aukema, B.; Bentz, B.J. [and others]. 2009. A literal use of "forest health" safeguards against misuse and misapplication. Journal of Forestry. 107: 276-277.

Randolph, KaDonna C. 2010. Equations relating compacted and uncompacted live crown ratio for common tree species in the South. Southern Journal of Applied Forestry. 34(3) 2010: 118-123.

Randolph, K.C.; Moser, W.K. 2009. Tree crown condition in Missouri, 2000–2003. Gen. Tech. Rep. SRS–113. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 11 p.

Reams, G.A.; Smith, W.D.; Hansen, M.H. [and others]. 2005. The Forest Inventory and Analysis sampling frame. In: Bechtold, W.A.; Patterson, P.L., ed. The Enhanced Forest Inventory and Analysis Program—National Sampling Design and Estimation Procedures. Asheville, NC: United States Department of Agriculture Forest Service, Southern Research Station: 11-26.

Rose, A.K.; Coulston, J. 2009. Ozone injury across the Southern United States, 2002–06. Gen. Tech. Rep. SRS–118. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 25 p.

Schomaker, M.E.; Zarnoch, S.J.; Bechtold, W.A. [and others]. 2007. Crown-condition classification: a guide to data collection and analysis. Gen. Tech. Rep. SRS-102. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 78 p.

Schulz, B.K.; Bechtold, W.A.; Zarnoch, S.J. 2009. Sampling and estimation procedures for the vegetation diversity and structure indicator. Gen. Tech. Rep. PNW-GTR-781. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 53 p.

Smith, W.D.; Conkling, B.L. 2004. Analyzing forest health data. Gen. Tech. Rep. SRS-077. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 33 p. http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs077.pdf. [Date accessed: November 6, 2007].

Smith, W.B.; Miles, P.D.; Perry, Charles H.; Pugh, S.A. 2009. Forest resources of the United States, 2007. Gen. Tech. Rep. WO-78. St. Paul, MN: U.S. Department of Agriculture Forest Service, Washington Office. 336 p.

Steinman, J. 2004. Forest Health Monitoring in the Northeastern United States: Disturbances and Conditions during 1993-2002. NA-Technical Paper 01-04. Newtown Square, PA: U.S. Department of Agriculture Forest Service, State and Private Forestry, Northeastern Area. 46 p. http://fhm.fs.fed.us/pubs/tp/dist_cond/dc.shtml. [Date accessed: December 8, 2009].

Woodall, C.W.; Amacher, M.C.; Bechtold, W.A. [and others]. 2010. Status and future of the forest health indicators program of the USA. Environmental Monitoring and Assessment. 177: 419-236. DOI 10.1007/s10661-010-1644-8.

Woudenberg, S.W.; Conkling, B.L.; O'Connell, B.M. [and others]. 2010. The Forest Inventory and Analysis database: database description and users manual version 4.0 for phase 2. Gen. Tech. Rep. RMRS-GTR-245. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. 336 p.