America's Forests Health Update

2009

Introduction

State of the Forests

America's forests provide many benefits and services, including clean water, recreation, wildlife habitat, sequestering carbon, and a variety of forest products. Most of our forests appear healthy and green; however, they face many threats to forest health and long-term sustainability. In the West, outbreaks of native pests have killed trees on millions of acres, fires are burning larger areas than in the past, and severe droughts have led to additional stress on forest ecosystems. In the East, invasive forest pests have changed the structure and composition of some forests and, in numerous locations, increasing human development has led to fragmentation. Many of these threats may be exacerbated by a changing climate.

Most of our forests appear healthy and green; however, they face many threats to forest health and long-term sustainability.

Leading Forest Health Indicators

To track the status and trends of forest health, the Forest Service, U.S. Department of Agriculture (USDA), has developed a suite of Leading Forest Health (LFH) indicators. These indicators enable us to periodically assess the overall health of America's forests and provide potential solutions to some of our greatest threats. While certainly not a complete list of all the indicators of forest health conditions, the LFH indicators focus on those that can be readily analyzed and mapped at national scales and represent some of the key stressors of forest ecosystems. These LFH indicators include:

- *Tree Mortality*
- *Fire*
- *Weather/Climate*
- *Forest Cover/Fragmentation*
- *Invasive Forest Pests*

We will address each of the LFH indicators by answering the following questions:

- Why is the indicator important?
- How are the data collected and analyzed?
- What are the current conditions and trends?
- What does it mean?
- What is the future outlook?

We intend to report on these LFH indicators every 3 to 5 years. By updating these LFH indicators periodically, we can begin to analyze trends that might indicate improvement or deterioration of forest health conditions and point to possible solutions.

While the death of trees is a normal process in all forest ecosystems, high levels of mortality may indicate forests under stress. Trees are killed by a variety of causes, including insects and pathogens, fires, extreme weather events, humans, and other interacting causes.

Current Tree Mortality Maps

The Forest Health Protection program annually maps areas of tree mortality, and other damage categories, through specially trained aerial observers in Federal and State land management agencies (http://www.fs.fed.us/foresthealth/fhm/dm/index.shtml. Observers fly in small aircraft at altitudes from 1,000 to 2,000 feet above ground level, recording visible tree damage or mortality. Visible pest activity is captured as a discrete polygon on 1:100,000-scale maps or directly into onboard computers linked to the aircraft's global positioning system. The digital sketch mapping system includes moving map displays on touch-sensitive screens that allow observers in moving aircraft to digitize and attribute polygons of tree damage and mortality. Attributes recorded for each polygon include tree species affected, likely cause of damage, number of trees (or trees per acre) affected, and severity of damage. Locations and numbers are estimates of activity visible that year. Because not all trees within an area are killed in 1 year, some areas might show pest activity over several years. Ground surveys of mapped polygons are conducted periodically to improve the quality of aerial detection surveys. Data from aerial and supplemental ground surveys are standardized and compiled annually by the Forest Health Technology Enterprise Team into a national geospatial database. These data are used to create national maps and summary tables for major damage types and causes (http://www.fs.fed.us/foresthealth/fhm/adsm.shtml). The national mortality map provides an overview of areas impacted by some of the major forest pests in the country (figure 1). In some regions of the country (e.g., Pacific Northwest), annual records exceed 60 years.

Trends in Tree Mortality

The Forest Health Protection program and its partners have conducted aerial surveys for many years. About 10 years ago, the Forest Health Monitoring program (a Federal-State partnership focused on monitoring the health of the Nation's forests) established national standards for collecting and reporting aerial survey information. These standards have facilitated analysis of temporal and spatial trends in tree mortality and other damage categories. A

Trees are killed by a variety of causes, including insects and pathogens, fires, extreme weather events, humans, and other interacting causes.

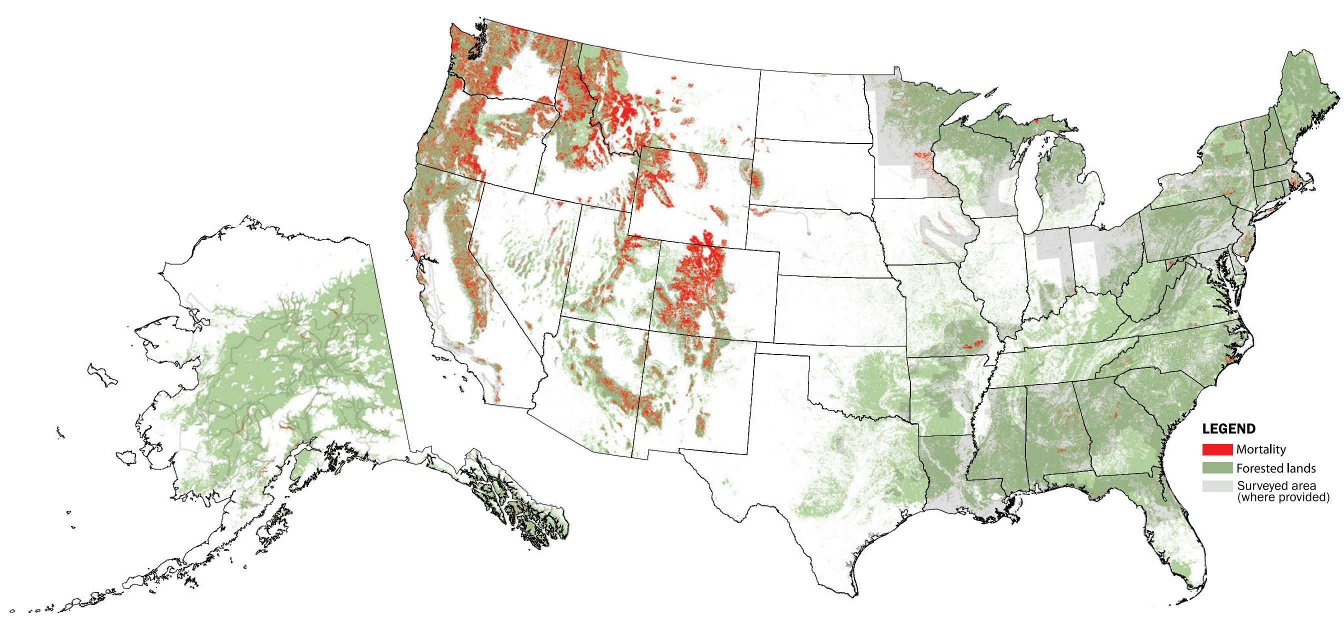

Figure 1. 2008 National Damage Overview Map [The figure 1 map in this electronic version varies from the printed publication of the report in order to more accurately portray southern pine beetle-caused mortality data.]

Galleries of pinyon Ips beetles under bark. Photo by William Ciesla, Forest Health Management International, http://www.forestryimages.org.

10-year trend for tree mortality is displayed in figure 2, indicating a large increase in tree mortality during the period from 2002 through 2008 compared to the previous 5 years. This increase was largely due to increased bark beetle activity in the West, much of it following severe regional drought.

