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Northeastern Area
State and Private Forestry

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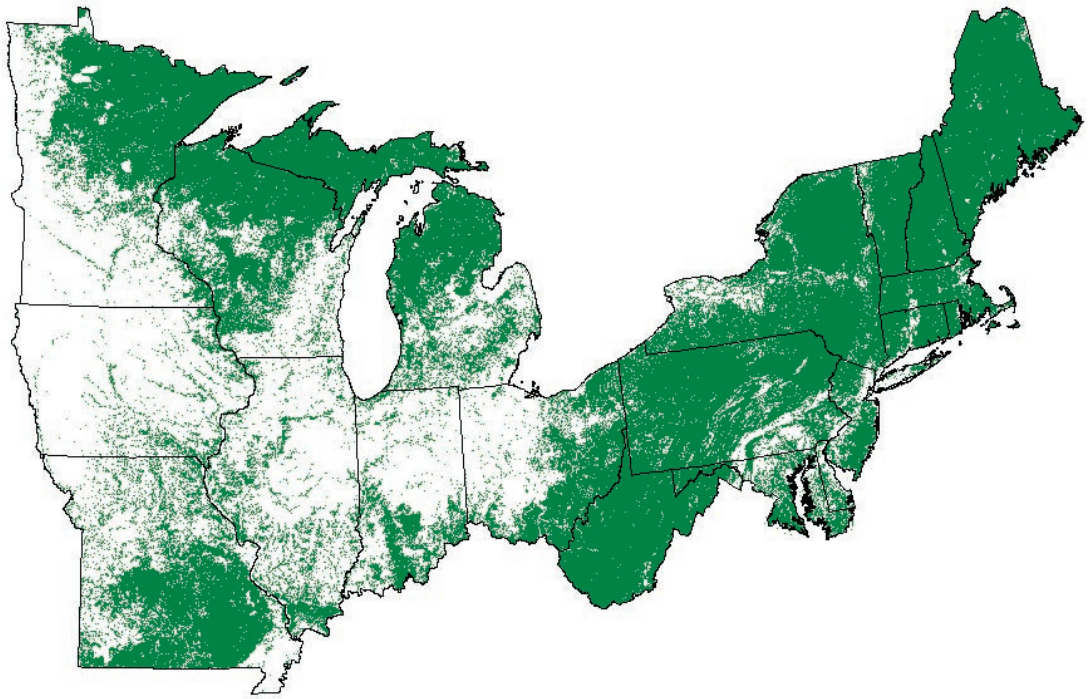
Newtown Square, PA
September 2004

Forest Health Monitoring in the Northeastern United States

Disturbances and Conditions during 1993-2002



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Jim Steinman
Forest Health Monitoring Program Coordinator
Northeastern Area, State and Private Forestry

Cover: Forest distribution in the Northeastern United States as determined by the U.S. Geological Survey.

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Executive Summary

A healthy forest is one having the capacity across the landscape for renewal, for recovery from a wide range of disturbances, and for retention of its ecological resiliency while meeting current and future needs of people for desired levels of values, uses, products, and services (USDA Forest Service, 2003a). The objective of the Forest Health Monitoring (FHM) Program of the USDA Forest Service is to report on the status, changes and trends in forest health conditions in a timely manner. The FHM Program accomplishes this mission through cooperation with the Forest Health Protection (FHP) Program, the Forest Inventory and Analysis (FIA) Program, State agencies, and other partners.

This report provides an update of forest disturbances and conditions for a 20-state region that constitutes the administrative region of the Northeastern Area, State and Private Forestry, USDA Forest Service. The report relies upon use of various scientific data that were mostly collected between 1993 and 2002 and obtained from all types of public and private ownerships. The FHM Program relies upon various partners to provide these data.

Various types of disturbances and conditions are presented in this report. Reporting topics correspond to key disturbance issues of forest cover and fragmentation, drought, fire, insects and diseases that damage trees, air pollutants, and soil erosion. The health conditions of forest trees associated with some of these disturbances are also evaluated.

The information related to each reporting topic will be periodically updated from ongoing monitoring efforts. Long-term trends in forest health conditions will eventually become evident as this information is produced.

Introduction

Background

A healthy forest is one having the capacity across the landscape for renewal, for recovery from a wide range of disturbances, and for retention of its ecological resiliency while meeting current and future needs of people for desired levels of values, uses, products, and services (USDA Forest Service, 2003a). The objective of the Forest Health Monitoring (FHM) Program of the USDA Forest Service is to report on the status, changes and trends in forest health conditions in a timely manner. The FHM Program works in cooperation with State agencies and other USDA Forest Service Programs including Forest Health Protection (FHP) and Forest Inventory and Analysis (FIA).

The FHM Program involves four types of activities: (1) Detection Monitoring, (2) Evaluation Monitoring, (3) Intensive Site Monitoring, and (4) Research on Monitoring Techniques. This report focuses on Detection Monitoring activities and indicates disturbance events and forest conditions that may warrant further investigation through Evaluation Monitoring and Intensive Site Monitoring.

Scope of Report

This report describes forest disturbances and conditions for a 20-state region that constitutes the administrative region of the Northeastern Area, State and Private Forestry, USDA Forest Service. The constituent States are Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin. Forest types of oak-hickory, sugar maple-beech-birch, aspen-birch, white-red-jack pine, and spruce-fir occur throughout the region, along with disturbance events and forest health issues common across state boundaries.

Data Sources

This report relies upon use of various scientific data that were mostly collected between 1993 and 2002 and obtained from all types of public and private ownerships. The FHM Program relies upon various partners to provide these data. Together, the FHM and Forest Health Protection (FHP) Programs provide aerial and ground data from surveys of damages caused by specific causal agents. The FHP Program also provides narratives of causal agent occurrences in Pest Condition Reports. The Forest Inventory and Analysis (FIA) Program provides data from remotely sensed sources (Phase 1) and from ground plots (Phase 2 and Phase 3) where a variety of forest health indicators are measured.

For this report, net growth rates and mortality rates were estimated from thousands of FIA plots (Phase 2) with an average measurement period of 1985 to 1995. Estimates of tree crown condition, tree damage, lichens, injury to ozone-sensitive plants, soil erosion, and coarse woody material were obtained from a subset of FIA plots (Phase 3). Details of sampling intensity and how plots were measured can be found on the FIA Internet site at http://www.fia.fs.fed.us/library.htm.
Ancillary data used in this report include drought information from the National Oceanic and Atmospheric Administration (NOAA), air pollutant data from the Environmental Protection Agency (EPA), wildland and prescribed fire data from the National Interagency Fire Center (NIFC), and human population data from the U.S. Census Bureau.

Forest Cover and Fragmentation

Forest Cover

About 41% of the total land area in the Northeast is forested, with northern New England and West Virginia having the highest percentages of forest cover (Figures 1a and 1b) (Smith and others 2001; U.S. Geological Survey 2003b). The amount of forest cover has remained steady for the past decade with minor decreases or increases within individual states.

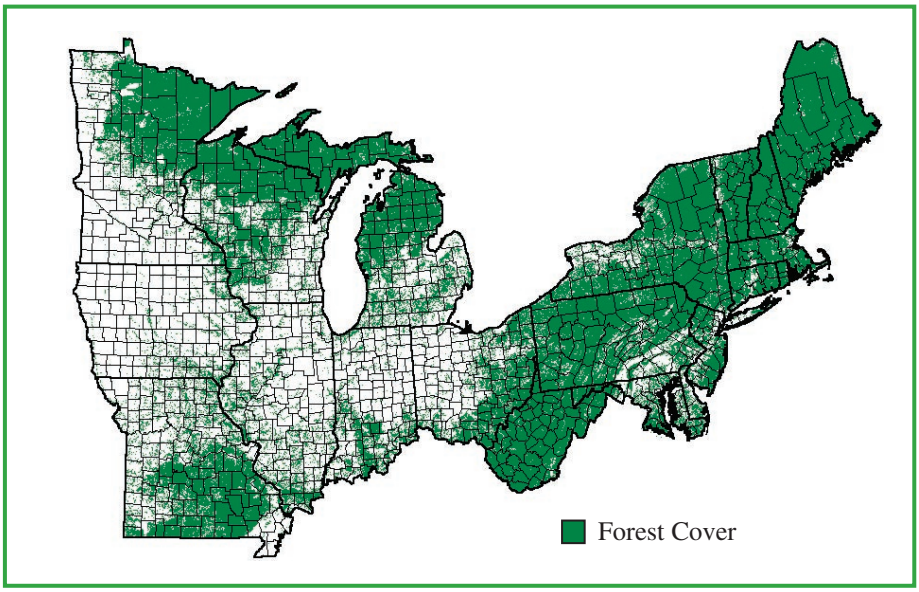


Figure 1a. Forest cover. (Source: U.S. Geological Survey 2003b).

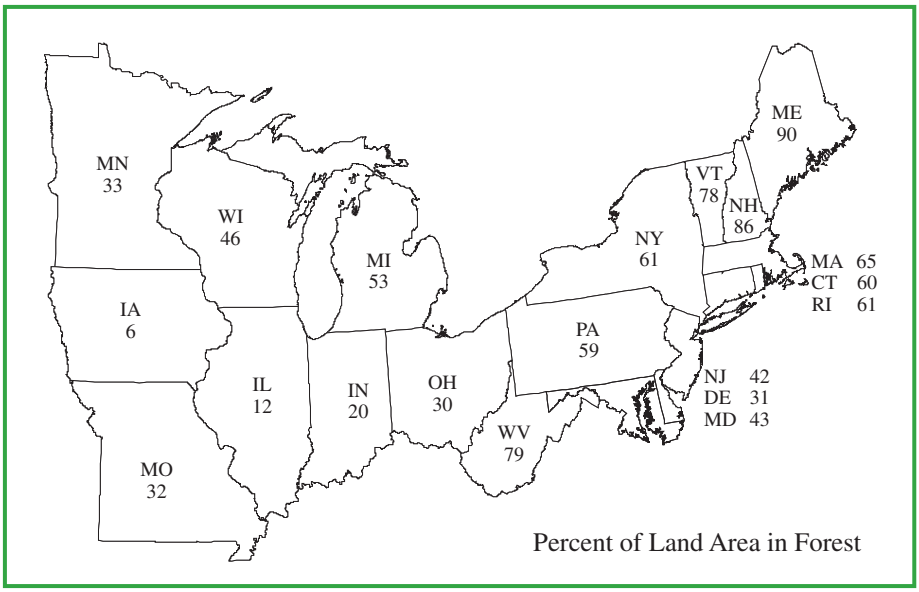


Figure 1b. Percent of land area in forest. (Source: Smith and others 2001).

Population Growth

The Northeast is the most densely populated region in the country, with many counties having more than 50 people per square mile (Figure 2) (U.S. Census Bureau 2003). The number of people in the region has increased 7% during the past decade, with greater-than-average increases occurring in Delaware (17%), Minnesota (12%), Maryland (11%), and New Hampshire (11%). States with the lowest population growth rates are West Virginia (1%), Pennsylvania (3%), Connecticut (4%), and Maine (4%).

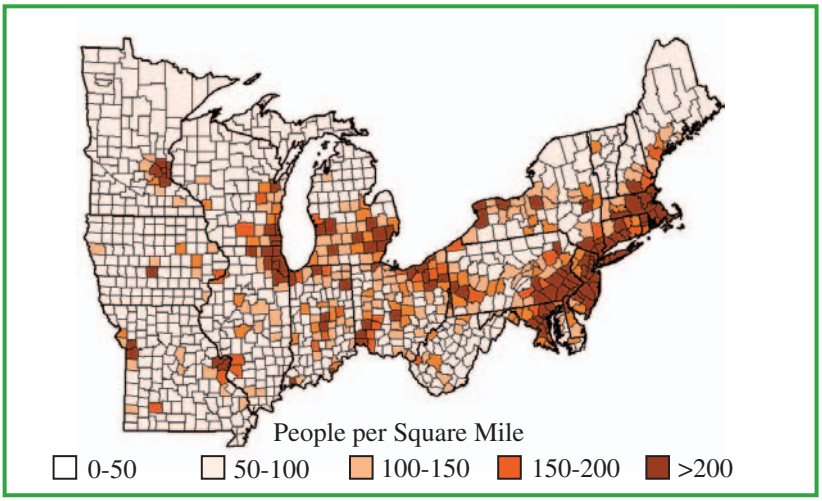


Figure 2. Distribution of people. (Source: U.S. Census Bureau 2003).

Forest Fragmentation

Continuing increases in population and urban sprawl contribute to the fragmentation of forested ecosystems into smaller parcels of wildlife habitat and protective cover for watersheds (Wade and others 2003). Highly fragmented forests are common in the Northeast and occur mostly near highly populated areas and in agricultural surroundings (Figure 3) (U.S. Geological Survey 2003a). As population growth continues, it is expected that forests near expanding urban areas will become more fragmented.

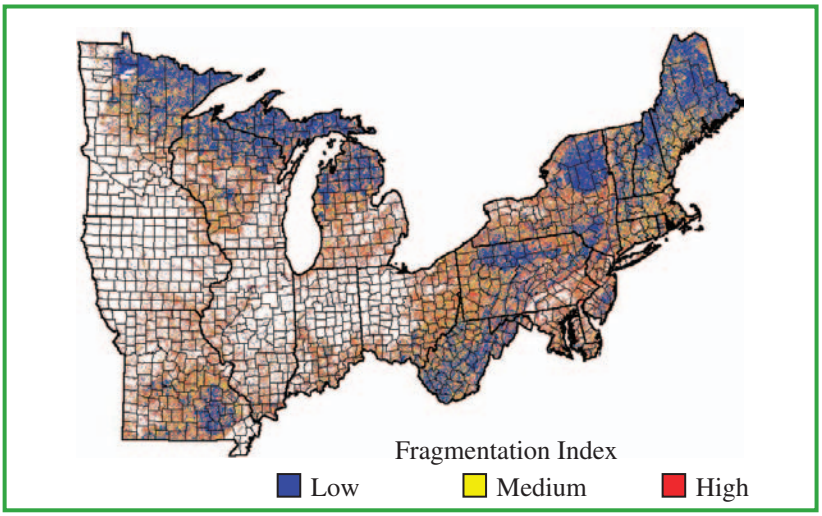


Figure 3. Forest fragmentation due to human causes. (Source: U.S. Geological Survey 2003a).

Drought

During recent years, most states within the Northeast have received less than the average amount of rainfall, which has led to droughts. This recent droughty period followed a wetter-than-average interval during the mid 1990s, however, and was not as severe as similar drought periods during the 1930s and 1960s (Figure 4) (National Oceanic and Atmospheric Administration 2003).

Trees are generally tolerant of dry soil conditions because of their large root systems. However, foresters in many states have reported premature loss of leaves from forest trees during the past few summers and subsequent tree mortality related to drought symptoms. These water deficits will also be directly related to less growth in tree diameter and height, and to mortality at some locations.

The coincidence of drought with insect and disease pests can cause additional stress to trees. Trees weakened from previous damage are likely to be less tolerant of drought than healthy trees. Likewise, the stress of drought can make trees more vulnerable to tree diseases that easily spread during subsequent growing seasons with normal to high amounts of rainfall. Recent examples within the region include drought associated with oak borers and subsequent oak decline on the Mark Twain National Forest in Missouri, gypsy moth defoliation and oak mortality in Pennsylvania, and southern pine beetles and mortality of loblolly and Virginia pines in some Mid-Atlantic States. Insects and diseases are discussed in more detail later in this report.

Trees in urban settings are typically subjected to wounding, soil compaction, and limited rooting space in addition to the insect and disease problems of forest trees. Many urban trees are not capable of surviving the additional stress of drought. In particular, trees along streets and confined in parking lot islands tend to suffer most. Dogwoods and red maples are particularly prone to multiple stresses when in urban environments.

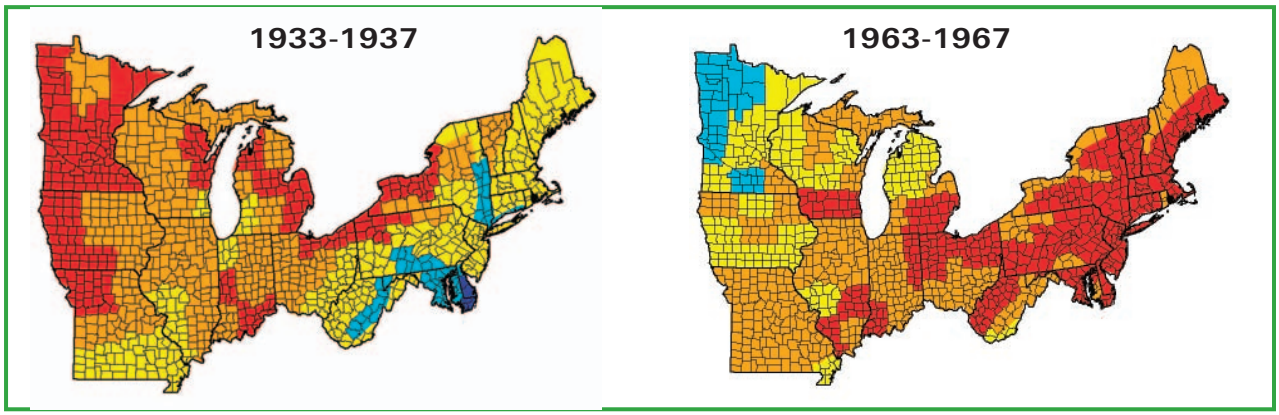
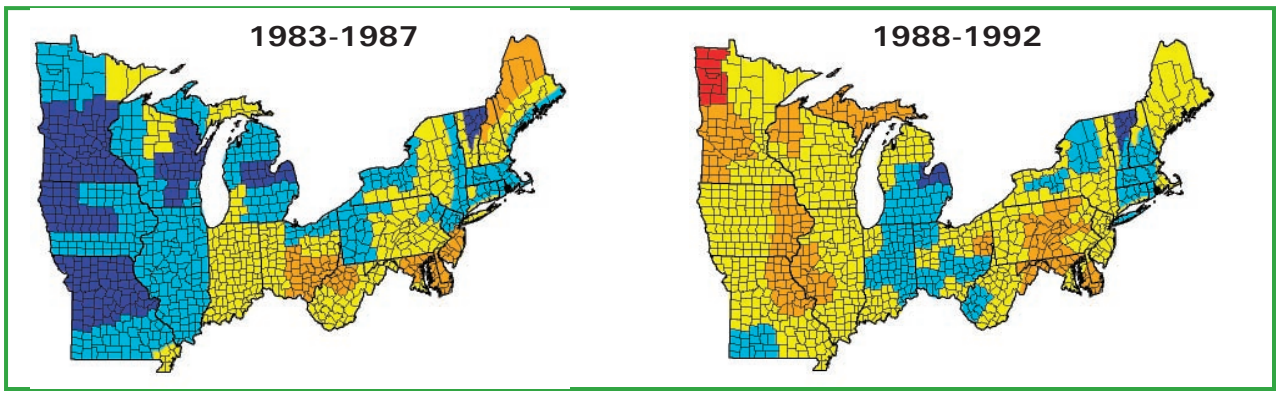


Figure 4a. Drought conditions during 1933-1937 and 1963-1967. (Source: National Oceanic and Atmospheric Administration 2003).

Palmer Drought Index

< -1.5 Moist | -1.5 to -0.5 | -0.5 to 0.5 Normal | 0.5 to 1.5 | > 1.5 Droughty



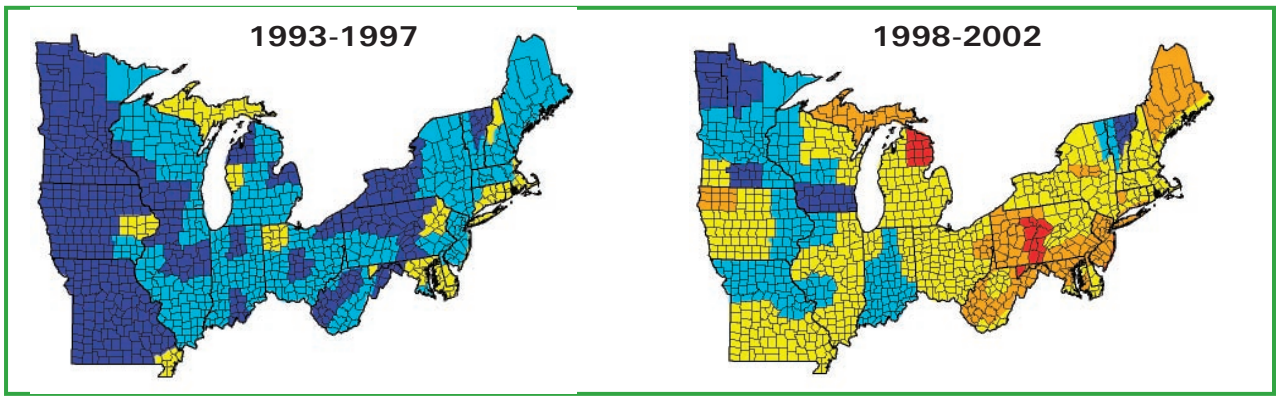


Figure 4b. Drought conditions during 1983-1987, 1988-1992, 1993-1997, and 1998-2002. (Source: National Oceanic and Atmospheric Administration 2003).

Wildland Fires

In addition to damaging and killing trees, wildland fires also threaten people and dwellings in close proximity to forests. The risk and incidence of damaging wildfires in most of the Northeast is low (Figure 5), but they still happen occasionally. In 2002, a wildfire in New Jersey burned over 1,300 acres of forested land, and in 2001, hundreds of small fires in West Virginia caused $25 million in damage to timber and property (USDA Forest Service 2003c). This incidence of many small fires is typical for the region where there have been over 60,000 fires during the past 5 years, with an average fire size of only 9 acres (National Interagency Fire Center 2003). In contrast, wildland fires in the western United States during the past 5 years averaged 60 acres, with some single fires burning many thousands of acres.

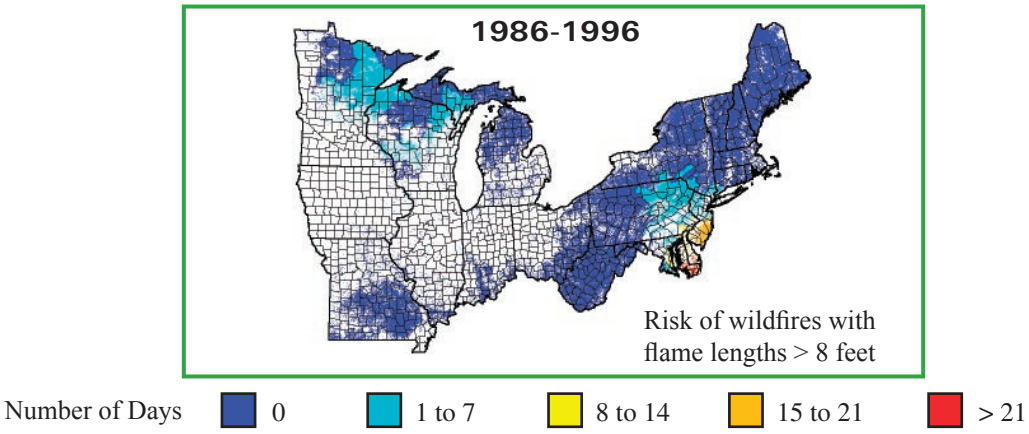


Figure 5. Risk of wildfires with flame lengths greater than 8 feet. (Source: USDA Forest Service 2003b).

The accumulation of leaves, twigs, and branches on the forest floor in conjunction with droughty conditions creates a fuel hazard that easily ignites. Quantifying the amount of down woody material on the forest floor can help predict the risk of fires to forest health. The FIA Program has begun measuring down woody material (USDA Forest Service 2003f), and Figure 6 shows preliminary information from unpublished data.

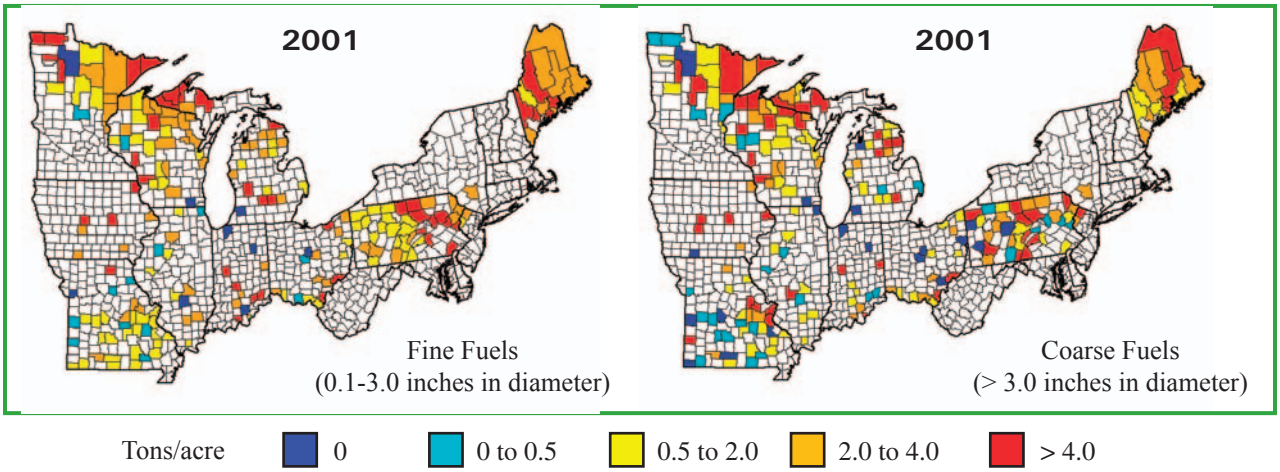
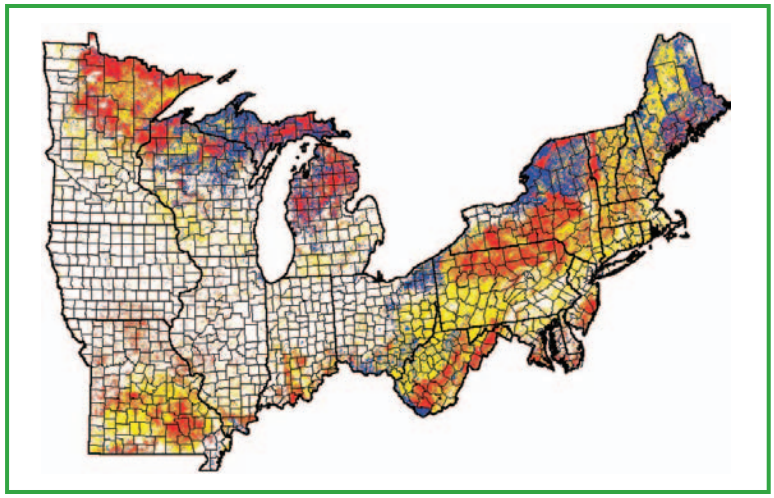


Figure 6. Conditions of (a) fine fuels and (b) coarse fuels that contribute to wildfire risk. (Source: USDA Forest Service. Forest Inventory and Analysis Program. Unpublished fuel load data obtained from C.W. Woodall, North Central Research Station, St. Paul, MN.)

Prescribed Fire

Ironically, the lack of fire in forest ecosystems in the Northeast is probably more detrimental to forest health than the destruction by wildfire. Forest characteristics, such as species composition, structural stage, and fuel loads, could have feasibly changed as a result of departures from historical fire regimes in the region (USDA Forest Service 2003b). In the Northeast, forest conditions in Pennsylvania, Minnesota, New York, and Wisconsin are estimated to have the greatest departures from historical fire regimes (Figure 7).

Some species of trees and other plants are dependent on fire to control competing vegetation. For example, regeneration of jack pine, pitch pine, aspen, and oak benefits from periodic fires and can decrease in abundance with its absence. Prescribed fire programs are implemented to favor these species for management objectives. In the past 5 years, over 2,500 prescribed fires with an average size of 160 acres have been implemented in the region (National Interagency Fire Center 2003).



Level of Departure: Low, Moderate, High

Figure 7. Departure of forest conditions from historical fire regimes. (Source: USDA Forest Service 2003b).

Insects and Diseases that Damage Trees

Between 1997 and 2002, 70 insects and 27 diseases were reported to cause tree damage or mortality on over 30 million acres of forestland in the Northeast (USDA Forest Service 2003c). Pests that caused damage in multiple States and years are listed in Tables 1-3, and their corresponding scientific names are listed in Appendixes A and B. Scientific names for their tree hosts are listed in Appendix C. Figures 8, 9, and 10 depict areas with damage associated with the most predominant insects and diseases in the region. Maps are grouped according to whether the pests are native to North America or introduced from other continents, because introduced pests pose a larger threat of causing unprecedented changes that may permanently disrupt ecological processes.

The most common type of observed damage was direct defoliation by larvae of forest tent caterpillar, gypsy moth, spruce budworm, eastern tent caterpillar, and many other insects that feed on tree leaves and needles. The second most common type of damage was indirect defoliation associated with wood boring insects and vascular diseases such as oak wilt, white pine blister rust, dogwood anthracnose, and beech bark disease. Other types of observed and reported tree damage from insects and diseases include branch dieback of crowns, cankers on stems and branches, and tree mortality. Although growth loss is not directly observed, defoliation, crown dieback, and other types of damage can lead to reduced increments in tree diameter and height. With the exception of white pine blister rust, damaging insects are generally more of a problem than diseases for softwood tree species. Declines of eastern white pine, balsam fir, and spruce are also evident in the region.

Specific insects and diseases generally affect only one to several tree species, are active within a limited area of several thousand acres, and endure for just a few years. Exceptions occur when some defoliators, such as gypsy moth and spruce budworm, attain high populations and cause epidemics over widespread areas. Exceptions also exist for many diseases, such as dogwood anthracnose, that tend to persist in areas once they have become established. As discussed earlier, drought can result in additional stress and premature tree mortality. Trees can normally tolerate up to 3 years of defoliation, but may die when just 1 year of defoliation is combined with the additional stress of drought.

It is difficult to quantify the loss of growth and the mortality of trees associated with insects and diseases. Impact assessments require data sets that can precisely demonstrate spatial correlations between the incidence of pests and tree conditions. In addition, tree conditions need to be represented by data collected after the occurrence of a damaging pest event because of the lag in associated tree growth loss and mortality. Most of the available FHP pest survey data for the Northeast are for 1997-2002, while most FIA data represent tree conditions before this time period. However, additional data are available for gypsy moth and spruce budworm for 1975-1997, and thus facilitate analyses to demonstrate associations between these pests and the condition of their respective host tree species. Additional analyses for these and other pests will become feasible as FIA data representing conditions beyond 2002 become available.

Table 1. Insects that damage hardwood trees.

NATIVE INSECTS	American beech	Ash species	Aspen species	Basswood species	Birch species	Black cherry	Oak species	Red maple	Sugar maple
Cherry scallop shell moth	X					X			
Common oak moth							X		
Eastern tent caterpillar	X				X	X			X
Fall cankerworm							X	X	
Fall webworm	X	X			X	X	X	X	X
Forest tent caterpillar			X	X			X		
Jumping oak gall							X		
Large aspen tortrix			X						
Maple leafcutter									X
Maple trumpet skeletonizer									X
Oak leaftier							X		
Oak skeletonizer							X		
Orange-striped oakworm							X		
Peach bark beetle						X			
Perodical cicada						X	X		
Scarlet oak sawfly							X		
Variable oakleaf caterpillar	X						X		
Walkingstick	X								X
INTRODUCED INSECTS									
Asian longhorned beetle		X			X			X	X
Basswood thrips				X					
Birch leafminer					X				
Emerald ash borer		X							
Gypsy moth			X	X			X		
Oystershell scale	X								
Pear thrips								X	X
Satin moth			X						

Table 2. Insects that damage softwood trees.

NATIVE INSECTS	Balsam fir	Eastern hemlock	Eastern white pine	Jack pine	Spruce species	Southern yellow pines
Eastern spruce budworm	X				X	
Hemlock looper	X	X			X	
Jack pine budworm				X		
Southern pine beetle						X
Spruce beetle					X	
White pine weevil			X			
INTRODUCED INSECTS						
Balsam woolly adelgid	X					
Common pine shoot beetle			X			
Hemlock woolly adelgid		X				
Pine false webworm			X			

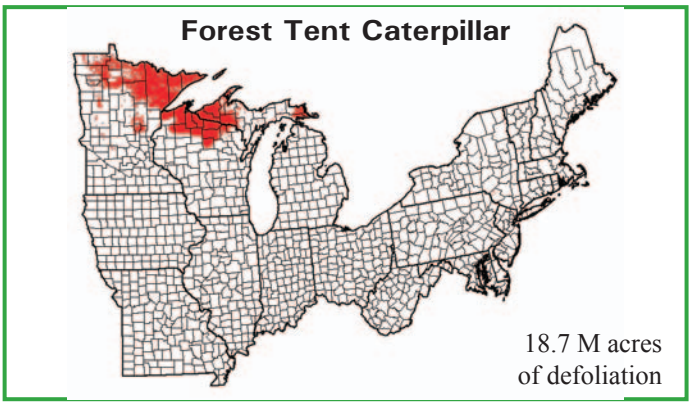
Table 3. Diseases that damage trees.

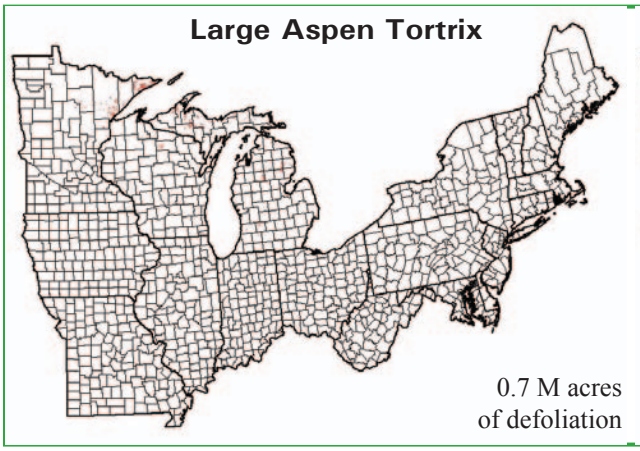
HARDWOOD TREES

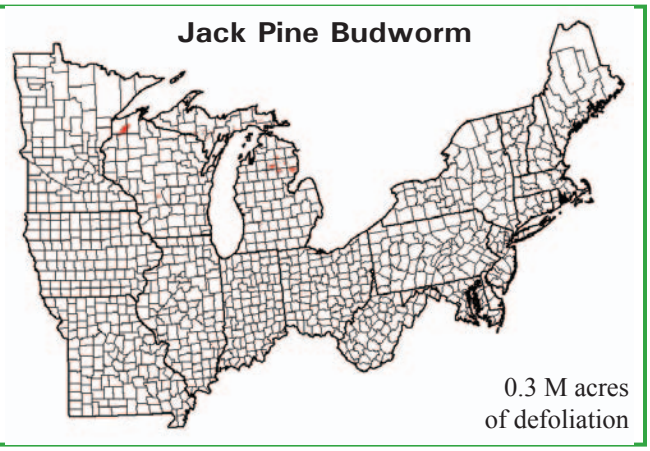
INTRODUCED DISEASES	American beech	Ash species	Butternut	Flowering dogwood	Oak species	Sugar maple
Ash yellows		X				
Bacterial leaf scorch					X	X
Beech bark disease	X					
Butternut canker			X			
Dogwood anthracnose				X		
Oak wilt					X	

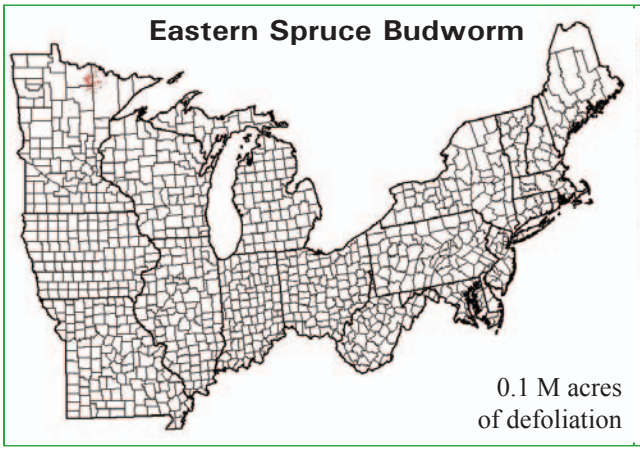
SOFTWOOD TREES

INTRODUCED DISEASES	Balsam fir	Eastern hemlock	Eastern white pine	Jack pine	Spruce species	Southern yellow pines
White pine blister rust			X			