Bark beetles and lodgepole pine have co-evolved in the West, so broad-scale mortality of lodgepole pine forests has occurred previously. The homogeneous age structure of these forests over broad landscapes combined with climate change has likely intensified the effect of tree mortality at a landscape scale. New, younger forests will emerge from these areas, and the cycle of tree mortality caused by bark beetles will repeat over time. The more heterogeneous these new forests are in age structure, the less likely it is that landscape-level mortality will occur in the future.

Much of the large increase in tree mortality that occurred in 2003 and 2004 was attributed to outbreaks of Ips bark beetles in pines in the Southwestern States of Utah, Colorado, Arizona, and New Mexico. Severe drought conditions in this area from 2000 to 2003 predisposed pinyon and ponderosa pines to attacks by Ips and other bark beetles. Mortality included trees of all ages and sizes. Stand-level mortality rates ranged from 40 to 80 percent of trees larger than seedlings.

Native bark beetles also caused extremely high levels of mortality in southern California during 2003 and 2004, following an extended drought period. Western pine beetle (*Dendroctonus brevicomis*), Jeffrey pine beetle (*Dendroctonus jeffreyi*), and mountain pine beetle (*Dendroctonus ponderosae*) killed large numbers of pine trees on the San Bernardino and Cleveland National Forests and adjacent lands. Massive wildfires driven by Santa Ana winds burned many of these beetle-killed forests, affecting surrounding communities.

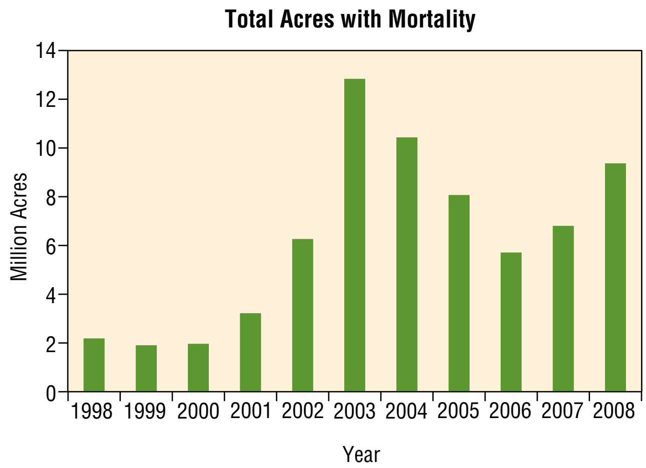

Figure 2. Ten-year trend in tree mortality

Bark Beetles in the West

Bark Beetles in the West—Bark beetles have killed many conifers over large areas of the West in recent years. The primary reasons for this are susceptible tree and stand conditions combined with recent droughts. The beetles causing most of this mortality in 2008 were native insects, including mountain pine beetle (6 million acres), western balsam bark beetle (533,000 acres), fir engraver (493,000), spruce beetle (210,000 acres), and Douglas-fir beetle (200,300 acres). Larger than any previously recorded outbreak, the mountain pine beetle outbreak in the central Rocky Mountains continues to expand. Damage is most widespread and dramatic in dense, aging lodgepole pine forests that dominate many mountainous areas of Colorado, Wyoming, Montana, Idaho, and Utah. Some of these outbreaks are occurring at higher elevations than in the past. Most notable is that high-elevation whitebark pines are being killed on sites previously thought to be too cold for serious beetle outbreaks. These changes in beetle activity might be related to warmer winter temperatures that have led to quicker development and higher survival rates for over-wintering insects. Human-caused climate change is implicated in this trend of increasing temperatures.

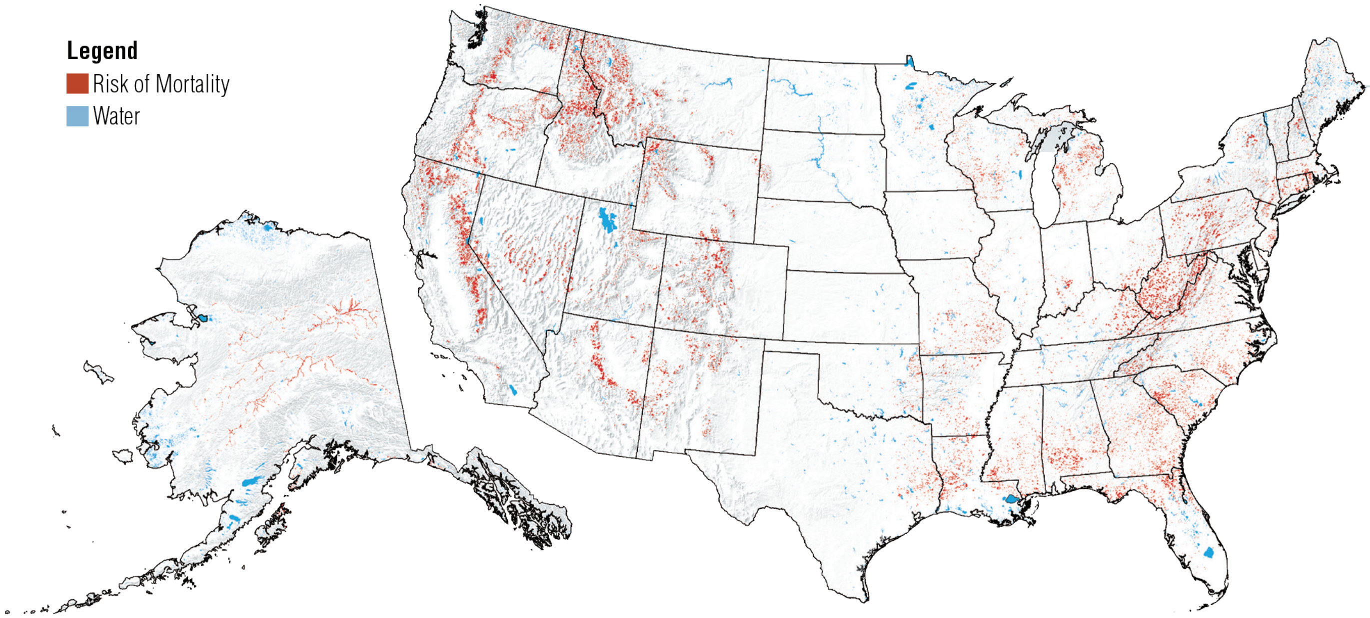

Figure 3. National Insect and Disease Risk Map

Future Projections of Tree Mortality—National Risk Map

The Forest Service and partners have recently completed a national risk assessment that maps potential future risk of tree mortality due to insects and diseases (http://www.fs.fed.us/foresthealth/technology/nidrm.shtml) (figure 3). Risk was defined as an expectation that 25 percent or more of the standing live basal area of trees greater than 1 inch in diameter will die over the next 15 years due to insect and disease activity. This level of mortality was selected to identify areas at risk of insect- and pathogen-caused tree mortality exceeding the nominal average mortality that ranges from 0.6 to and 0.7 percent of growing stock per year. It does not, however, identify the potential loss of a tree species in a mixed-species forest if it constitutes less than 25 percent of the stand. Teams of forest health experts from Federal and State agencies assembled the latest risk models for the most important forest insects and pathogens. These models were then applied to forest inventory and other data layers to identify those areas at

Pinyon pine killed by Ips beetles in Mesa Verde National Park. Photo by William Ciesla, Forest Health Management International, http://www.forestryimages.org.