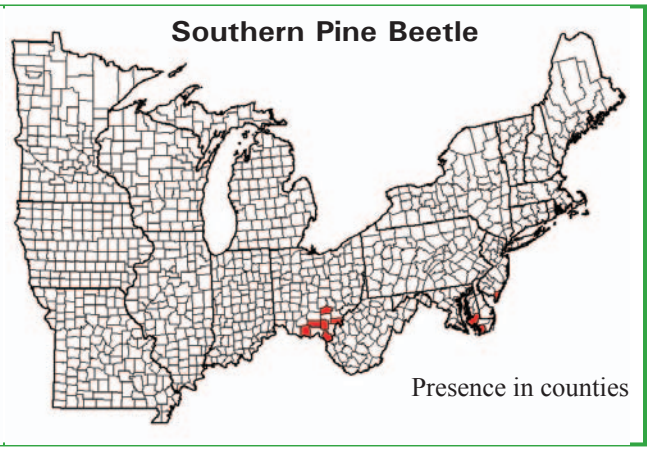
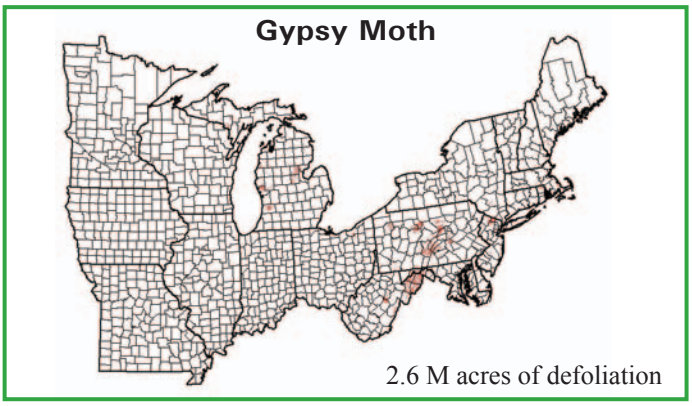
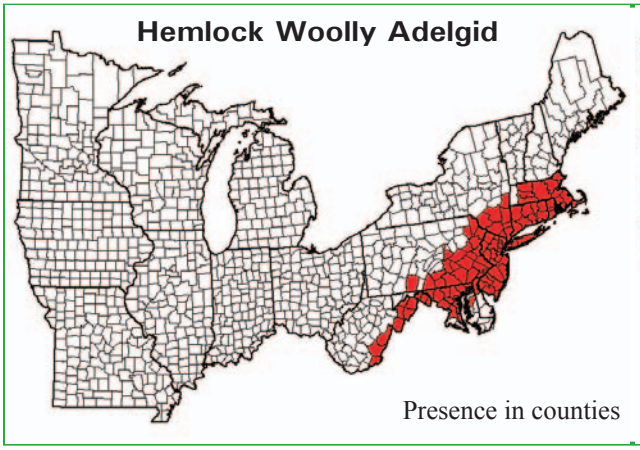
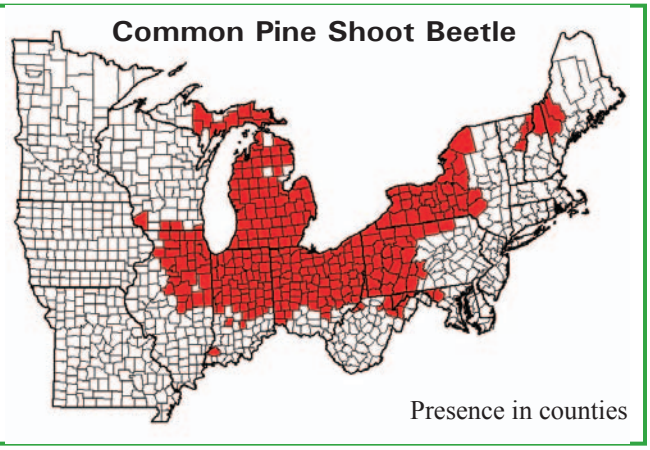
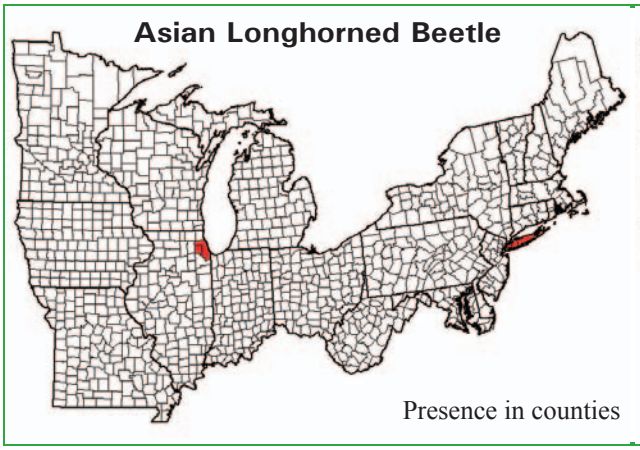


Figure 8. Forest areas with trees damaged during 1997-2002 by native insects of forest tent caterpillar (*Malacosoma disstria*), large aspen tortrix (*Choristoneura conflictana*), jack pine budworm (*Choristoneura pinus*), spruce budworm (*Choristoneura fumiferana*), and southern pine beetle (*Dendroctonus frontalis*). (Source: USDA Forest Service. Unpublished data, Forest Health Protection Program).









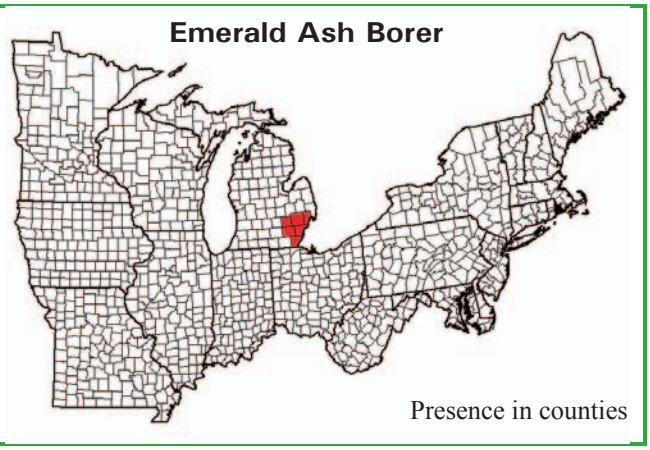
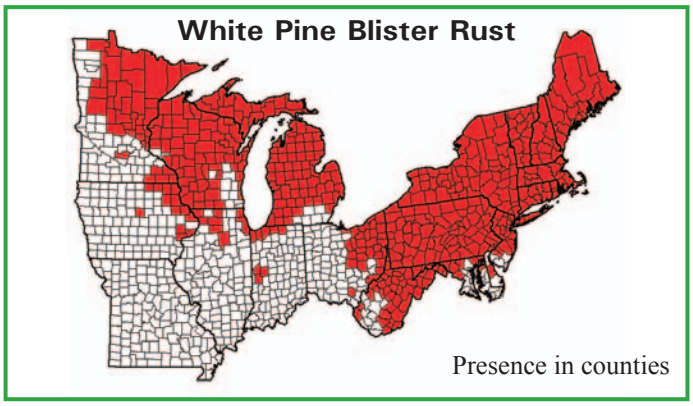


Figure 9. Forest areas with trees damaged during 1997-2002 by introduced insects of gypsy moth (*Lymantria dispar*), hemlock woolly adelgid (*Adelges tsugae*), common pine shoot beetle (*Tomicus piniperda*), Asian longhorned beetle (*Anoplophora glabripennis*), and emerald ash borer (*Agrilus planipennis*). (Source: USDA Forest Service. Unpublished data, Forest Health Protection Program).



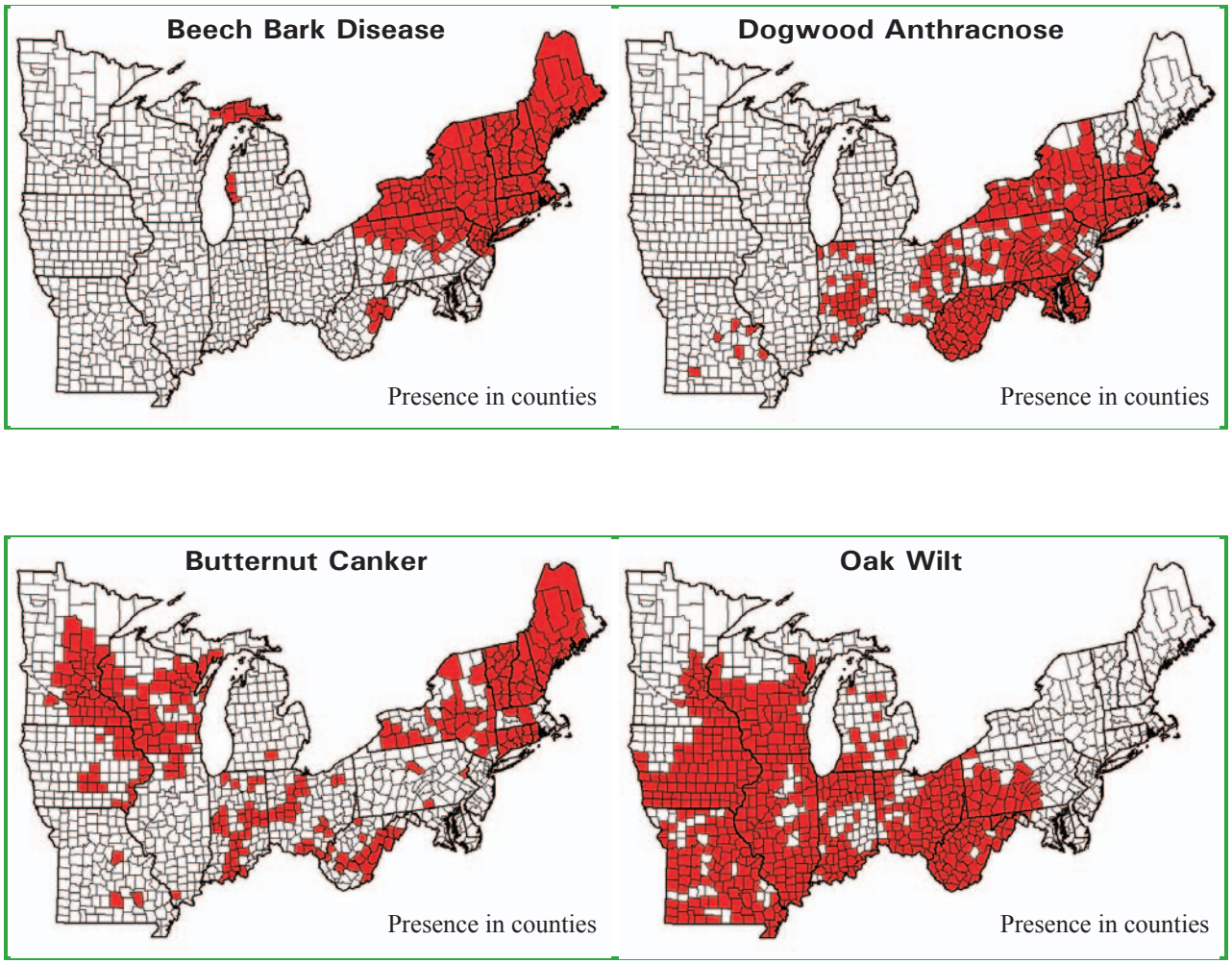
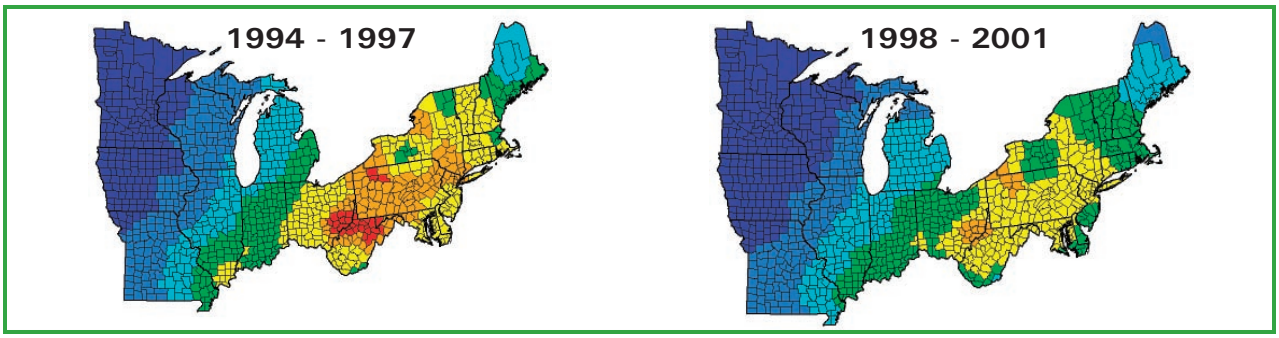


Figure 10. Forest areas with trees damaged during 1997-2002 by introduced diseases of white pine blister rust (*Cronartium ribicola*), beech bark disease (*Nectria* spp.), dogwood anthracnose (*Discula destructiva*), butternut canker (*Sirococcus clavigignenti-juglandacearum*), and oak wilt (*Ceratocystis fagacearum*). (Source: USDA Forest Service. Unpublished data, Forest Health Protection Program).

Acidic Deposition

Acidic deposition is a consequence of atmospheric emissions of nitrogen and sulfur compounds from some power generation plants, industries, and automobiles. Recognition of related problems has led to mandates to reduce emissions, and to a resulting decrease in acidic deposition in the Northeast from 1994 to 2001 (Figure 11).



Hydrogen Ion Inputs (kg/ha)

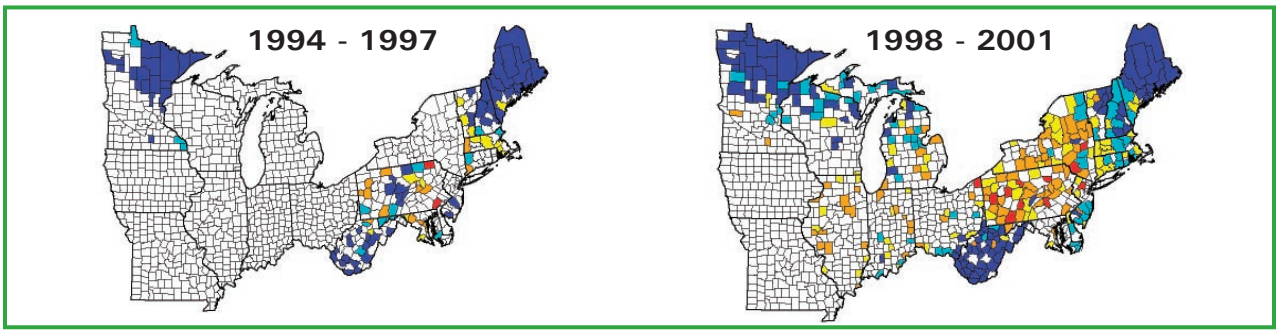
0 to 0.1 | 0.1 to 0.2 | 0.2 to 0.3 | 0.3 to 0.4 | 0.4 to 0.5 | 0.5 to 0.6 | > 0.6

Least Acid — Most Acid

Figure 11. Acidic deposition during 1994-1997 and 1998-2001. (Source: National Atmospheric Deposition Program 2003).

Although pollutant emissions and acidic deposition have decreased, forest ecosystems are still monitored for residual and long-term effects. Accumulation of pollutants in forest ecosystems can increase soil acidity, interfere with uptake of nutrients by plants, predispose their roots to pathogens, and result in growth loss or premature mortality. Such relationships are difficult to demonstrate, however, because of three factors: (1) the presence of other disturbances that contribute to tree growth loss and mortality, (2) the lack of historical data prior to the onset of air pollution, and (3) an inability to conduct controlled experiments in forests.

Difficulties with demonstrating the effects of air pollution on forests have led to using forest lichens as surrogate indicators of pollutants (USDA Forest Service 2003f). Lichens readily uptake nitrogen and sulfur compounds and die as a result of absorbed toxic amounts. Data from FIA plots as shown in Figure 12 show a low number of lichen species in Pennsylvania and New York as a possible response to air pollutants in these States.



Species Richness: 0 to 0.1 | 0.1 to 0.2 | 0.2 to 0.3 | 0.3 to 0.4 | 0.4 to 0.5

Low — High

Figure 12. Species richness of lichens as an inverse indicator of air pollutants. (Source: USDA Forest Service 2003e).

Ground-Level Ozone

Ozone naturally occurs in the upper atmosphere as a protective layer that inhibits harmful levels of incoming ultraviolet radiation. Ozone is also an air pollutant that forms near the ground as a byproduct of emissions from power plants, industrial facilities, and automobiles. Direct uptake of ozone by plants through openings in their leaves (stomata) can interfere with the assimilation of carbon dioxide for photosynthesis. A decrease in photosynthetic abilities can in turn result in foliar injury, reductions in plant growth, and predisposing stress to other pathogenic problems.

Ambient ozone near ground level is continually monitored by the U.S. Environmental Protection Agency (EPA) and serves as an indicator of the amount of ozone exposure to the forest. For a given year, the cumulative amount of ozone from June 1 to August 31 at 8 am to 8 pm can be used to express exposure to plants during the growing season (USDA Forest Service 2003g). As shown in Figure 13a, the average of values during 1998-2001 shows that ground-level ozone is commonly greater in much of the lower portion of the Northeast.

Effects of ground-level ozone on forest plants in the Northeast are not yet fully understood; however, several forest plant species are known to be sensitive to ground-level ozone and are monitored on FIA plots to detect foliar injury from ozone (USDA Forest Service 2003f). Ozone-sensitive species that are common throughout the Northeast are black cherry (*Prunus serotinus*), milkweed (*Asclepias* spp.), and blackberry (*Rubus allegheniensis*). The incidence of foliar injury on these indicator species, as summarized from FIA data (USDA Forest Service 2003e) in Figure 13b, shows that amounts of foliar injury in southern parts of the Northeast are greater than those in northern parts of the region. The correspondence between locations of foliar injury and incidence of high amounts of ambient ozone suggests there may be other types of damage to the forest.

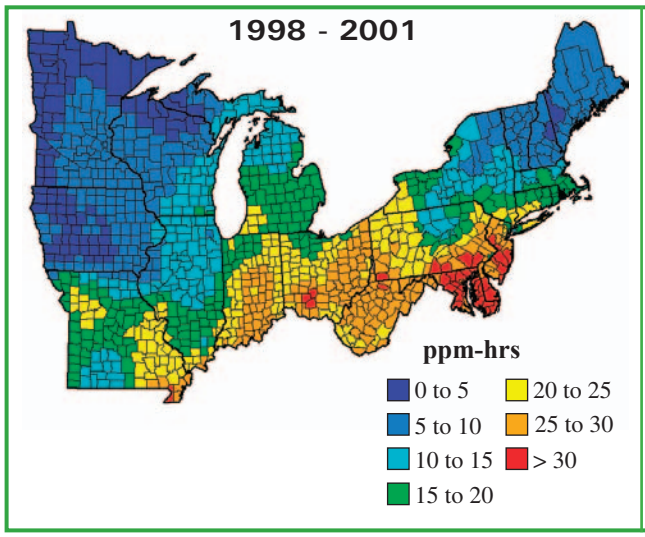


Figure 13a. Ambient ground-level ozone during 1998-2001. (Source: USDA Forest Service 2003g).

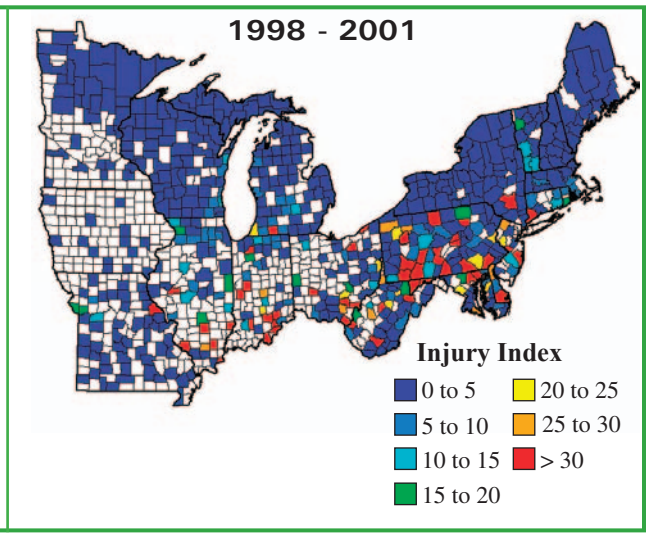


Figure 13b. Ozone injury to indicator plants of black cherry (*Prunus serotinus*), milkweed (*Asclepias* spp.), and blackberry (*Rubus allegheniensis*) during 1998-2001. (Source: USDA Forest Service 2003e).

Soil Erosion

Soil in forest ecosystems provides mechanical support to plant roots, supplies roots with water, nutrients and air, and helps store carbon. The soil environment also serves as habitat for many species of fauna. The physical and chemical characteristics of the soil at a given forest location are key factors in overall site quality and influence the composition of the residing plant communities and their productivity.

Soil types and properties vary greatly across the Northeast and reflect differences in parent geology and cumulative influences of climate and vegetation histories. Soils also vary within small distances due to local differences in topography and drainage. For example, soils positioned on ridge tops tend to be less deep, less fertile, and more rapidly drained than soils down slope with the same parent geology and local climate history. Local variations in soil properties are also related to historical differences in land use. Much of the land in the region that has forest cover was once cleared, burned, and plowed for agricultural purposes.