Southern Pine Beetle Hazard Maps

Southern pine beetle (SPB) is the most destructive forest insect in the Southern United States. The SPB range covers the Southeastern United States from New Jersey to Florida and west to Texas, and from Arizona and New Mexico through Mexico to Nicaragua. Southern pine beetles prefer loblolly, shortleaf, pitch, pond, and Virginia pines growing in overcrowded conditions (basal area > 120 sq.ft/acre). Identifying where high hazard (dense stands of loblolly and shortleaf pine) forests are located and most prevalent has always been considered a key component in the attempt to mitigate impacts from SPB. In March of 2008, Forest Health Protection (Southern Region) announced the release of new 30-meter resolution SPB Hazard Maps (Version 1.0) produced by the Forest Health Technology Enterprise Team. Maps were developed for all 13 Southern Region States and 5 adjacent States that occasionally experience SPB activity (figure 4). The maps were designed as a tool to aid forest health specialists and land managers in implementation of the SPB Prevention and Restoration Program (for more information, visit http://www.fs.fed.us/foresthealth/publications/southern_pine_beetle_prevention.pdf). The National Risk Map mentioned earlier has a resolution of 1 km, so the SPB maps represent a significant improvement by providing a finer resolution. The maps will be used to identify macro-level (i.e., county level) areas of the States where SPB prevention treatments could be prioritized on the landscape and to assist foresters at the local level to identify areas with concentrations of high hazard pine stands (figure 5).

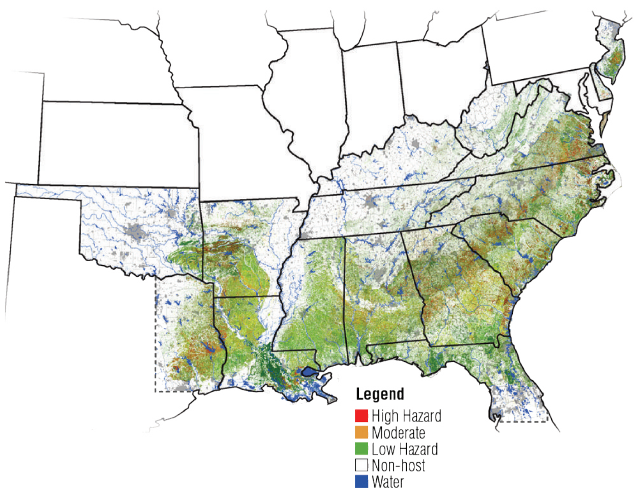

Figure 4. Southern pine beetle Hazard Map V.1.0: Southern Region

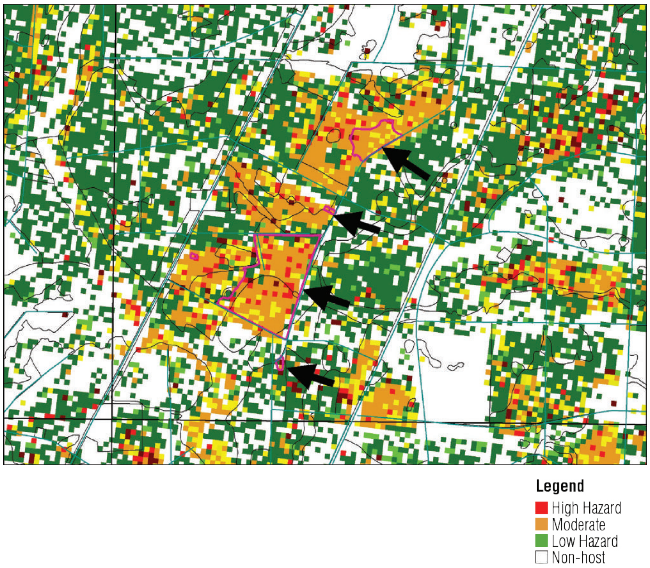

Figure 5. Southern pine beetle Hazard Map V.1.0: Stand level view—gulf coast Florida

risk to future tree mortality. According to this assessment, more than 58 million acres of 749 million acres of forest lands are at risk. Most of this risk can be attributed to 11 risk agents, including bark beetles of western conifers, oak decline, southern pine beetle, root diseases, and gypsy moth. This strategic assessment provides a useful tool in developing broad prevention strategies for the major forest insects and pathogens affecting America's forests. The current National Risk Map was based on current climate conditions and does not take into account the effects of global climate change. Future enhancements will include mapping risk at finer resolutions (see sidebar for southern pine beetle example) and incorporation of future climate change scenarios.

The national and regional risk maps previously described provide land managers with projections of future mortality given current forest stand and climatic conditions. Without proactive management strategies to reduce some of the key risk factors (such as high tree density and homogeneous species composition), mortality rates will continue to increase, especially in areas most affected by climate change.

Total Area of Forest Fires

Fire is a major disturbance agent in many forests of North America. Many forest ecosystems are adapted to particular fire frequencies and intensities. The annual amount of forest area burned varies depending on weather conditions, fuel loading, and forest stand conditions. The total area of wildland fires by year is compiled by the National Interagency Coordination Center (for more information, visit http://www.nifc.gov/fire_info/fires_acres.htm). Summaries of total area burned for all vegetation types in the United States since 1960 are presented in figure 6. Many years of fire exclusion have resulted in increased fuel loads and dense forests, leading to an increased risks of uncharacteristic wildfires. The recent increase in number, size, and severity of fires in the Western United States has also been linked to recent climatic changes (figure 7). In addition, large bark beetle outbreaks in the West have also increased fuel loading in many forests. Large fire frequency and total area burned have increased markedly since the mid-1980s in strong association with increased spring and summer temperatures and an earlier spring snowmelt. The total area burned in the United States in 2006 was the largest fire-affected acreage in the last 46 years.

High-intensity wildfire in northeast Oregon. Photo by Dave Powell, Forest Service, http://www.forestryimages.org.

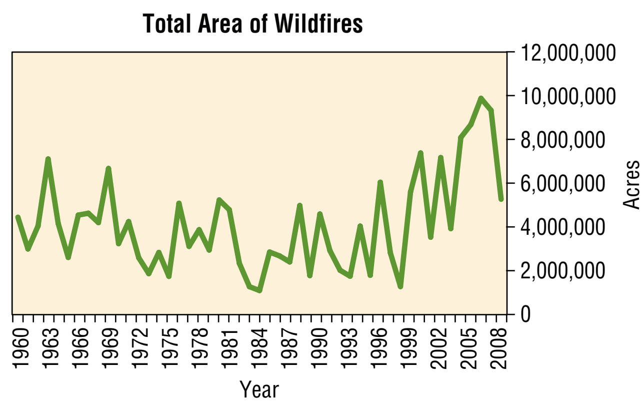

Figure 6. Total area of wildfires in all vegetation types in the United States from 1960 to 2008.

Lightning-ignited wildfire in Blue Mountains, northeastern Oregon. Photo by Dave Powell, Forest Service, http://www.forestryimages.org.

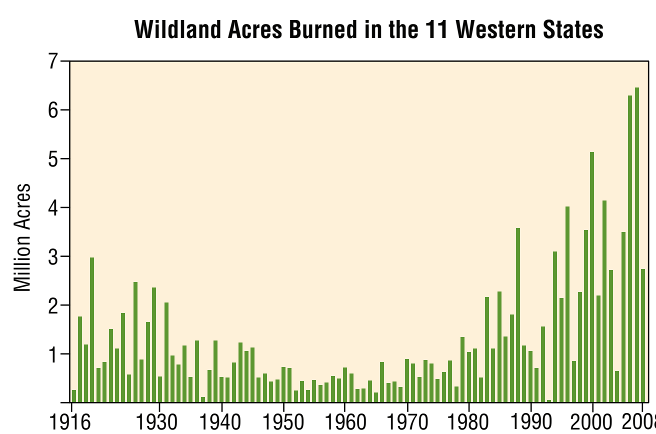

Figure 7. Total area burned for all vegetation types in the Western United States from 1916 to 2008.

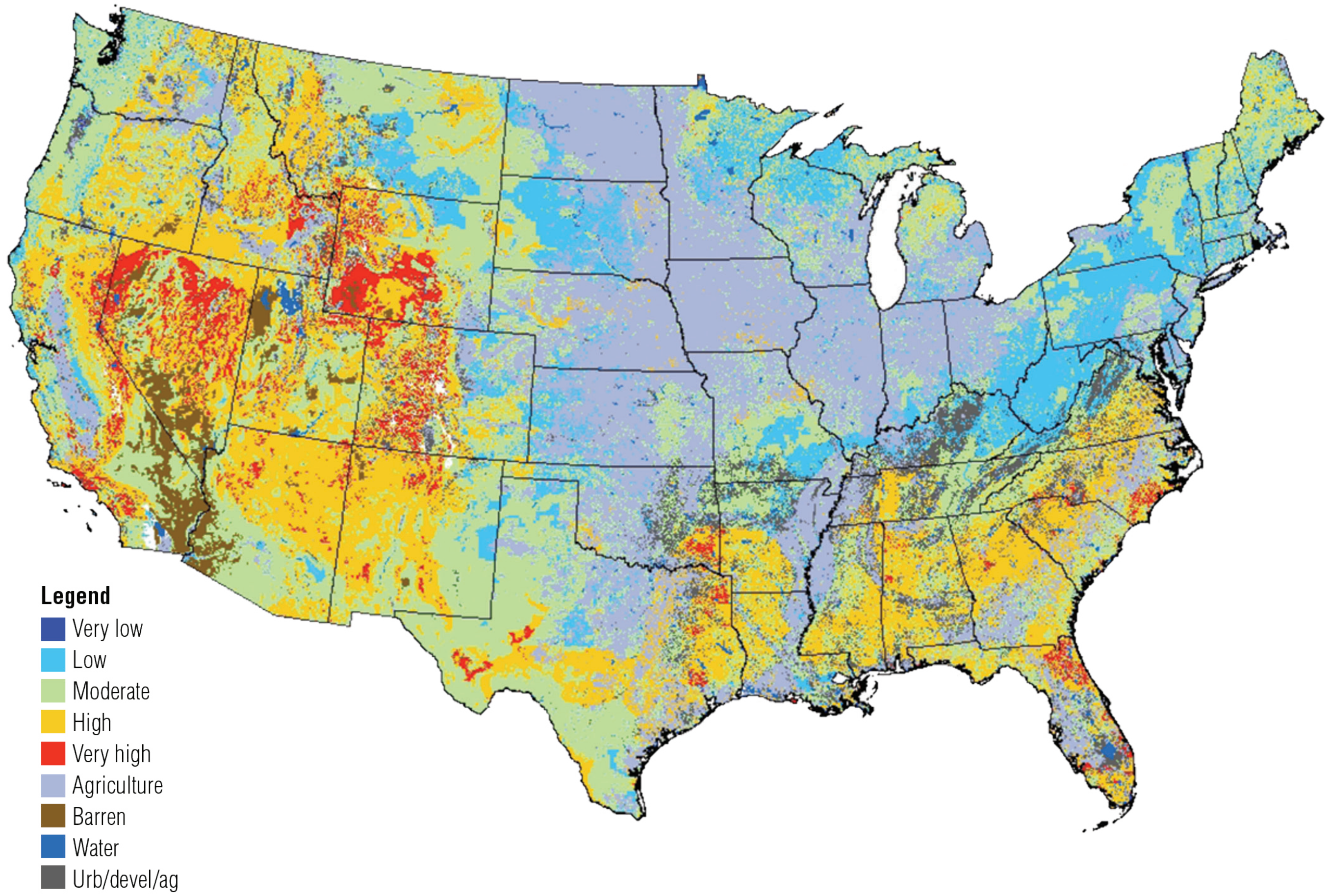

Figure 8. Wildland Fire Potential.

Many years of fire exclusion have resulted in increased fuel loads and dense forests, leading to an increased risks of uncharacteristic wildfires.

Wildland Fire Potential

The Fire Modeling Institute of the Forest Service Missoula Fire Science Laboratory recently mapped the wildland fire potential as an intersection of fire behavior and fire probability under extreme conditions (figure 8). Fire behavior includes projections of crown fire and surface fire potential based on maps of forest cover types and fuel characteristics. The Fire Modeling Institute assessed fire probability by considering both fire weather and fire occurrence. Fire weather includes average number of problem fire days (exceeds threshold of temperature, wind, and humidity) from 1982 to 1997 and length of fire seasons (average number of days where energy release component[1] exceeds 95 percent) from 1980 to 2005. Fire occurrence is based on mapping small (one-tenth acre to 500 acres) and large fires (> 500 acres) from 1980 to 2003. Large portions of the Western and Southern United States exhibit high to very high wildland fire potential (figure 8). Unless aggressive measures are taken to reduce fuel loads in forested ecosystems, the outlook for the future is for continued increases in number and severity of fires in areas affected by droughts and pest outbreak.

[1]Energy release component is related to the thermal energy (BTUs) per unit area (sq. ft.) within the flaming front at the head of a fire.

Drought—Deviation From Historic

Drought occurrence is a major factor affecting forest health. Periods of below normal precipitation, often coupled with above normal temperatures, can lead to increased tree stress, reduced tree resistance to insects and pathogens, accelerated insect life cycles, and insect abundance, resulting in higher levels of tree mortality and increased wildfires. Regional droughts have been linked to decadal climate cycles and increasing temperatures. The National Climate Data Center has compiled and archived drought severity by month for the conterminous United States back to 1895. Drought severity is represented by the Palmer Drought Severity Index (PDSI), which incorporates relative temperature and precipitation amounts by climatic region to determine drought. An assessment of monthly PDSI for forested areas of the United States indicates that much of the Interior West was significantly drier during the period from 1996 to 2005, compared to the 110-year average (figure 9). This regional drought was one of the factors associated with dramatic increases in bark beetle-caused tree mortality and wildfires as previously discussed in other sections.