Several forest soil properties are measured on FIA plots to determine if changes are occurring as related to management practices and environmental influences (USDA Forest Service 2003f). Forthcoming data will help determine potential problems with soil erosion, compaction, nutrient levels, carbon reservoirs, acidity, and toxic heavy metals. For this report, available FIA plot measurements of forest age, topographic slope, and percentage of bare soil (USDA Forest Service 2003e) were used to estimate soil erosion using the Watershed Erosion Prediction Project (WEPP) Model (Hall and Elliott 2001). Estimates for sampled locations in the Northeast show that most locations have rates of erosion less than 0.1 ton per acre per year (Figure 14). These results are not surprising considering that the vast majority of sampled forest stands were more than 5 years old with little bare soil (i.e., factors that greatly determine low estimates of soil erosion in the WEPP Model).

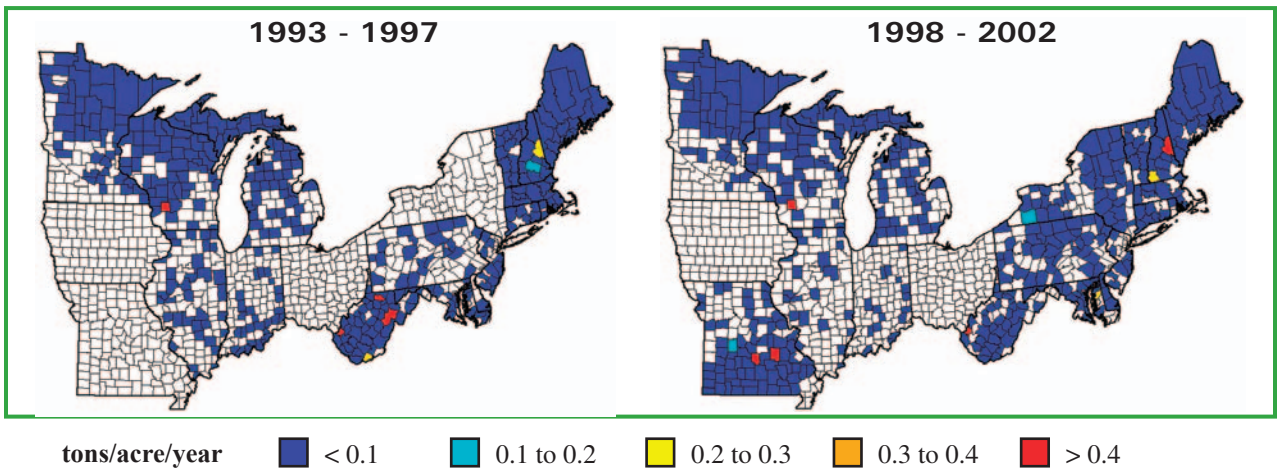


Figure 14. Soil erosion rates during 1993-1997 and 1998-2002. (Source: USDA Forest Service 2003e).

Tree Health

The status and trends of the health of forest trees is of primary interest when assessing forest conditions. Tree health is affected by a wide variety of acute and chronic disturbances described in this report. Other types of disturbances include competition from invasive plants and storm events. In this section, overall tree health in the Northeast is described in terms of growth rate, mortality rate, crown condition, and incidence of damage. These same parameters are used to describe the health of individual tree species and species groups.

Health of All Combined Tree Species

Net growth and mortality are key indicators of tree health that help determine if rates in certain geographic areas differ from regional averages (USDA Forest Service 2003f). An examination of FIA data (USDA Forest Service 2003d) for all tree species in the Northeast during 1985-1995 indicates problems with tree growth and mortality rates at only some localities (Figure 15). Net tree growth rates are good—commonly more than 2% a year across the region. Growth rates are lower, however, in such places as northern Maine, the southern tier of Pennsylvania, and central Minnesota. High mortality rates are indicative of locations with problems. Numerous counties in Maine, Pennsylvania, Illinois, Indiana, Minnesota, and Wisconsin have mortality rates greater than 1% a year, suggesting some kind of influence from disturbances that probably affect more than one tree species.

The condition of tree crowns and incidence of different types of tree damage help explain reduced growth rates and tree mortality. For this report, unhealthy crowns are defined as trees having at least 25% dieback, at least 30% foliage transparency, or less than 35% crown density. The most frequent types of damage selected for display were tree decay; breakage of tree roots, stems, and branches; and mechanical wounds.

As shown in Figure 15, tree crowns within New York and New England appear less healthy than in other parts of the Northeast. Decay is the most frequent type of observed tree damage, with more than 15% of the living trees having decay in many States. Breakage of tree stems, roots, and branches is more localized, with States in the northern tier of the region having a greater-than-average incidence of this type of damage. Mechanical wounding is generally low in comparison. These detrimental conditions feasibly can be associated with one or more disturbances described in previous sections.

Health of All Combined Tree Species

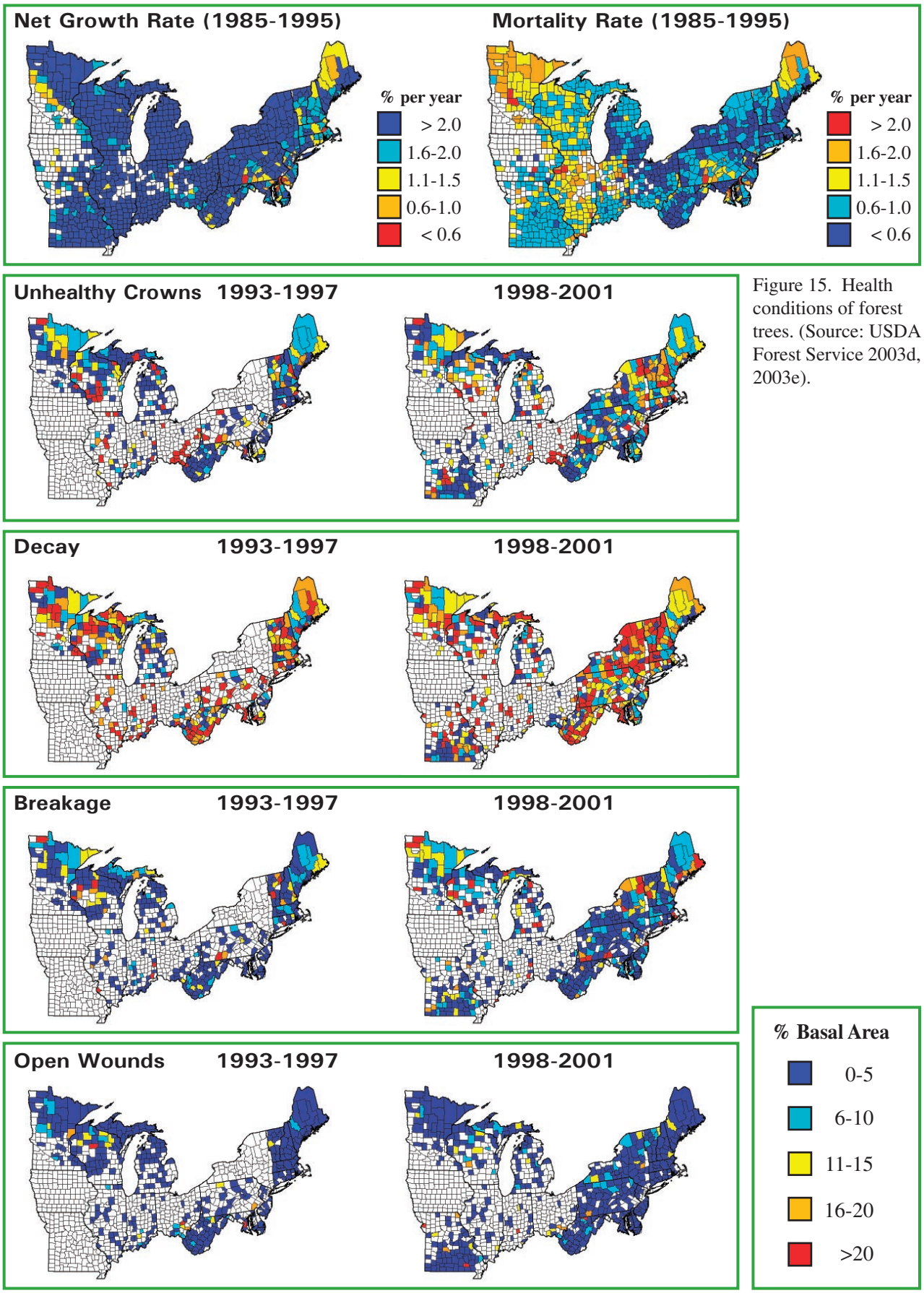


Figure 15. Health conditions of forest trees. (Source: USDA Forest Service 2003d, 2003e).

Health of Individual Tree Species

Comparisons among tree species in the Northeast can show whether some are prone to more problems than others. Net growth and mortality rates, and crown condition and tree damage for different tree species and species groups are shown in Figures 16-36, to help determine which ones contribute to the forest-wide health status.

The maps of growth and mortality rates generally show that each species is healthy in most of the region, with the exception of fir species (Figure 30). Past epidemics of defoliation by eastern spruce budworm is associated with low growth rates and high mortality rates of fir in New England and the Lake States.

Condition of tree crowns and damage of different tree species help determine which ones contribute to the forest-wide conditions. These maps of crown condition and tree damage generally show that each species is healthy in most of the region. The relatively high incidence of decay among most hardwood species corresponds to forest-wide estimates, and is most likely associated with the mature age of forest stands throughout much of the region.

American Beech

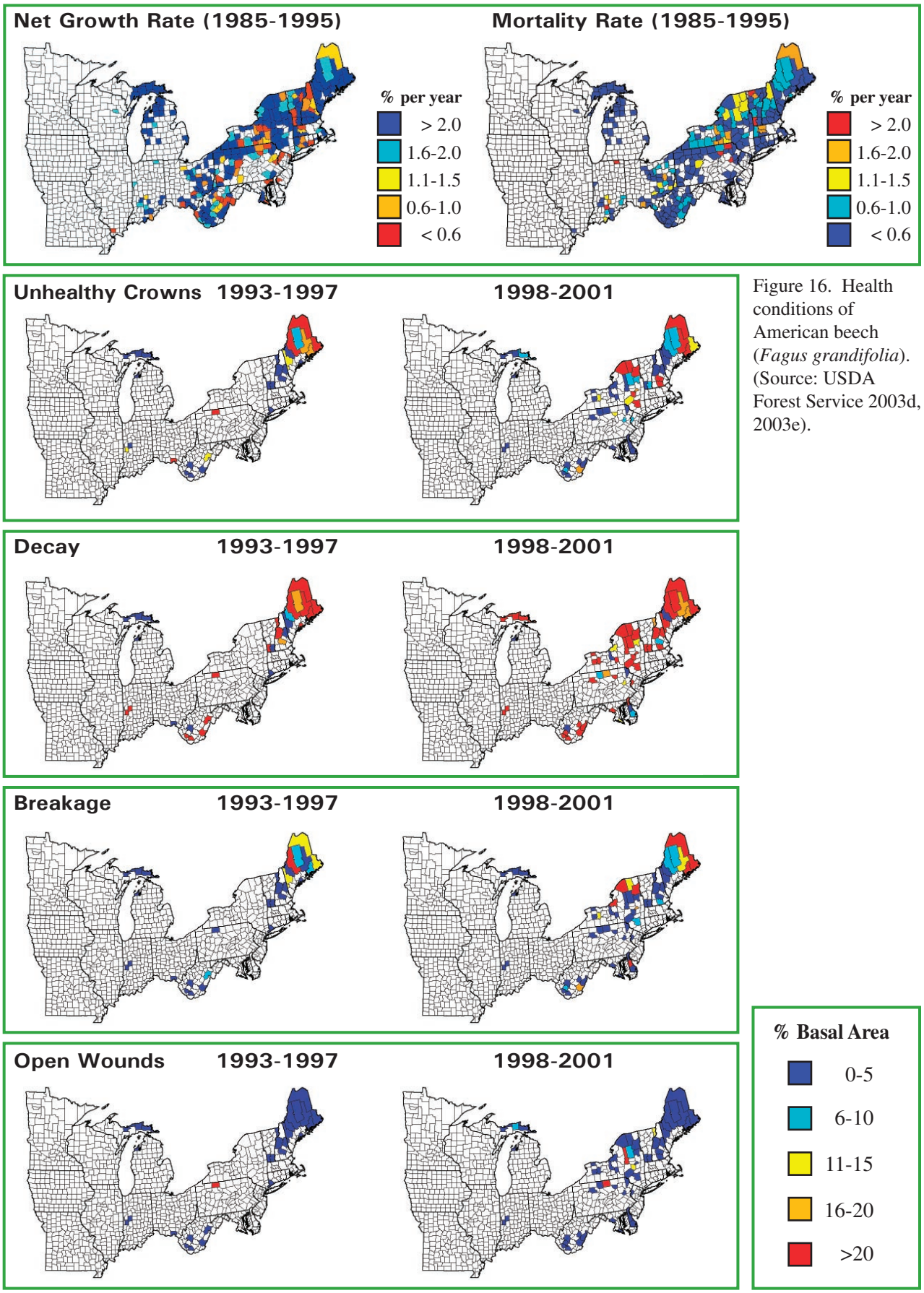


Figure 16. Health conditions of American beech (*Fagus grandifolia*). (Source: USDA Forest Service 2003d, 2003e).

Ash Species

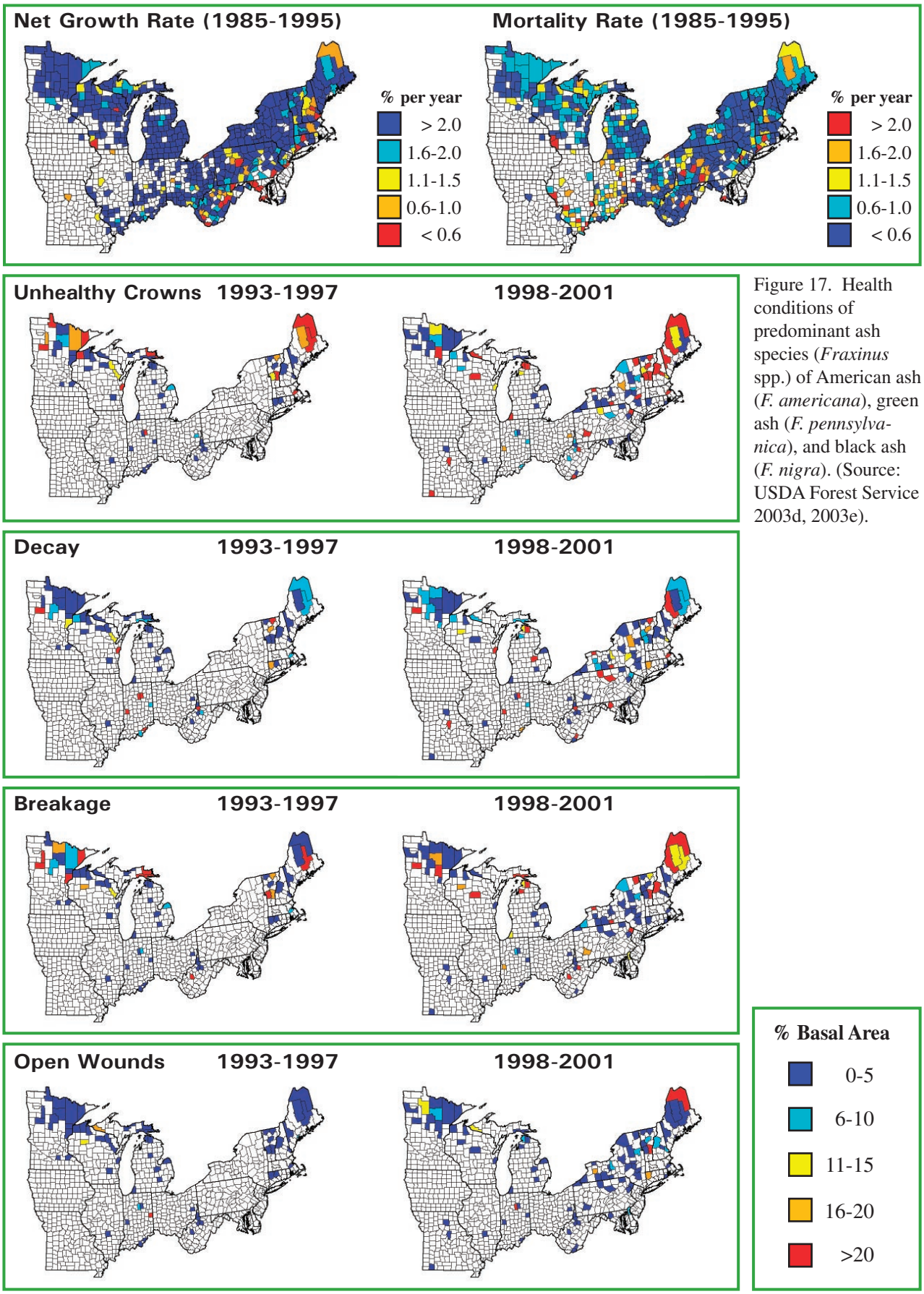


Figure 17. Health conditions of predominant ash species (*Fraxinus* spp.) of American ash (*F. americana*), green ash (*F. pennsylvanica*), and black ash (*F. nigra*). (Source: USDA Forest Service 2003d, 2003e).

Aspen Species

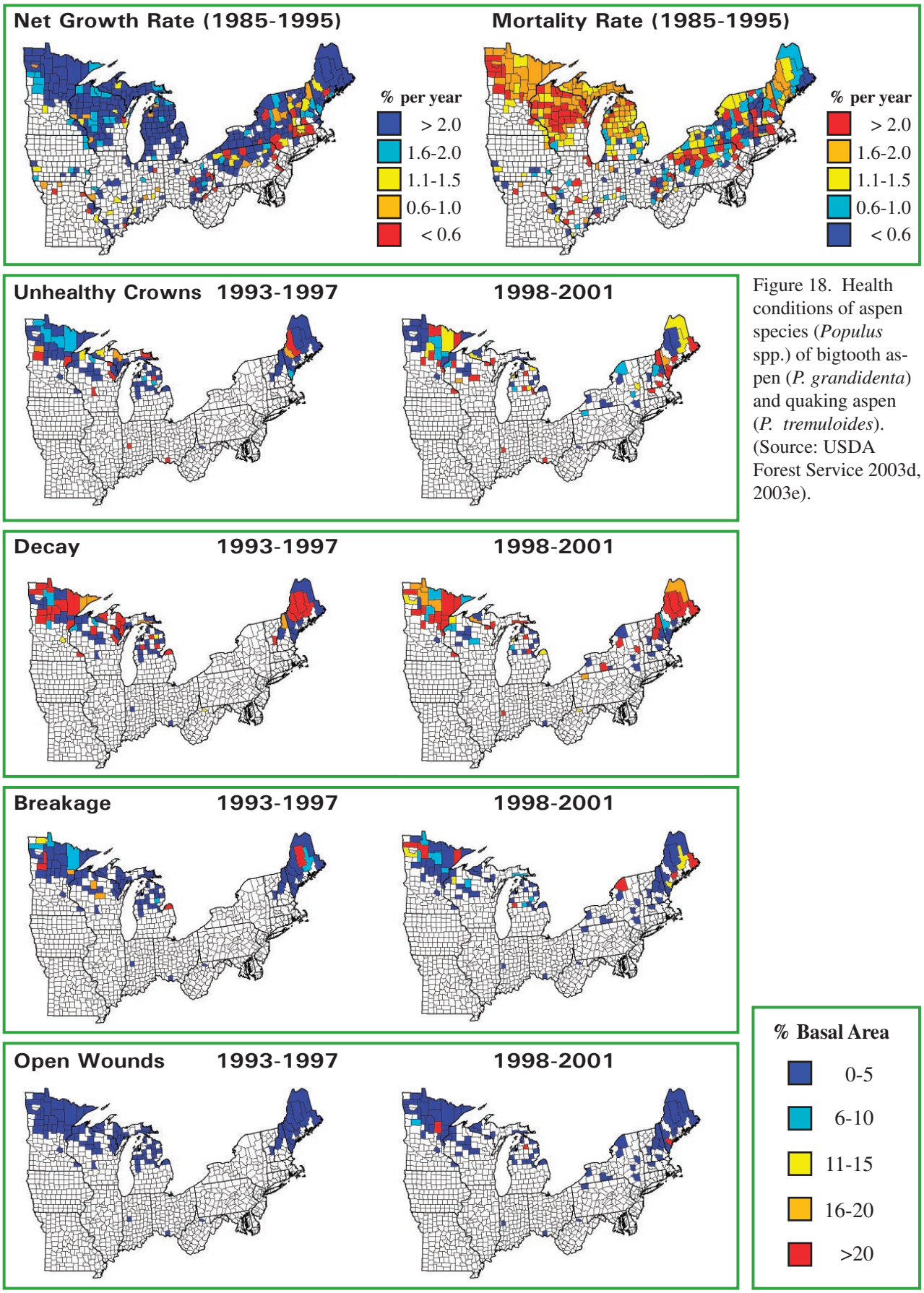


Figure 18. Health conditions of aspen species (*Populus* spp.) of bigtooth aspen (*P. grandidenta*) and quaking aspen (*P. tremuloides*). (Source: USDA Forest Service 2003d, 2003e).

Basswood Species

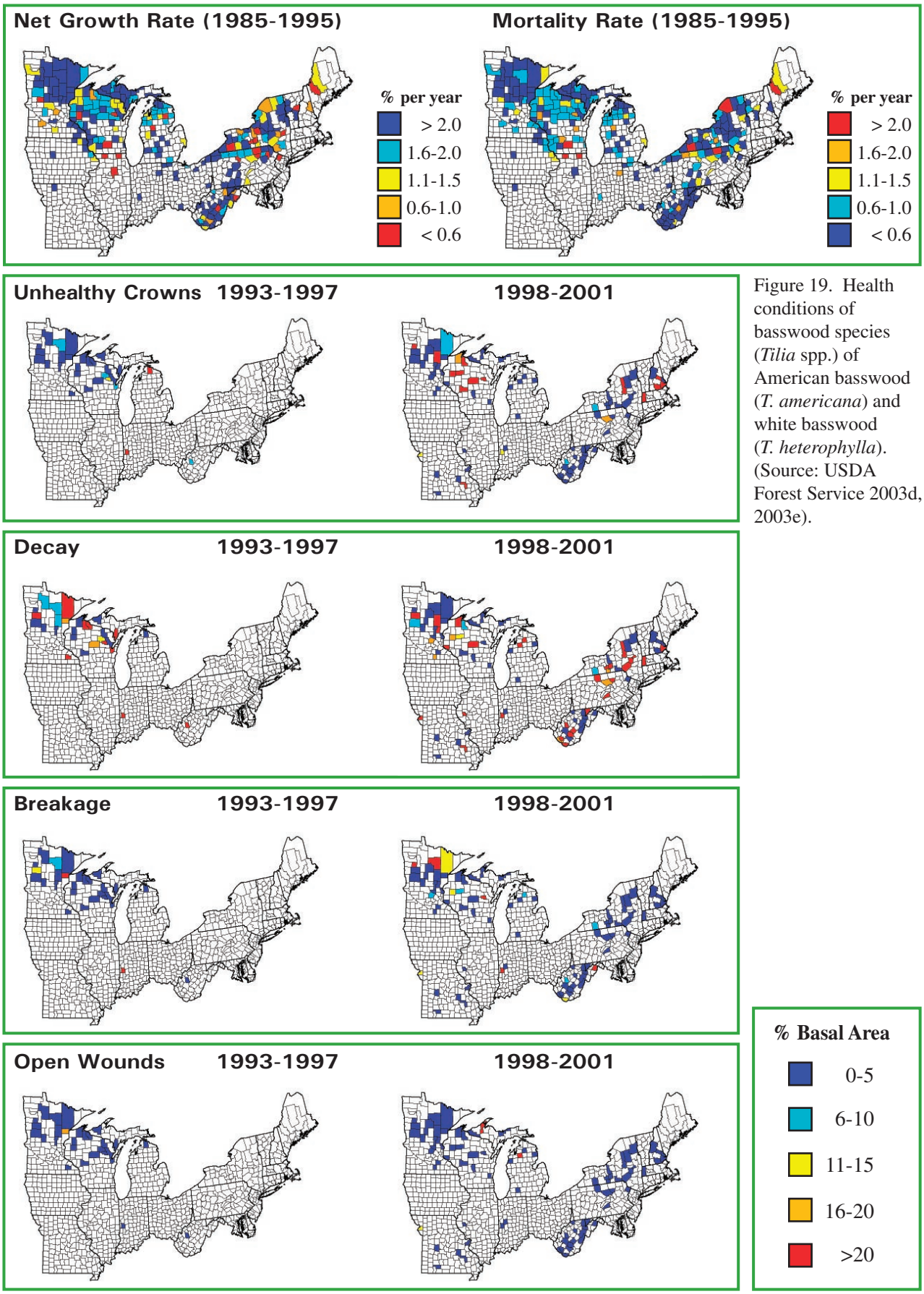


Figure 19. Health conditions of basswood species (*Tilia* spp.) of American basswood (*T. americana*) and white basswood (*T. heterophylla*). (Source: USDA Forest Service 2003d, 2003e).

Birch Species

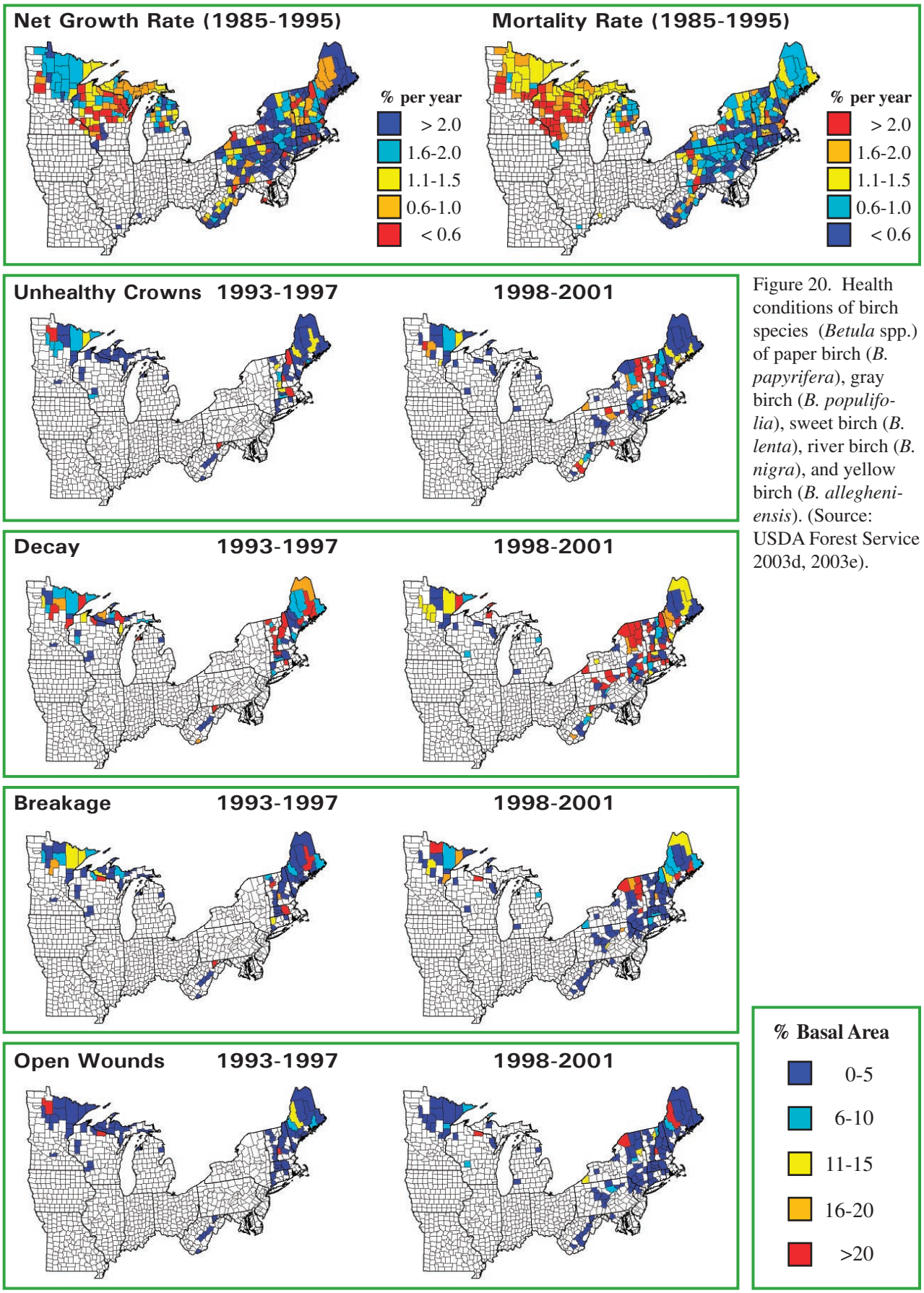


Figure 20. Health conditions of birch species (*Betula* spp.) of paper birch (*B. papyrifera*), gray birch (*B. populifolia*), sweet birch (*B. lenta*), river birch (*B. nigra*), and yellow birch (*B. alleghenieensis*). (Source: USDA Forest Service 2003d, 2003e).

Black Cherry

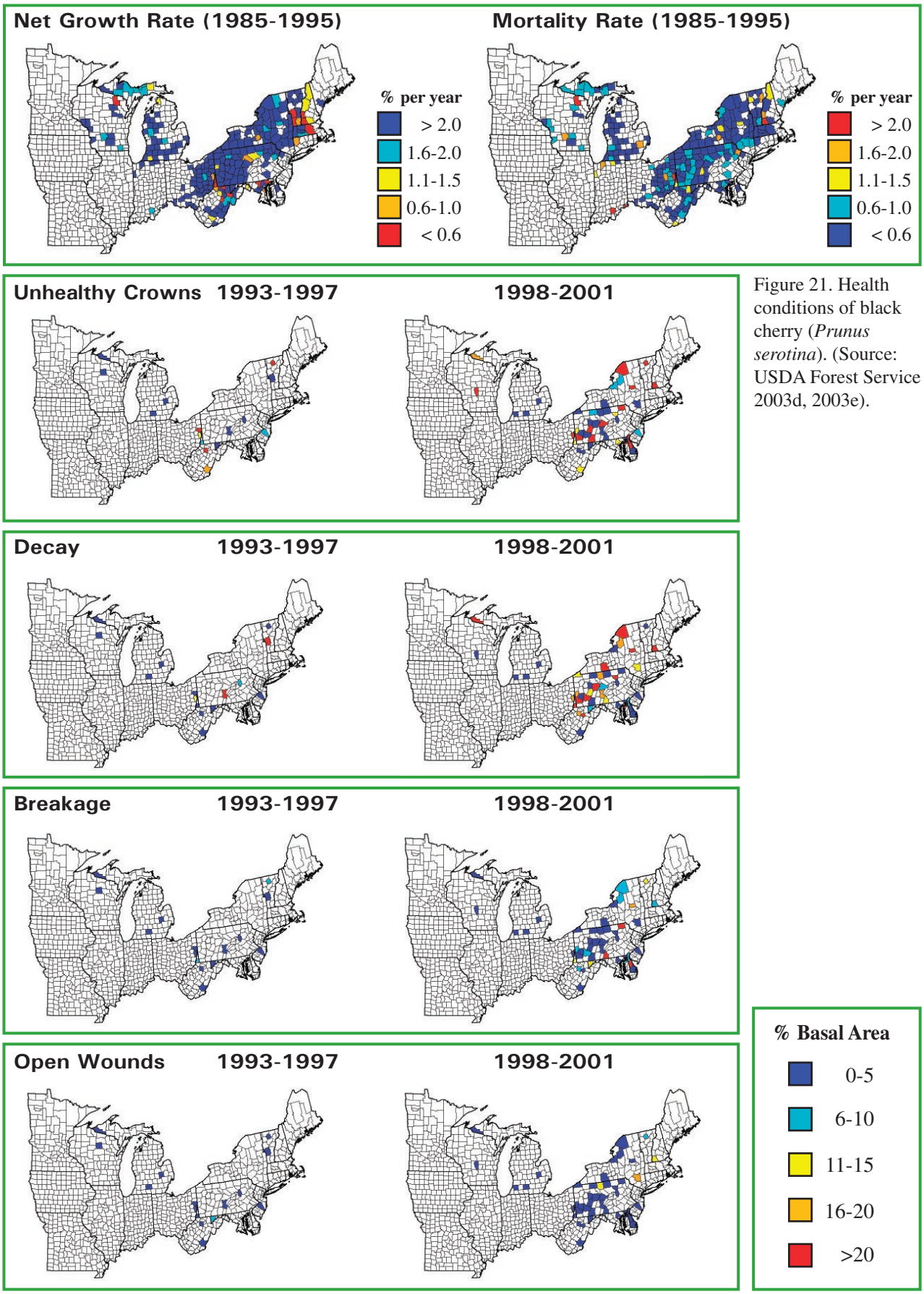


Figure 21. Health conditions of black cherry (*Prunus serotina*). (Source: USDA Forest Service 2003d, 2003e).

Butternut

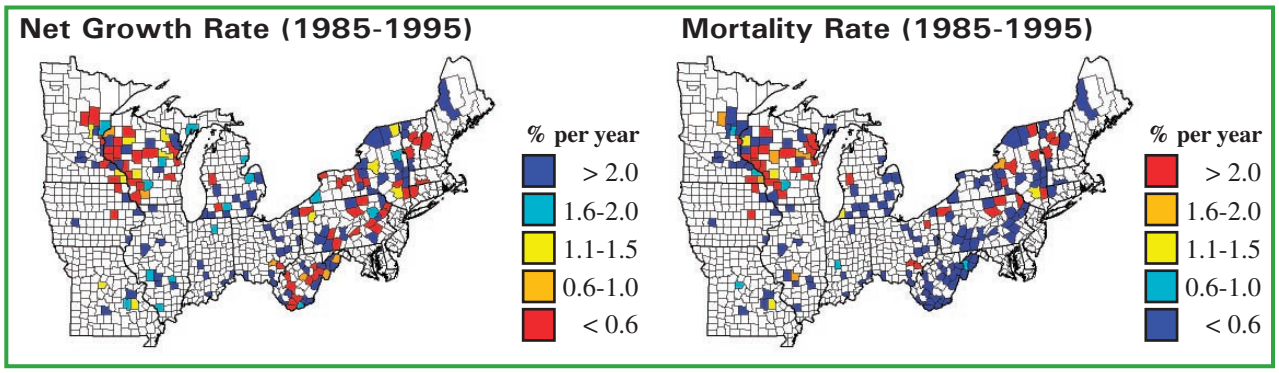


Figure 22. Health conditions of butternut (*Juglans cinerea*). (Source: USDA Forest Service 2003d, 2003e).

Flowering Dogwood

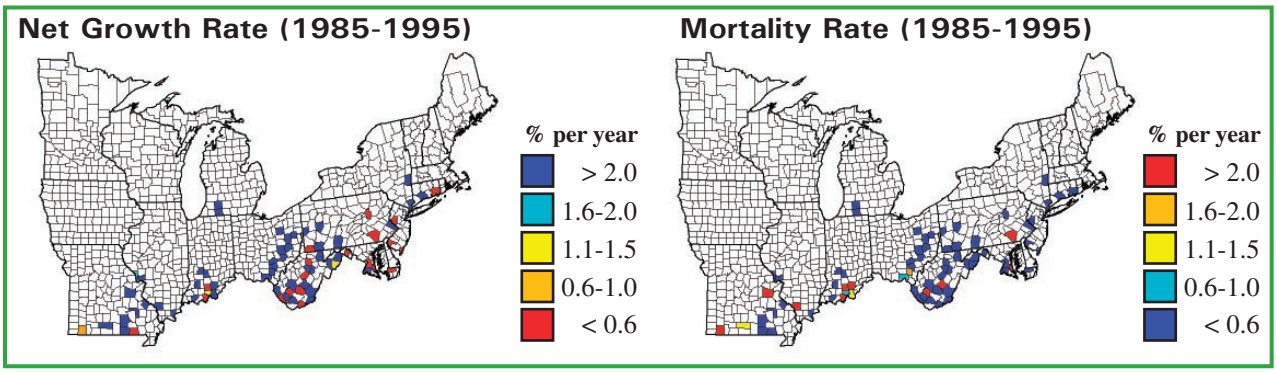


Figure 23. Health conditions of flowering dogwood (*Cornus florida*). (Source: USDA Forest Service 2003d, 2003e).