Yellow-Cedar Decline

More than half a million acres of yellow-cedar mortality have been mapped during aerial surveys in southeast Alaska. The affected areas contain mixtures of long-dead, recently-dead, and dying yellow-cedar trees. Analysis of aerial survey data reveals that this widespread tree mortality is concentrated at lower elevations and on wet soil types. Research indicates that the problem began about 100 years ago at the end of the Little Ice Age. Tree death appears to be a form of root freezing, predisposed by low snow accumulations in the 1900s, shallow roots in anaerobic soils, and a unique vulnerability to cold injury by yellow-cedar in early spring. Knowledge of the cause of yellow-cedar decline and associated site risk factors is leading to a conservation strategy for this valuable tree species in the context of a warming climate with reduced snow.

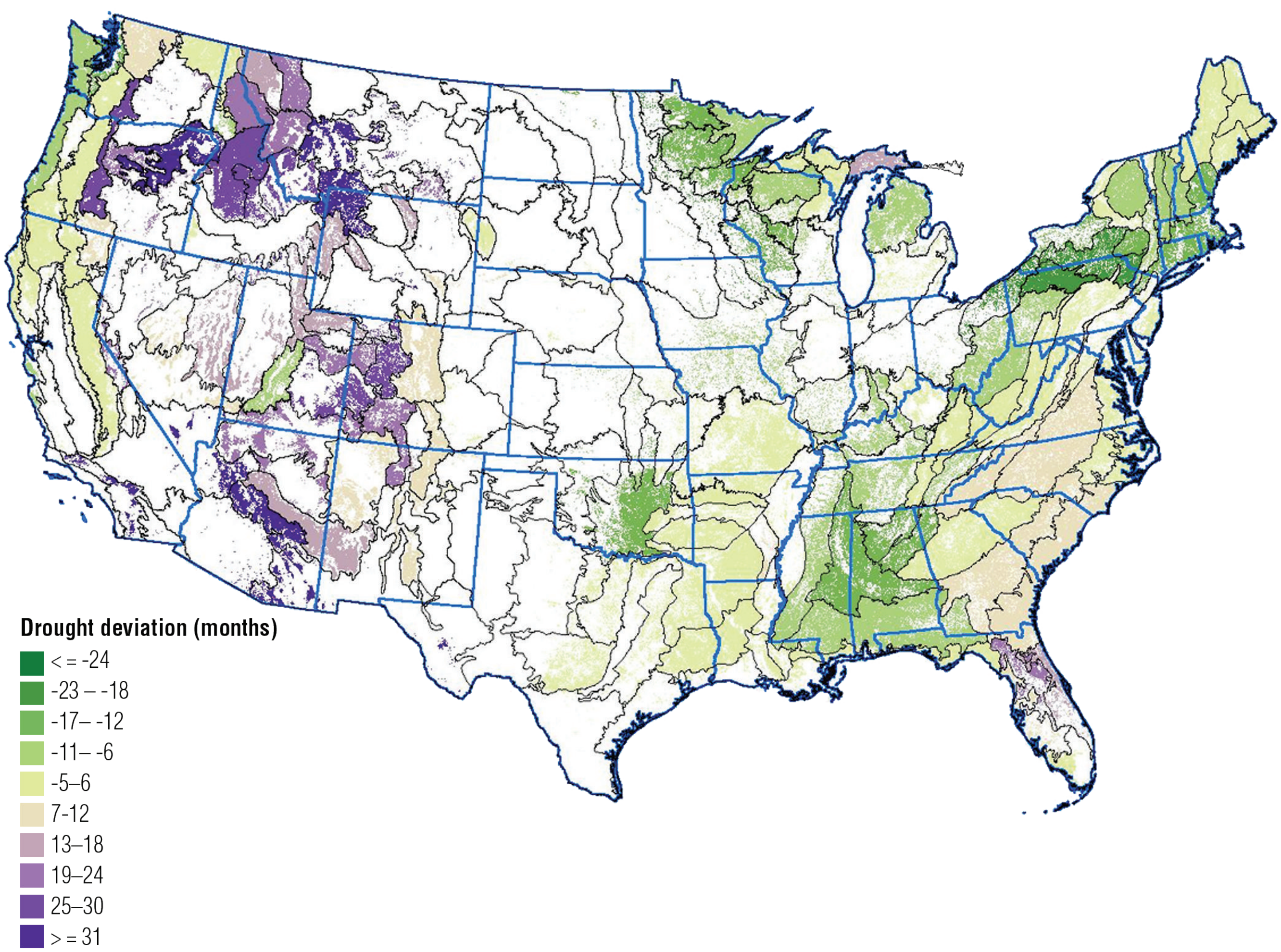

Figure 9. Drought deviation for the period of 1996–2005, as compared to 1895–2005.

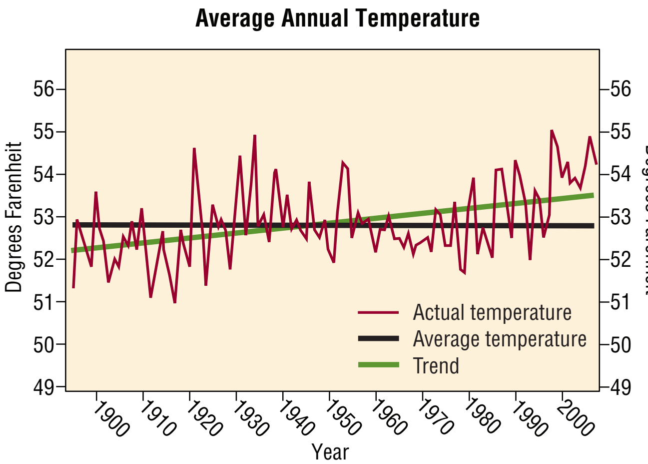

Figure 10. Average annual temperatures for the United States from 1895 to 2007 (Source: NOAA, NCDC).

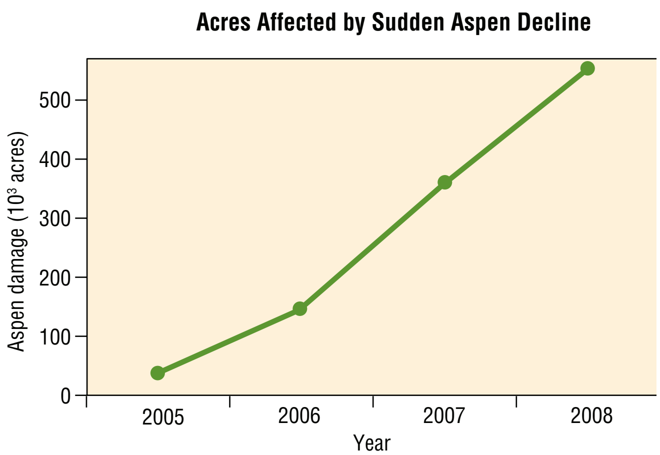

Figure 11. Acres affected by sudden aspen decline in Colorado from 2005 to 2008.

Sudden Aspen Decline

Foresters and forest health specialists in western Colorado have noted recent, large-scale mortality of aspen. Aerial surveys indicate that the area of aspen stands affected by multiple agents in Colorado increased from 139,000 acres in 2006 to over 550,000 acres in 2008 (figure 11). Similar mortality of aspen has been detected in southern Utah and northern Arizona. Evaluations in Colorado revealed that mortality was concentrated at lower elevations or on droughty sites, particularly on south/southwestern aspects. Although a variety of insects and pathogens were found associated with dying trees, no single mortality agent appeared to be the primary cause for the decline. This sudden onset of widespread mortality has been linked to a recent prolonged drought and higher-than-normal temperatures during the growing season. A complex of normally secondary insects and pathogens hastened the decline and mortality of many of the older, larger trees. In many areas, the root systems of affected clones appear to be dying and regeneration is scarce, raising concerns that aspen may be permanently lost from some ecosystems.