Hickory Species

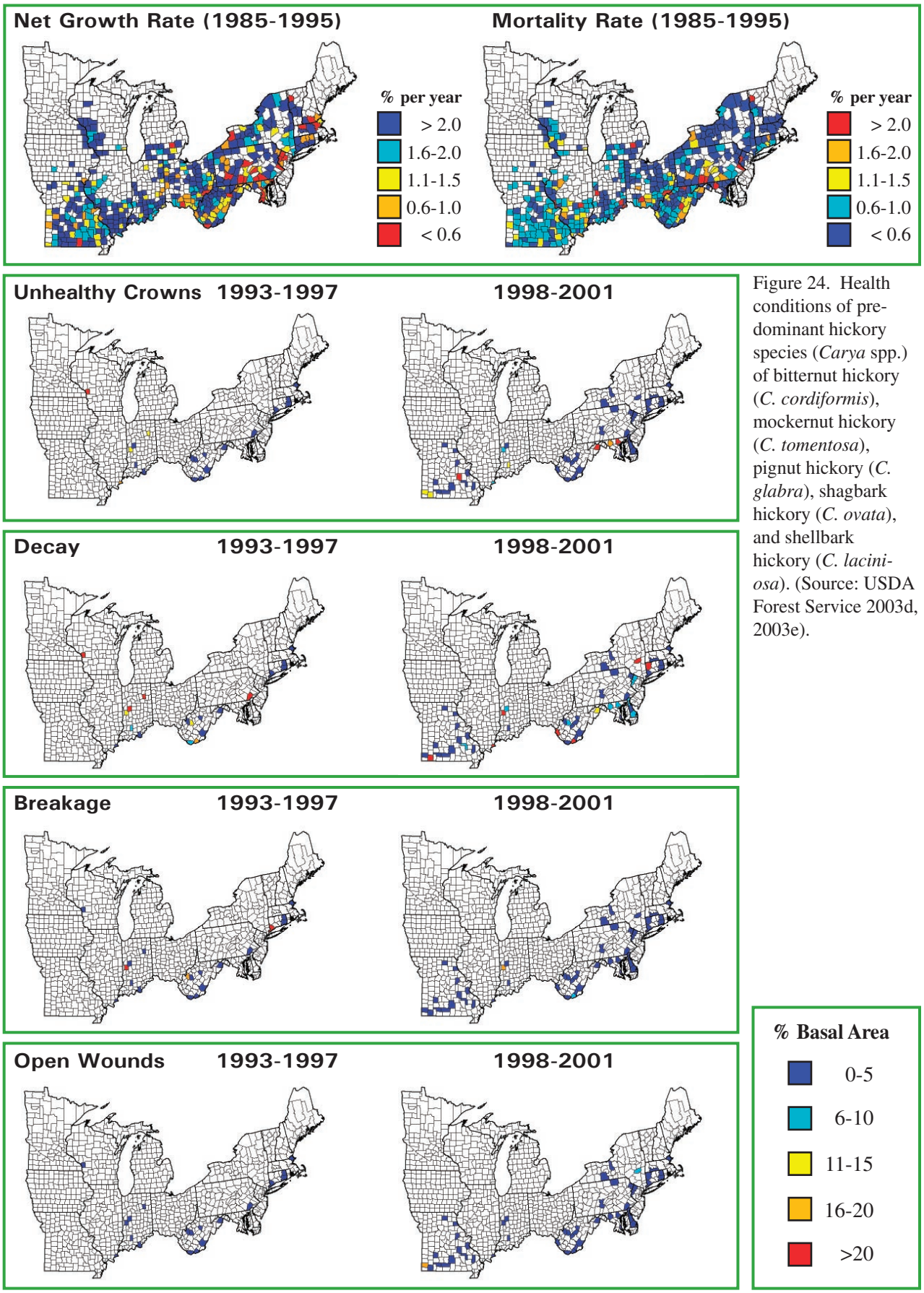


Figure 24. Health conditions of predominant hickory species (*Carya* spp.) of bitternut hickory (*C. cordiformis*), mockernut hickory (*C. tomentosa*), pignut hickory (*C. glabra*), shagbark hickory (*C. ovata*), and shellbark hickory (*C. laciniosa*). (Source: USDA Forest Service 2003d, 2003e).

Oak Species

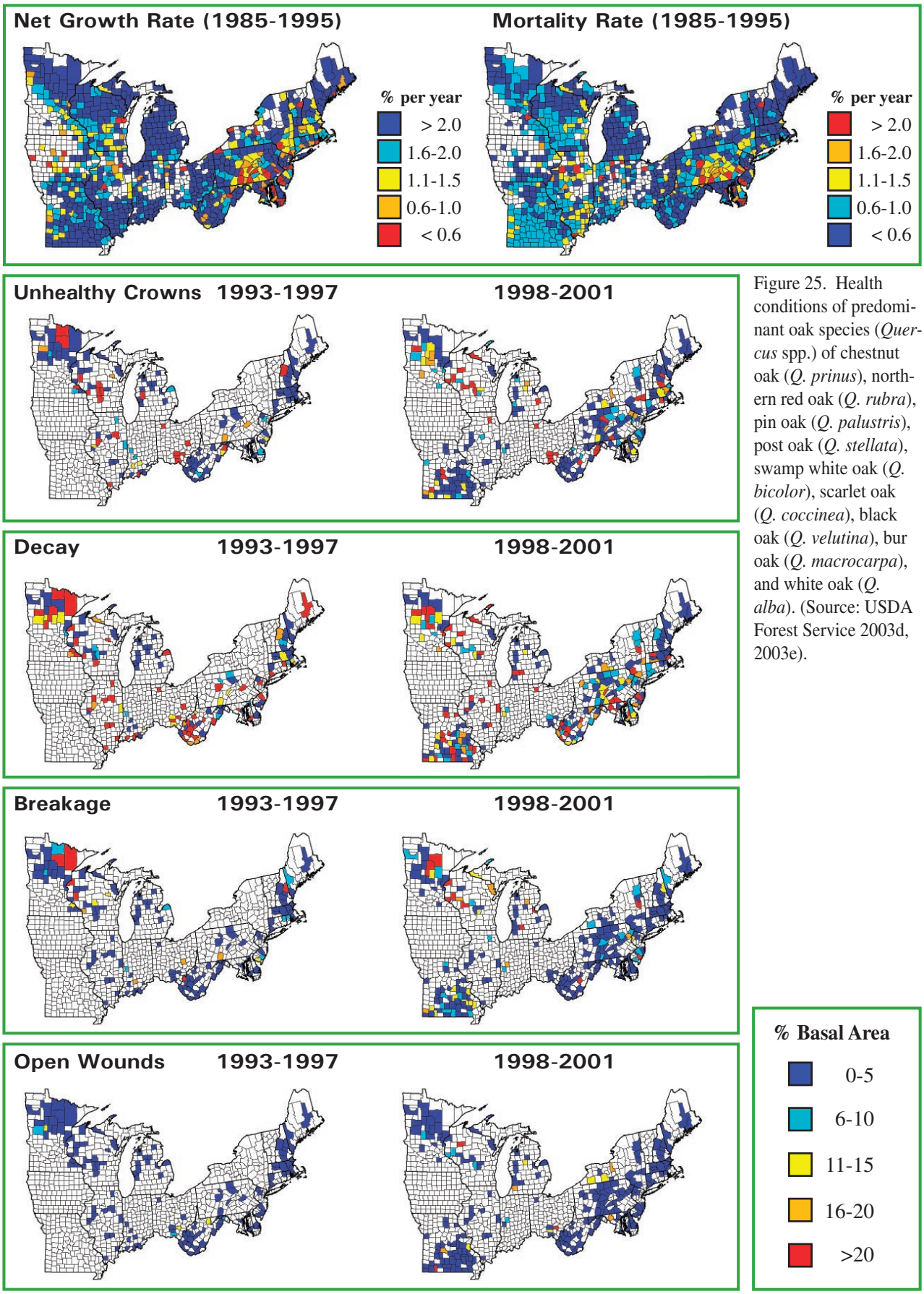


Figure 25. Health conditions of predominant oak species (*Quercus* spp.) of chestnut oak (*Q. prinus*), northern red oak (*Q. rubra*), pin oak (*Q. palustris*), post oak (*Q. stellata*), swamp white oak (*Q. bicolor*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), bur oak (*Q. macrocarpa*), and white oak (*Q. alba*). (Source: USDA Forest Service 2003d, 2003e).

Red Maple

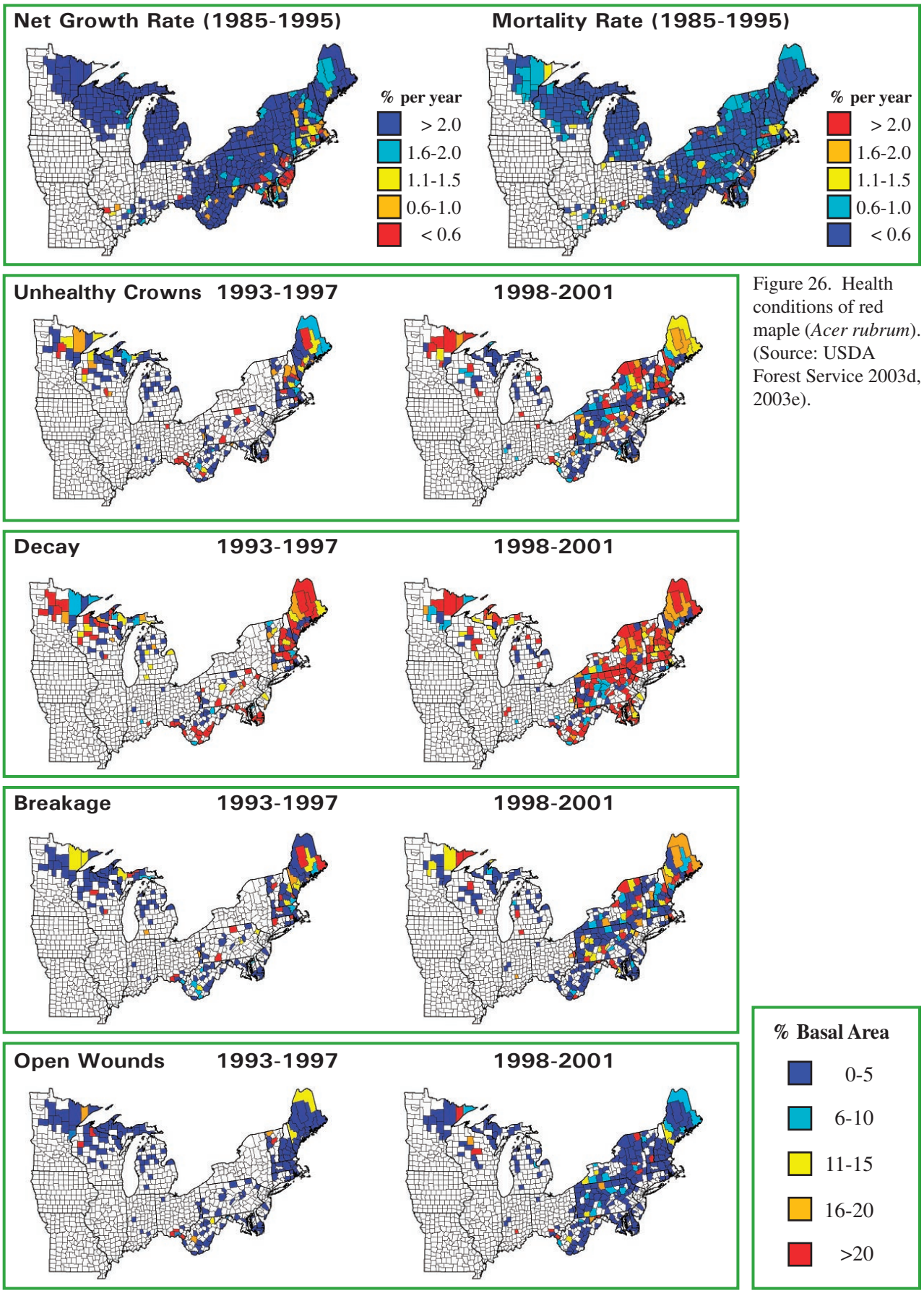


Figure 26. Health conditions of red maple (*Acer rubrum*). (Source: USDA Forest Service 2003d, 2003e).

Sugar Maple

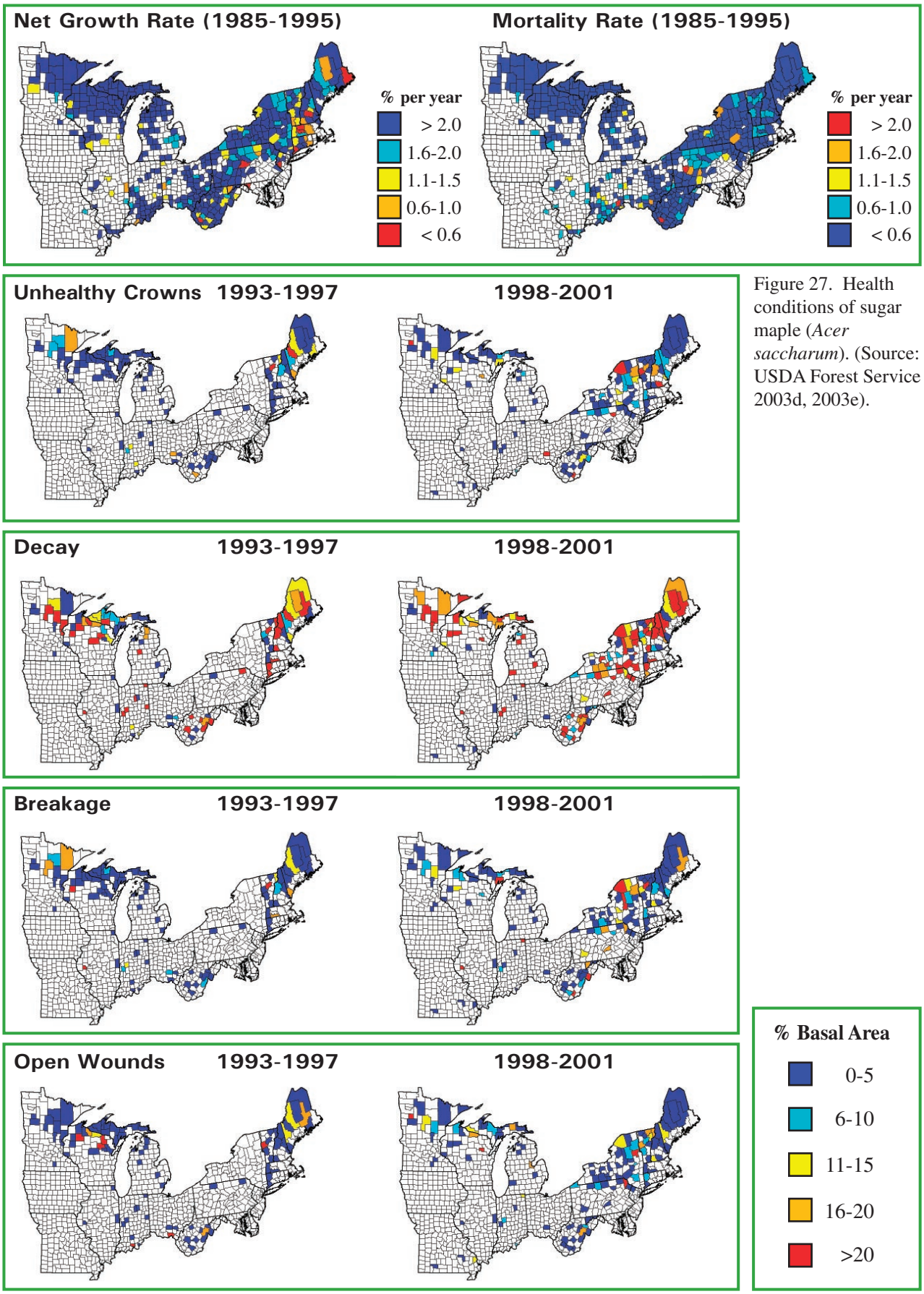


Figure 27. Health conditions of sugar maple (*Acer saccharum*). (Source: USDA Forest Service 2003d, 2003e).

Yellow-Poplar

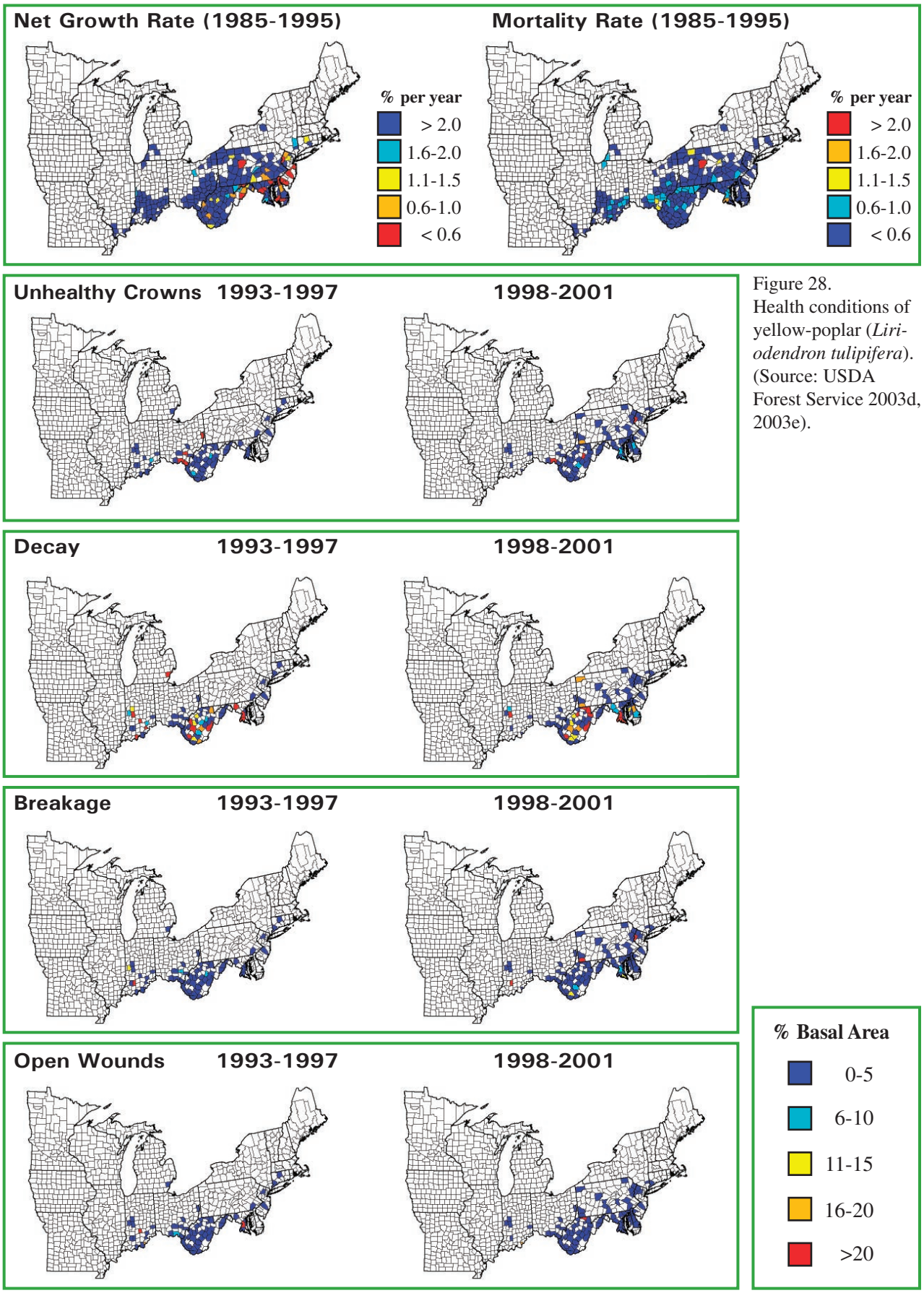


Figure 28. Health conditions of yellow-poplar (*Liriodendron tulipifera*). (Source: USDA Forest Service 2003d, 2003e).

Eastern White Pine

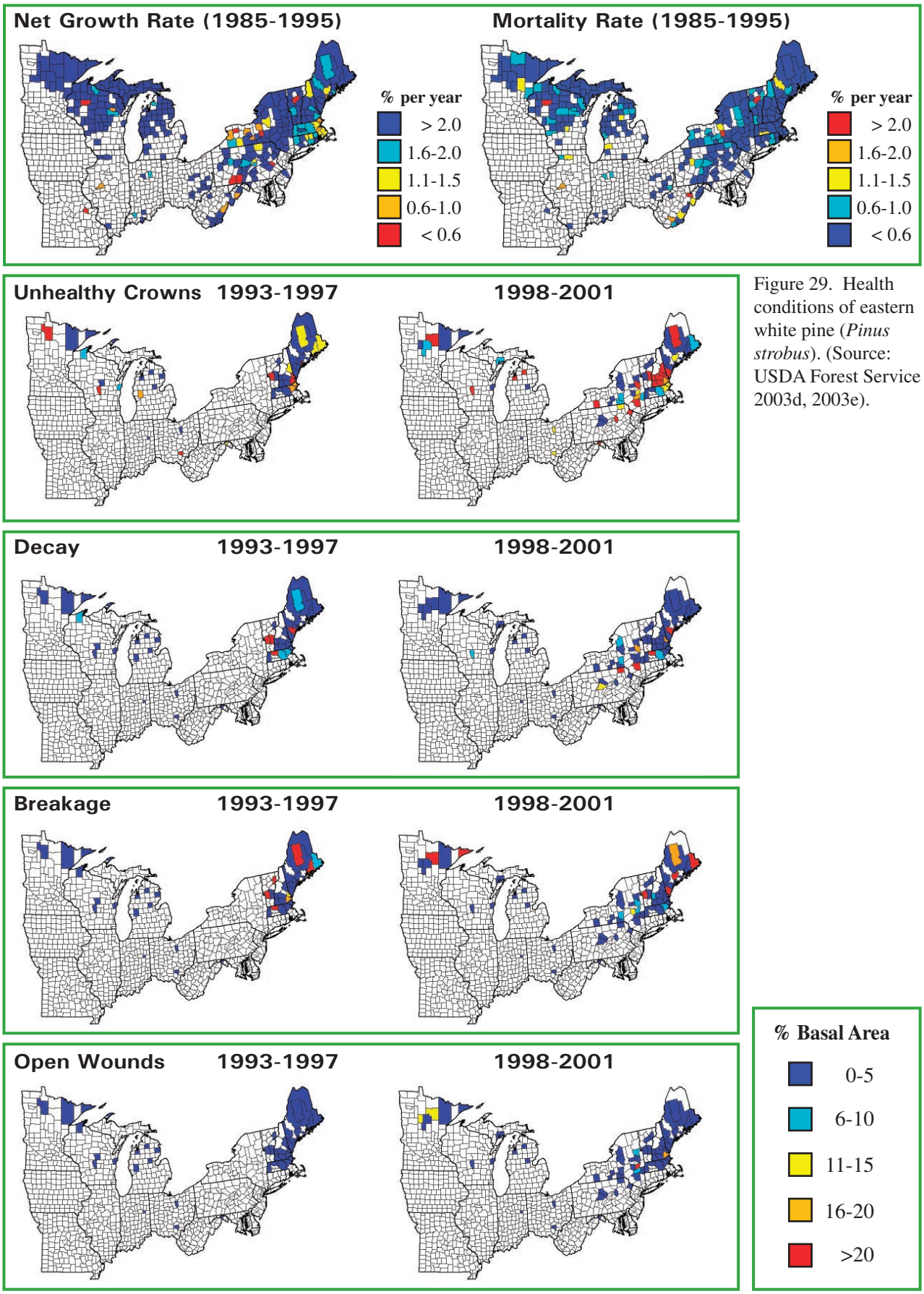


Figure 29. Health conditions of eastern white pine (*Pinus strobus*). (Source: USDA Forest Service 2003d, 2003e).

Fir Species

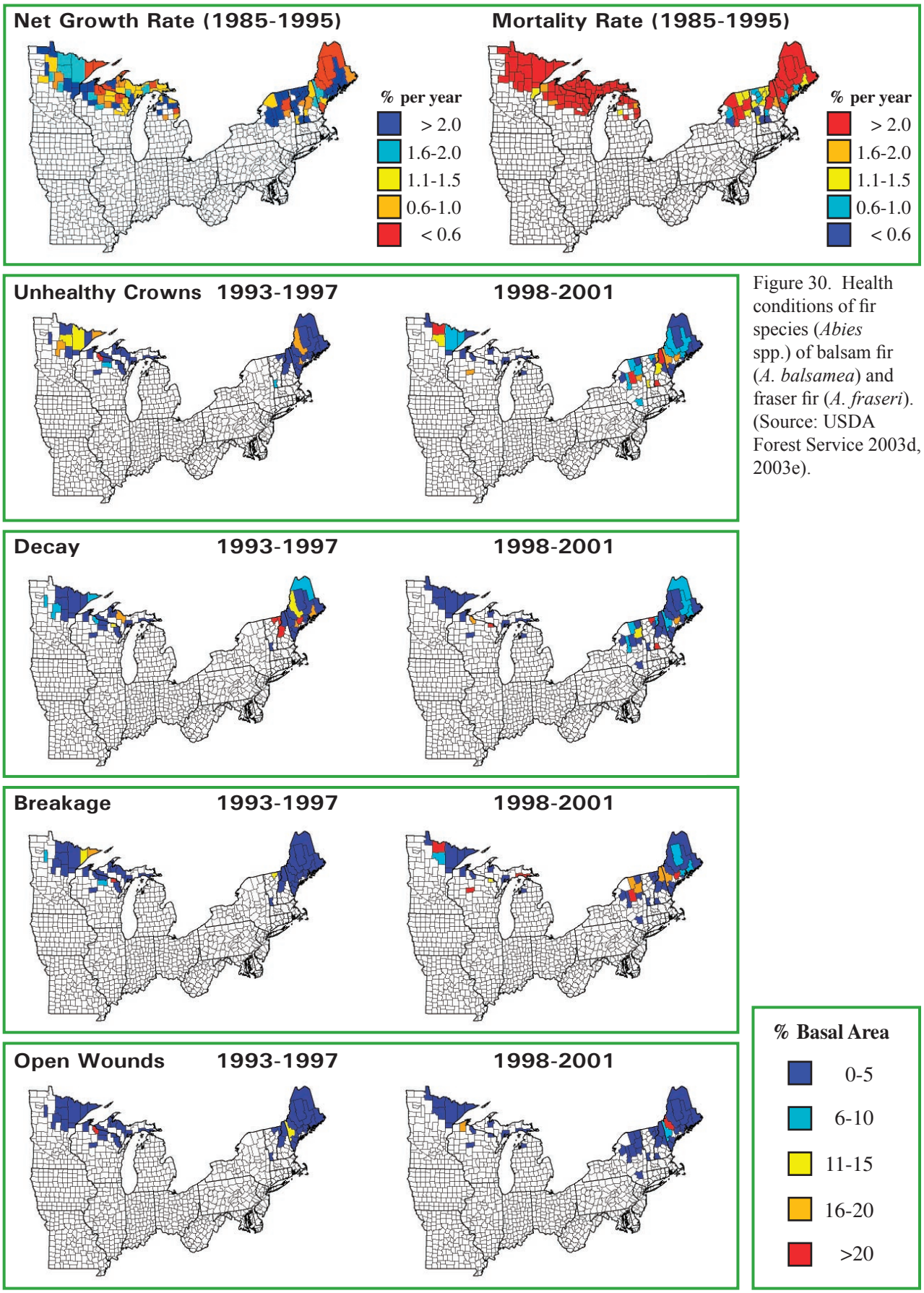


Figure 30. Health conditions of fir species (*Abies* spp.) of balsam fir (*A. balsamea*) and fraser fir (*A. fraseri*). (Source: USDA Forest Service 2003d, 2003e).

Hemlock Species

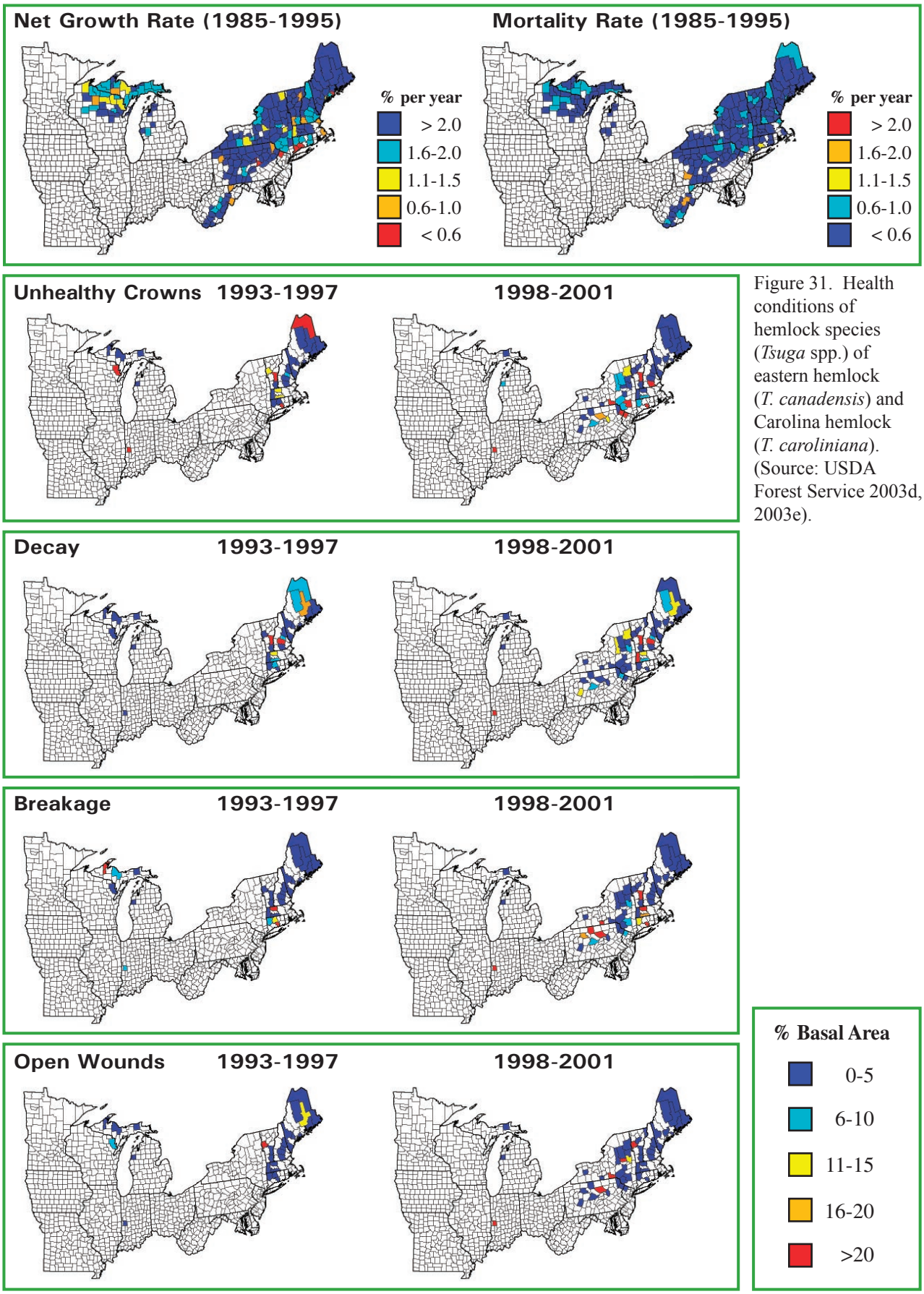


Figure 31. Health conditions of hemlock species (*Tsuga* spp.) of eastern hemlock (*T. canadensis*) and Carolina hemlock (*T. caroliniana*). (Source: USDA Forest Service 2003d, 2003e).

Jack Pine

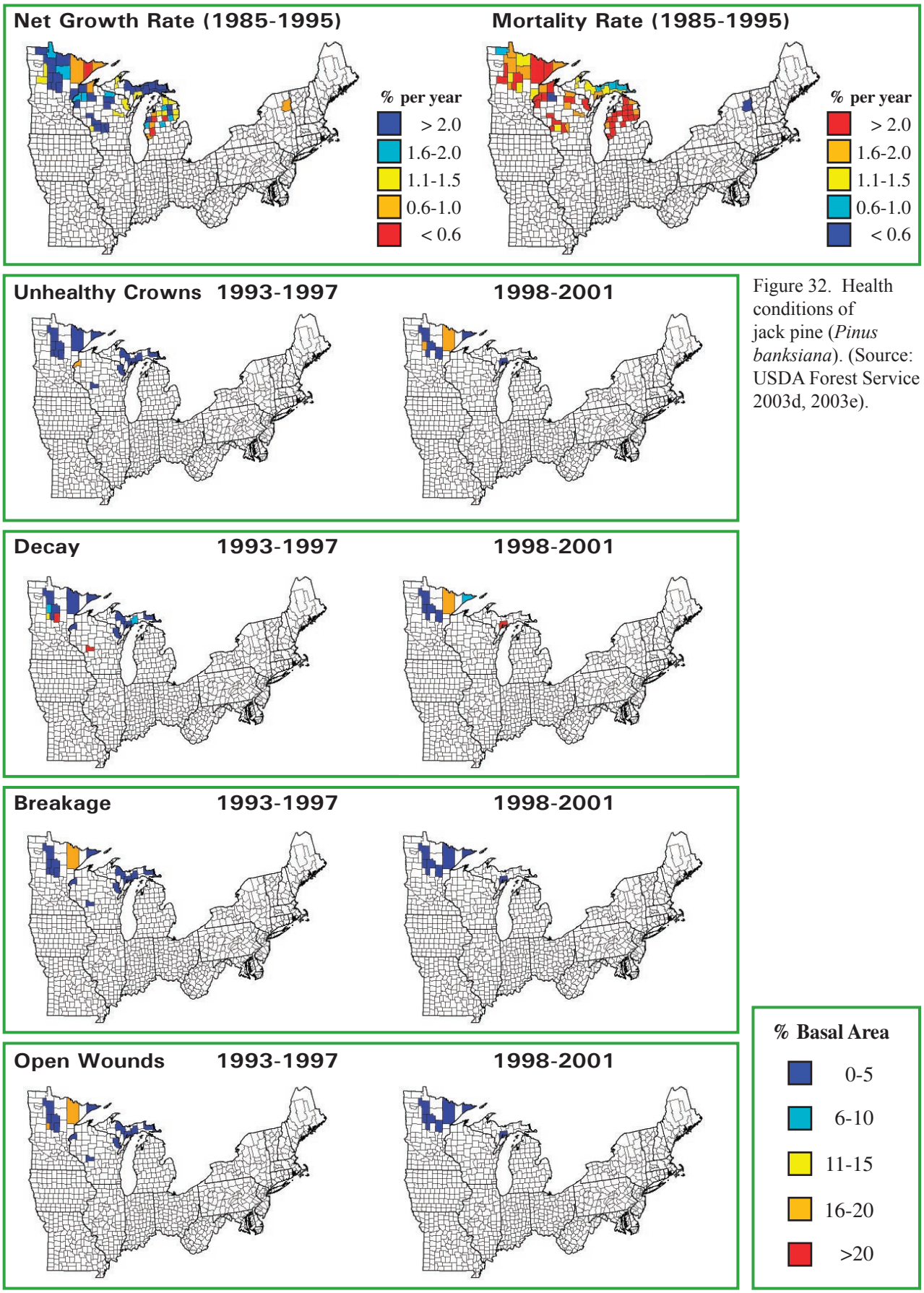


Figure 32. Health conditions of jack pine (*Pinus banksiana*). (Source: USDA Forest Service 2003d, 2003e).

Northern White-Cedar

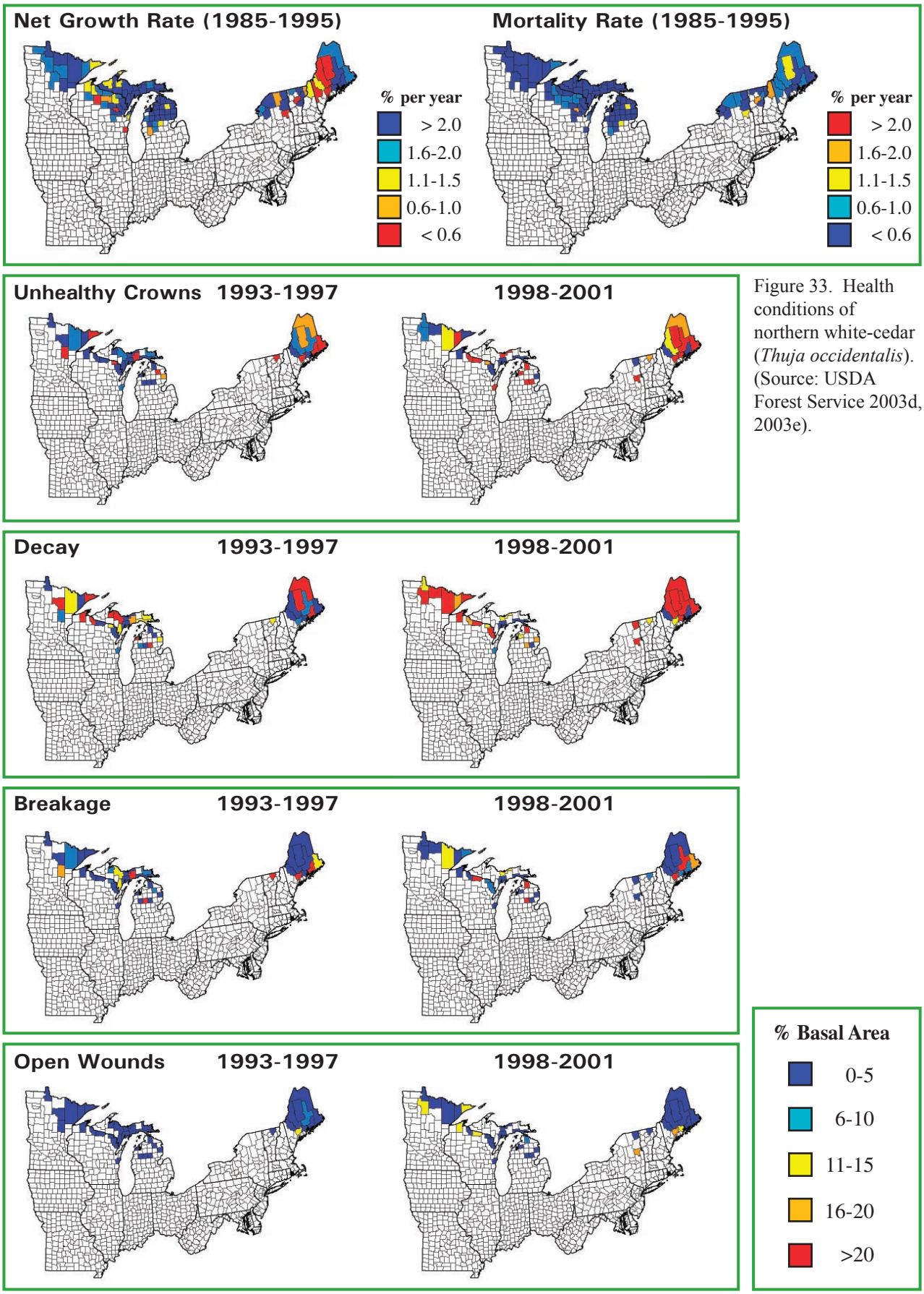
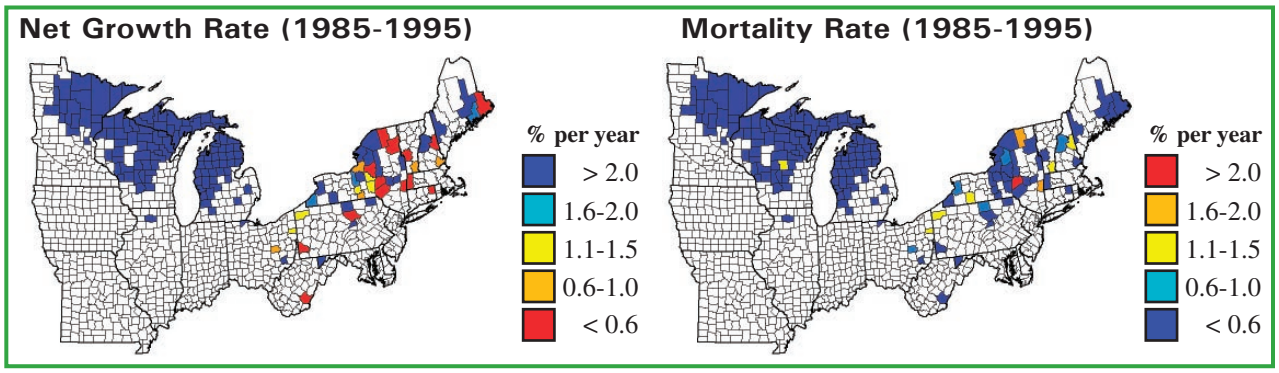
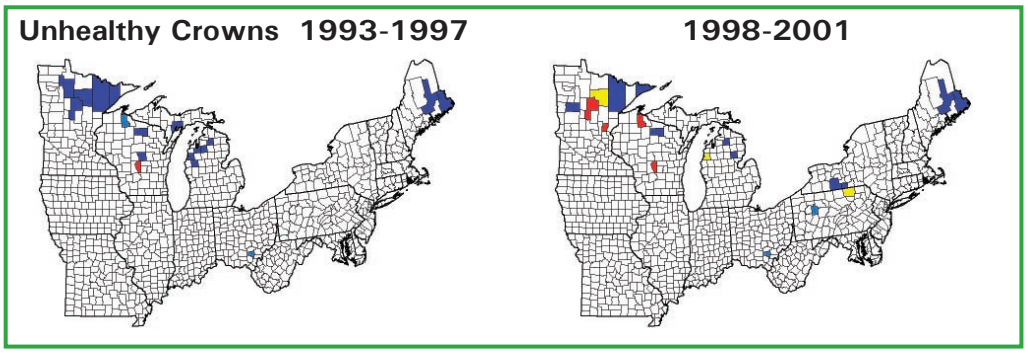
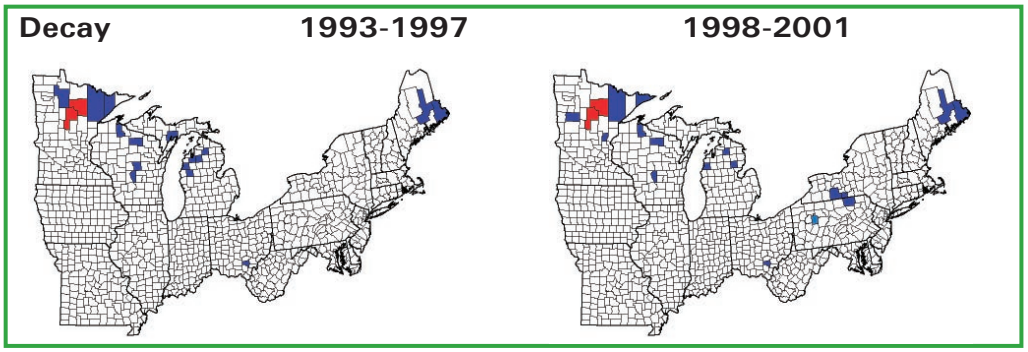