There is mounting scientific evidence that the Earth's surface is warming, in part, due to human activities.

Temperature—Warming Trend

There is mounting scientific evidence that the Earth's surface is warming, in part, due to human activities. Increases in greenhouse gases, such as carbon dioxide, have been linked to burning of wood, peat, and fossil fuels. As the greenhouse gasses trap heat in the Earth's atmosphere, average surface temperatures rise. Figure 10 indicates an increasing trend in average annual temperatures for the United States since 1895, based on weather station data throughout the country summarized by the National Climatic Data Center of the National Oceanic and Atmospheric Administration. Increasing temperatures have been linked to increased severity of wildfires, insect outbreaks, and tree declines.

The frequency of large fires and fire season length has increased significantly since 1985. These changes have been linked to earlier spring snowmelt and increases in spring and summer temperatures. Fire activity has increased dramatically in mid-elevation forests of the Rocky and Sierra Nevada Mountains. Higher monthly minimum temperatures in the winter have increased bark beetle survival at higher elevations in the Rocky Mountains. This effect—combined with warmer-than-normal temperatures in the spring, summer, and fall—has reduced the time to complete insect life cycles, leading to more severe outbreaks occurring at higher-than-expected elevations. All of these factors, prolonged drought, warmer winter temperatures, higher bark beetle-caused tree mortality, and increased fire severity, act synergistically, causing abrupt and long-term changes in the ecosystem. Bark beetles and fires are inextricably linked in these fire-adapted ecosystems. The outlook for the next 3 to 5 years is for continued increases in extent and severity of fires unless proactive measures are taken to reduce fire risk, as mentioned in Fire section.

Forest Cover

Forests cover about 749 million acres or about one-third of the total area of the United States. Although the total forest area in the United States has declined since 1850, it has been relatively stable since the early 1900s (figure 12). The loss of forest cover in the latter part of the nineteenth century in the north and south regions of the United States was largely due to conversion of forests to other uses (i.e., agricultural and urban).

Forest Fragmentation

Forests in some portions of the country have been increasingly fragmented. Fragmentation of forests may lead to changes in ecological processes, reduction in biological diversity, and the spread of invasive species from disturbed edges. Even small openings may provide an opportunity for additional impacts affecting undisturbed portions of the adjacent forest. Analyses of high-resolution forest land cover maps derived from satellite imagery indicate that while forest land is usually dominant where it occurs, fragmentation is extensive. Seventy-two percent of all forest land was in landscapes classified as “dominant” (greater than 60 percent forested) (figure 13). About half the fragmentation consisted of small (less than 7 hectares) gaps in interior forest areas. More detailed assessments of forest edge revealed that about 44 percent of forest land is within 90 meters of the forest edge, 62 percent within 150 meters of forest edge, and less than 1 percent is more than 1,230 meters from the forest edge. Equal amounts of forest edge were created because of anthropogenic (human-caused) activity (i.e., forest edge with urban or agricultural landcover types) versus semi-natural events (i.e., forest edge with water, wetland, barren, grassland, or shrubland). Most anthropogenic forest edge was found in

Analyses of high-resolution forest land cover maps derived from satellite imagery indicate that while forest land is usually dominant where it occurs, fragmentation is extensive.

Housing development in mountain pine beetle-infested lodgepole pine forest in Colorado. Photo courtesy of Forest Service Rocky Mountain Region.

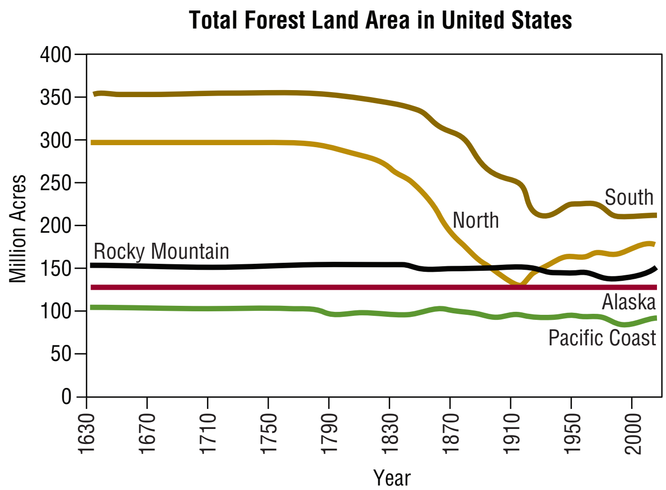

Figure 12. Total forest land area in the United States since 1850.

the Eastern United States, whereas seminatural forest edge was more common in the Western United States. While specific impacts naturally depend on local circumstances, the physical evidence alone indicates that most forest land is exposed to and, therefore, at risk from "edge effects" extending only several hundred meters from the forest edge. Specific impacts depend on the local causes of fragmentation (what is on the "other side" of an edge) and the particular aspect of forest health, such as biodiversity, invasive species, or microclimate. Fragmentation of forests is expected to increase in the near future as more private parcels are cleared for housing development. Housing density is projected to increase on more than 44 million acres of rural private forested lands by 2030 (http://www.fs.fed.us/openspace/fote/housing.html).