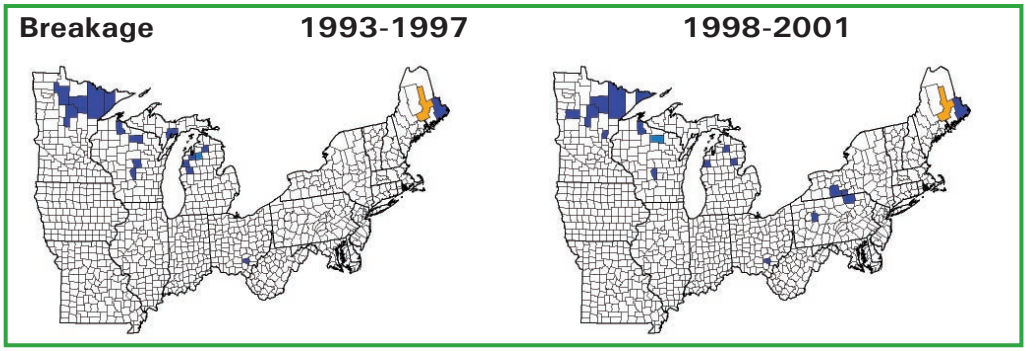
Figure 33. Health conditions of northern white-cedar (*Thuja occidentalis*). (Source: USDA Forest Service 2003d, 2003e).

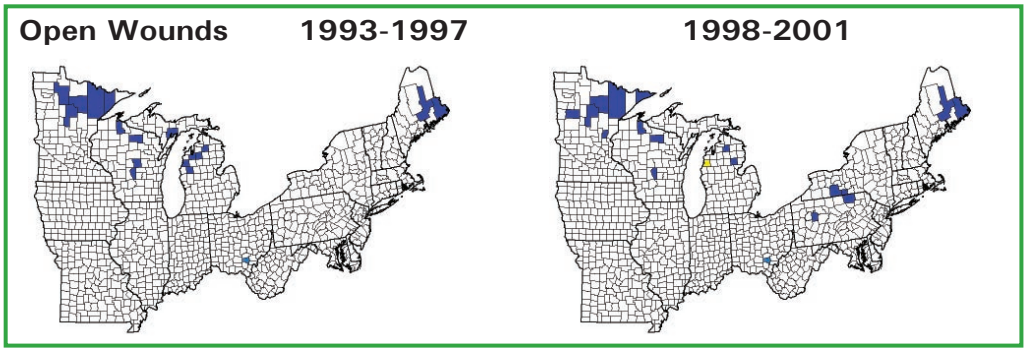
Red Pine











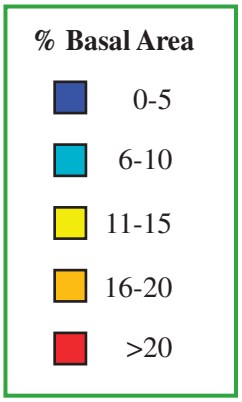


Figure 34. Health conditions of red pine (*Pinus resinosa*). (Source: USDA Forest Service 2003d, 2003e).

Spruce Species

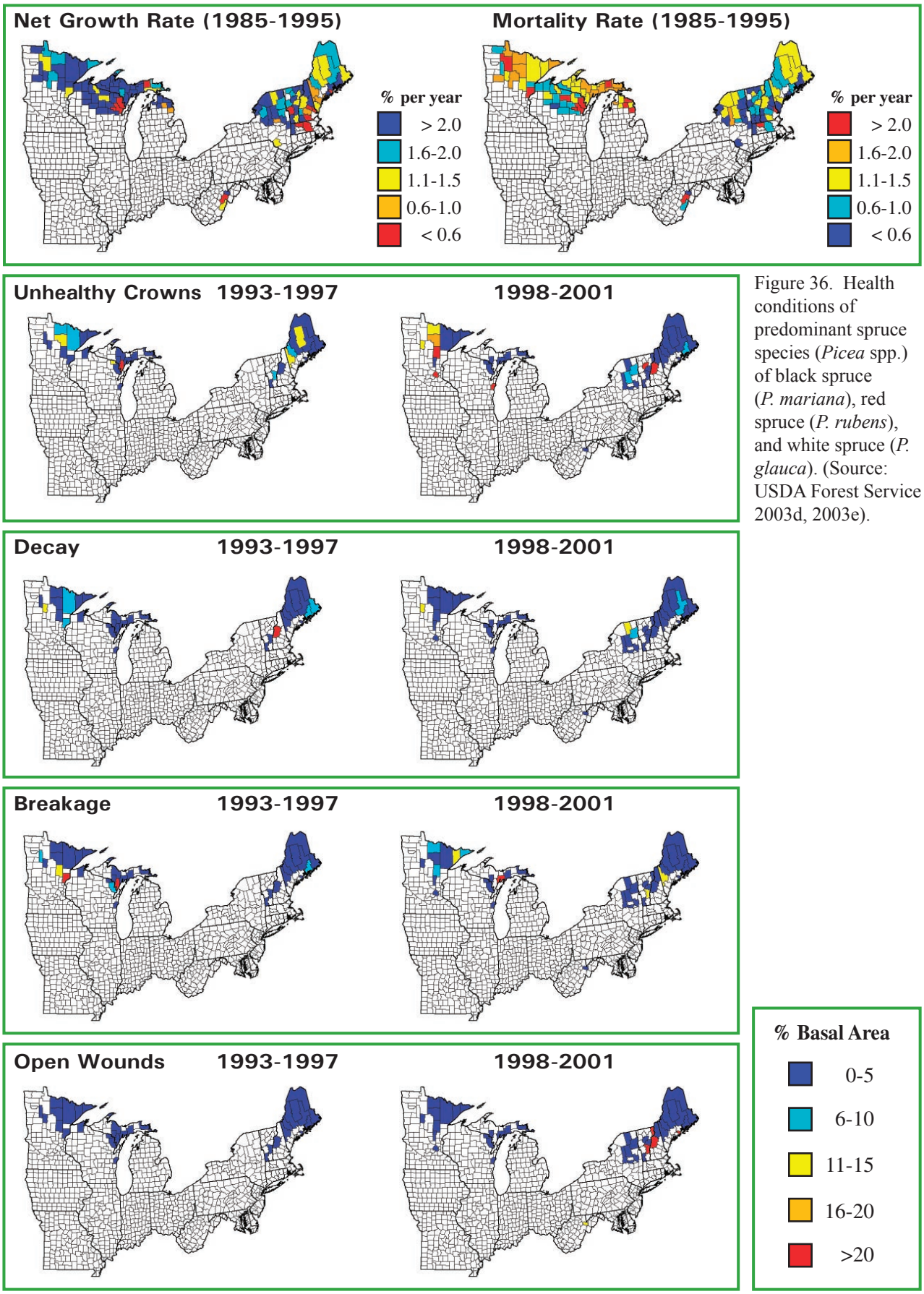


Figure 36. Health conditions of predominant spruce species (*Picea* spp.) of black spruce (*P. mariana*), red spruce (*P. rubens*), and white spruce (*P. glauca*). (Source: USDA Forest Service 2003d, 2003e).

Yellow Pine Species

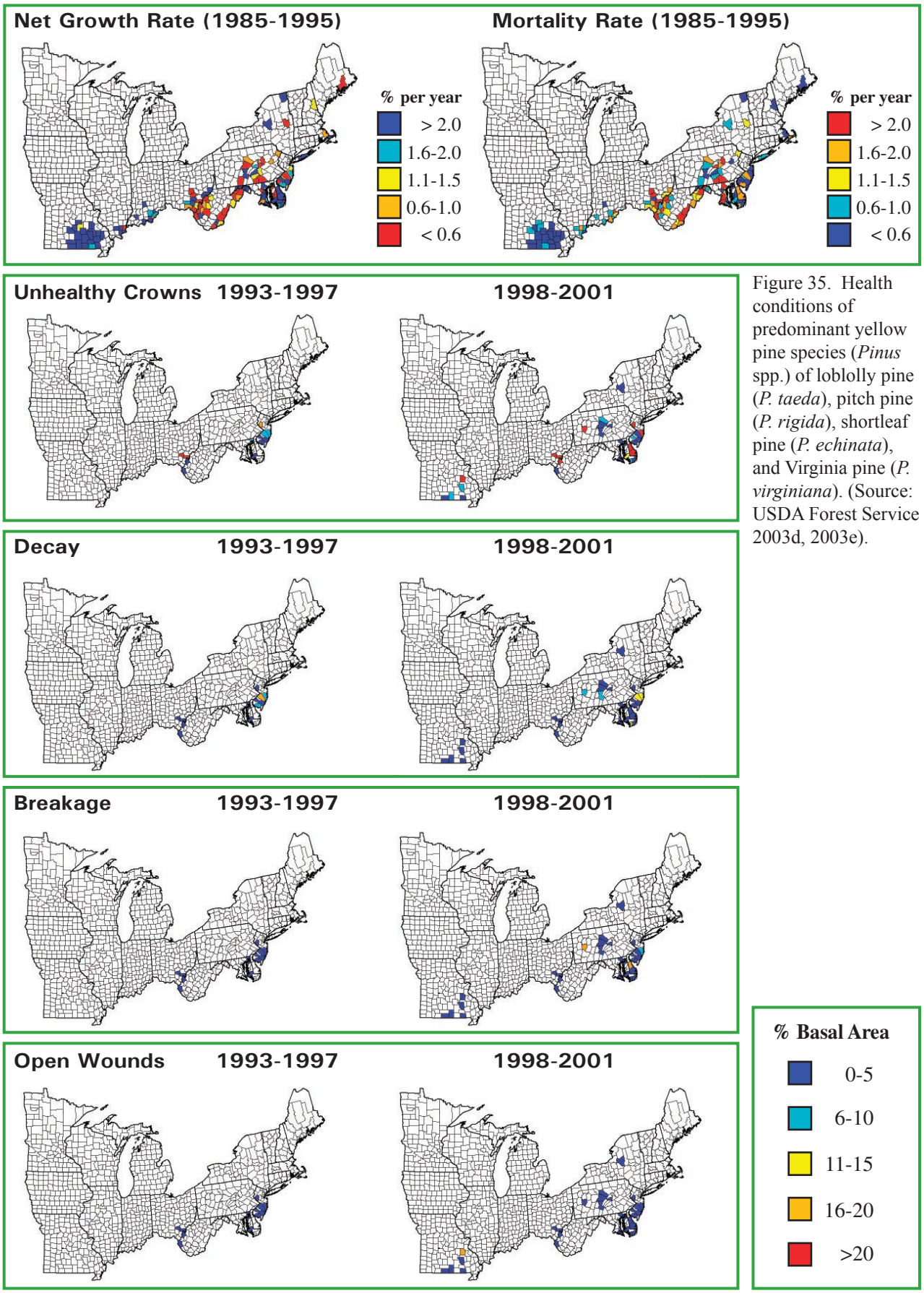


Figure 35. Health conditions of predominant yellow pine species (*Pinus* spp.) of loblolly pine (*P. taeda*), pitch pine (*P. rigida*), shortleaf pine (*P. echinata*), and Virginia pine (*P. virginiana*). (Source: USDA Forest Service 2003d, 2003e).

Conclusions

This report for the Forest Health Monitoring Program of the USDA Forest Service provides a summary of quantitative data collected during the past decade for a variety of indicators of forest health in the Northeastern United States. Despite the incidence of air pollution, drought, damaging insects and diseases, and population growth pressures, the health conditions examined in this report suggest that forests are resilient to these and other disturbances. Even so, the summarized information also suggests that some localities within the region might experience problems with one or more forest ecosystem components in the future. This report will be periodically updated using data from ongoing monitoring efforts and assess long-term trends in forest health conditions in the Northeast.

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Appendix A. Common and scientific names of insects

Native insects that damage hardwood trees

Common Name	Scientific Name
cherry scallop shell moth	*Hydria prunivorata*
common oak moth	*Phoberia atomaris*
eastern tent caterpillar	*Malacosoma americanum*
fall cankerworm	*Alsophila pometaria*
fall webworm	*Hyphantria cunea*
forest tent caterpillar	*Malacosoma disstria*
jumping oak gall	*Neuroterus saltatorius*
large aspen tortrix	*Choristoneura conflictana*
maple leafcutter	*Paraclemensia acerifoliella*
maple trumpet skeletonizer	*Epinotia aceriella*
oak leaftier	*Croesia semipurpurana*
oak skeletonizer	*Bucculatrix recognita*
orange-striped oakworm	*Anisota senatoria*
peach bark beetle	*Phloeotribus liminaris*
periodical cicada	*Magicicada septendecim*
scarlet oak sawfly	*Caliroa quercuscoccineae*
variable oakleaf caterpillar	*Heterocampa manteo*
walkingstick	*Diapheromera femorata*

Introduced insects that damage hardwood trees

Asian longhorned beetle	*Anoplophora glabripennis*
basswood thrips	*Thrips calcaratus*
birch leafminer	*Fenusa pusilla*
emerald ash borer	*Agrilus planipennis*
gypsy moth	*Lymantria dispar*
oystershell scale	*Lepidosaphes ulmi*
pear thrips	*Taeniothrips inconsequens*
satin moth	*Leucoma salicis*

Native insects that damage softwood trees

eastern spruce budworm	*Choristoneura fumiferana*
hemlock looper	*Lambdina fiscellaria*
jack pine budworm	*Choristoneura pinus*
southern pine beetle	*Dendroctonus frontalis*
spruce beetle	*Dendroctonus rufipennis*
white pine weevil	*Pissodes strobi*

Introduced insects that damage softwood trees

balsam woolly adelgid	*Adelges piceae*
common pine shoot beetle	*Tomicus piniperda*
hemlock woolly adelgid	*Adelges tsugae*
pine false webworm	*Acantholyda erythrocephala*

Appendix B. Common and scientific names of diseases

Native diseases that damage hardwood trees

Common Name	Scientific Name
Armillaria root rot	*Armillaria* spp.
Ash yellows	(a microplasm-like organism)

Introduced diseases that damage hardwood trees

bacterial leaf scorch	*Xylella fastidiosa*
beech bark disease	*Nectria coccinea* / *N. galligena*
butternut canker	*Sirococcus clavigignenti-juglandacearum*
dogwood anthracnose	*Discula destructiva*
oak wilt	*Ceratocystis fagacearum*

Introduced diseases that damage softwood trees

white pine blister rust	*Cronartium ribicola*

Appendix C. Common and scientific names of tree species

Hardwood trees

Common Name	Scientific Name
American basswood	*Tilia americana*
American beech	*Fagus grandifolia*
balsam poplar	*Populus balsamifera*
bigtooth aspen	*Populus grandidentata*
bitternut hickory	*Carya cordiformis*
black ash	*Fraxinus nigra*
black cherry	*Prunus serotina*
black oak	*Quercus velutina*
bur oak	*Quercus macrocarpa*
butternut	*Juglans cinerea*
chestnut oak	*Quercus prinus*
flowering dogwood	*Cornus florida*
green ash	*Fraxinus pennsylvanica*
mockernut hickory	*Carya tomentosa*
northern red oak	*Quercus rubra*
paper birch	*Betula papyrifera*
pignut hickory	*Carya glabra*
pin oak	*Quercus palustris*
post oak	*Quercus stellata*
quaking aspen	*Populus tremuloides*
red maple	*Acer rubrum*
river birch	*Betula nigra*
scarlet oak	*Quercus coccinea*
shagbark hickory	*Carya ovata*
shellbark hickory	*Carya laciniosa*
sugar maple	*Acer saccharum*
swamp white oak	*Quercus bicolor*
sweet birch	*Betula lenta*
white ash	*Fraxinus americana*
white basswood	*Tilia heterophylla*
white oak	*Quercus alba*
yellow birch	*Betula alleghaniensis*
yellow-poplar	*Liriodendron tulipifera*

Softwood trees

Common Name	Scientific Name
balsam fir	*Abies balsamea*
black spruce	*Picea mariana*
eastern hemlock	*Tsuga canadensis*
eastern redcedar	*Juniperus virginiana*
eastern white pine	*Pinus strobus*
fraser fir	*Abies fraseri*
jack pine	*Pinus banksiana*
loblolly pine	*Pinus taeda*
northern white-cedar	*Thuja occidentalis*
pitch pine	*Pinus rigida*
red pine	*Pinus resinosa*
red spruce	*Picea rubens*
shortleaf pine	*Pinus echinata*
tamarack	*Larix laricina*
Virginia pine	*Pinus virginiana*
white spruce	*Picea glauca*

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