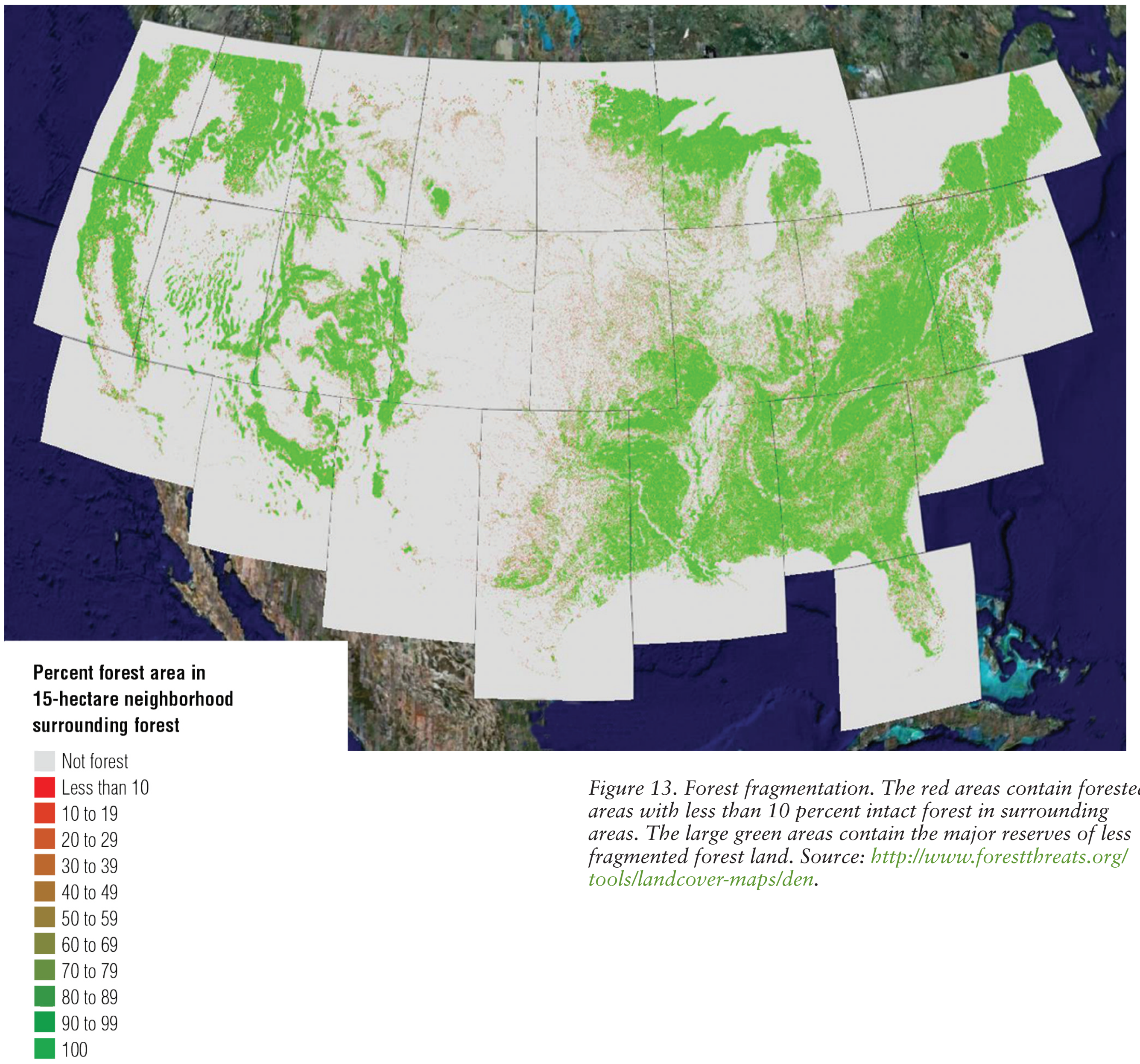

Figure 13. Forest fragmentation. The red areas contain forested areas with less than 10 percent intact forest in surrounding areas. The large green areas contain the major reserves of less fragmented forest land. Source: http://www.forestthreats.org/tools/landcover-maps/den.

Invasive Forest Pests

The greatest threats facing U.S. native forests are invasive forest pests. Exotic forest insects and pathogens that have been introduced into new ecosystems can become invasive due to lack of natural controls, such as predators or pathogens, or inadequate host defenses. The makeup of many native U.S. forests has been drastically altered as invasive forest pests became established. The chestnut blight has virtually eliminated the American chestnut, a major overstory tree in the Eastern United States. Dutch elm disease has killed most American elms in urban areas throughout the country. White pine blister rust continues to invade new ecosystems, including high elevation sites in the Rocky Mountains, killing five needle pines. Balsam wooly adelgid has led to the decline of balsam and Fraser firs throughout the mountains of the Eastern United States. The following invasive forest pests present significant threats to U.S. forests in the near future:

Gypsy moth
Hemlock woolly adelgid
Emerald ash borer
Sudden oak death
Sirex wood wasp

Currently, the best indicator of the distribution and spread of any particular invasive forest pest is the number of infested counties (see figures 14 and 16).

Sudden oak death in California.
Photo by Borys Tkacz, Forest Service.

Figure 14. Counties quarantined for gypsy moth from 1905 to 2005.

Gypsy Moth

Since its accidental introduction near Boston, MA, in 1868, the gypsy moth (*Lymantria dispar*) has become established in all or parts of 19 States and the District of Columbia (figure 14). Outbreaks of this insect are cyclical, leading to defoliation of many broad-leaved trees during outbreaks. A single year of defoliation rarely kills a healthy tree; however, repeated defoliation can lead to death of stressed trees. Tree and stand mortality are affected by severity and frequency of defoliation, along with tree vigor, host susceptibility, and environmental conditions. Trees under stress from drought are often killed more rapidly than healthy trees. Mortality is often most severe in areas with abundant preferred hosts along the advancing front of the gypsy moth infestation (figure 15). A fungus that attacks gypsy moth, *Entomophaga maimaiga*, was released near Boston between 1910 and 1911; however, significant effects on gypsy moth populations were not observed until the early 1990s. Since then, the fungus has become the most visible natural control agent of gypsy moth. The national gypsy moth management program focuses on three strategies: suppressing outbreaks to reduce damage to forests and trees; eradicating isolated spot infestations beyond the generally infested area; and slowing the spread of gypsy moth along the advancing front of the infestation. Since 1970, almost 14 million acres have been treated through cooperative suppression projects to reduce gypsy moth impacts in high-value areas. Isolated spot infestations have been eradicated in Oregon,

European gypsy moth larva. Photo by John H. Ghent, Forest Service, http://www.forestryimages.org.

Exotic forest insects and pathogens that have been introduced into new ecosystems can become invasive due to lack of natural controls, such as predators or pathogens, or inadequate host defenses.

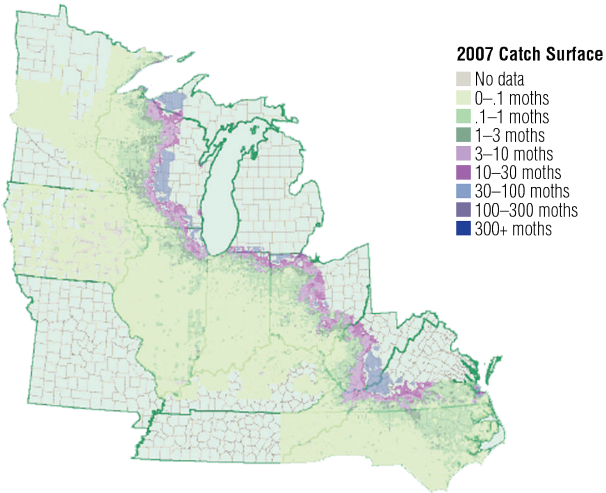

Figure 15. Gypsy moth trap catches along the advancing front in 2007.

Gypsy moth defoliation of oaks and other hardwood in Pennsylvania. Photo by William Ciesla, Forest Management International, http://www.forestryimages.org.

Wisconsin, North Carolina, Utah, Idaho, Tennessee, and Arkansas. Additionally, as a result of the National Slow the Spread of Gypsy Moth strategy (http://www.gmsts.org/), spread of gypsy moth along the advancing front has been reduced by more than 70 percent—from the historical average spread of 13 miles per year to 3 miles per year. Furthermore, the western part of the United States has no established populations of the insect due to early detection and rapid response strategies.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (*Adelges tsugae*) is native to Japan and was first reported near Richmond, VA, in the early 1950s. While it was initially considered an ornamental pest of urban trees, it was found causing mortality of forest trees in Connecticut and New Jersey in 1985. Since then, it has spread to 17 Eastern States from southern Maine to northeastern Georgia and west to eastern Kentucky and Tennessee (figure 16). This insect spreads naturally by wind and birds, and artificially on infested nursery stock. The adelgid depletes stored nutrients in the xylem leading to stunted growth, dieback, and eventually mortality. The loss of eastern and Carolina hemlocks is having devastating ecological impacts, particularly in riparian areas, where overstory trees moderate stream temperatures. Biological control through the release of predators offers the best hope for long-term management of hemlock woolly adelgid. Three species of predatory beetles have been released in 13 States. The success of the

Hemlock woolly adelgid. Photo by Connecticut Agricultural Experiment Station Archive, Connecticut Agricultural Experiment Station, http://www.forestryimages.org.

Figure 16. Distribution of selected invasive forest pests: hemlock wooly adelgid (HWA), emerald ash border (EAB), sudden oak death (SOD), and sirex wood wasp (SWW).

Sudden Oak Death in Southwestern Oregon

Aerial detection surveys conducted by the Forest Service and Oregon Division of Forestry under the Forest Health Monitoring program during the summer of 2001 identified an isolated infestation of *Phytophthora ramorum* near Brookings in Curry County, Oregon. Small centers of dead and dying tanoak were mapped, and the presence of the pathogen was confirmed via laboratory techniques. The Oregon Department of Agriculture issued a quarantine for the infested area, and a cooperative eradication/containment program was initiated. Treatments include removal of diseased tanoak trees and associated host plants and then burning. Treated areas are continually monitored for *P. ramorum* infestation of vegetation, soils, and water. New satellite infestations have also been found in the surrounding area, increasing the quarantined area to 162 square miles in 2008. While monitoring results indicate that the pathogen has not yet been eliminated from the infested sites, the rate of spread has been dramatically reduced.

biocontrols has been mixed, but improvements are being made every year, and the hope is that biocontrol agents will eventually be very helpful in slowing the spread of this insect pest.

Emerald Ash Borer

The emerald ash borer (*Agrilus planipennis*) is native to China, Korea, Japan, Mongolia, Taiwan, and the Russian Far East. The first report of this insect in the United States was in 2002 on ash trees in the Detroit, MI, area. Spread of this insect is accelerated by transport of infested ash nursery stock, firewood, and logs. By the end of 2008, Federal and State quarantines were established in all or parts of Illinois, Indiana, Maryland, Michigan, Missouri, Ohio, Pennsylvania, Virginia, West Virginia, and Wisconsin (figure 16). The emerald ash borer is an efficient tree killer, having killed more than 20 million trees since its introduction into the United States. The lack of resistance in North American ash trees indicates that the emerald ash borer could, over time, eliminate much of the ash resource across the country. Management strategies employed against this insect include conducting extensive surveys, eradicating isolated infestations by felling and destroying infested trees, identifying and regulating pathways of artificial movement, and providing public communication and outreach. The Forest Service continues to work with partners, especially the USDA Animal and Plant Health Inspection Service, to develop new control strategies using biological agents and chemical insecticides. At this point, it is too early to say how effective these control options will be.

Ultimately, the best strategy for dealing with invasive forest pests lies in preventing new introductions.

Adult emerald ash borer. Photo by David Cappaert, Michigan State University, http://www.forestryimages.org.

Sudden Oak Death

Sudden oak death, caused by the pathogen *Phytophthora ramorum*, has killed over 3 million tanoaks and native oaks in central and northern coastal areas of California over the past decade. An isolated infestation has also been found in southwestern Oregon near the town of Brookings. While the pathogen attacks over 100 species of plants, most of the affected species will not die but can serve as sources of infection. The spores of *P. ramorum* can be spread in rainwater washing down from infested leaves, infecting the main trunks of tanoaks, California live oaks, California black oaks, and Shreve oaks. Trunk infections expand to form girdling cankers that eventually kill the trees. The pathogen has also been moved artificially by transport of infected nursery plants throughout the United States. Laboratory testing has revealed that several species of eastern oaks are susceptible to this disease, raising the concern that the vast oak forests of the Eastern United States may be at risk. Management strategies for this disease vary by region and history of outbreak. Throughout the infested area in California, management strategies focus on mitigating the negative impacts of tree mortality. Detection surveys using remote sensing techniques and ground and water sampling attempt to identify new infestations outside the generally infested area. Quarantines issued by Federal and State agencies target artificial movement of the pathogen on infected plants and plant products. Isolated infestations, such as the one in Oregon, are being treated with the goal of containing the pest and confining its impact to a small geographic area.

Sirex Wood Wasp

Sirex wood wasp (*Sirex noctilio*) is native to Europe, Asia, and northern Africa. It was first found in the United States in a Cooperative Agricultural Pest Survey trap deployed to monitor exotic insects near Fulton, New York in 2004. Delimitation surveys in succeeding years have identified infestations in New York, Pennsylvania, Vermont, and Michigan (figure 16). This insect was also introduced into New Zealand, Australia, Uruguay, Argentina, Brazil, Chile, and South Africa, where it is a serious pest in plantations of North American pines. While all North American commercial pine species are susceptible to *Sirex noctilio*, the coniferous forests of the Southeastern and Western United States are at particular risk. This insect is a strong flyer and can readily spread to uninfested areas, especially poorly managed forests that are stressed. Artificial movement occurs through transport of infested wood. Management strategies in Southern Hemisphere pine plantations focus on reducing the susceptibility of pines through silvicultural treatments and application of biological controls. Current emphasis in the United States is on determining the extent of the infestation through conducting detection surveys, implementing quarantines to prevent human-assisted spread, developing biological controls, and evaluating silvicultural treatments to improve tree resistance.

Sirex wood wasp. Photo by David R. Lance, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, http://www.forestryimages.org.

Galleries of the emerald ash borer. Photo by David Cappaert, Michigan State University, http://www.forestryimages.org.

Outlook for Invasive Forest Pests

Increasing global travel and trade will likely lead to increasing introductions of invasive forest pests into the United States. As is evident from the examples presented above, invasive forest pests will continue to present difficult management challenges once they are established in new environments. Eradication is often impossible and control measures can be costly. Resource impacts can be devastating to natural forests and urban landscapes. Ultimately, the best strategy for dealing with invasive forest pests lies in preventing new introductions. Invasive forest pests are a global threat requiring international cooperation. The Forest Service is working with the USDA Animal and Plant Health Inspection Service and many other partners in the United States and abroad to identify and assess potential new invaders, develop effective mitigation strategies against pathways of introduction (i.e., Asian gypsy moth monitoring program in Asia and Russia), and monitor and manage outbreaks of forest pests in their native environments.

The Forest Service

The Forest Service provides national leadership for monitoring and protecting forest health on all lands in the United States through authority granted by the Cooperative Forestry Assistance Act of 1978, as amended through 2002.

While this publication highlights the key indicators of current forest ecosystem health concerns and some actions taken to address them, it is not intended to be a comprehensive list of all forest health issues across the country. More specific information is available based on the surveys and monitoring conducted by the Forest Service and its partners through the Forest Health Protection and Forest Health Monitoring Programs.

For more information contact:

Forest Service
Forest Health Protection
1400 Independence Ave. SW
Mailstop: 1110
Washington, DC 20250-1110

Phone: 703-605-5344

Web sites:
http://www.fs.fed.us/foresthealth
http://www.fs.fed.us/foresthealth/fhm

United States
Department of
Agriculture

Forest Service

AIB-804

June 2009