Summary and Synthesis

6

EARLIER CHAPTERS PROVIDED an overview of northern forests—current resource conditions, what makes these forests unique, and the challenges they face. Chapter 2 summarized threats to northern forests expressed by managers and other stakeholders, including concerns about forest area, composition, structure, biodiversity, and fragmentation; wood products production, consumption, and trade; invasive species; insects; disease; water quality; recreation; stewardship; and environmental literacy (Dietzman et al. 2011). One commonality of all these issues is their large spatial scale. Invasive insects, for example, have organismal and stand-scale effects, but the long-term, cumulative effects are observed at the landscape scale. Cumulative effects stemming from changes in forest area, composition, biodiversity, product consumption, and species composition, among others, can limit (or enhance) the capacity of northern forests to provide beneficial products and services to society.

Chapters 3 and 4 introduced the concept of forest sustainability and offered a set of strategies that we believe are essential for sustainable forest management at the spatial scale of ecoregions, States, and the nation. There is no single metric for quantifying forest sustainability; rather we rely on many interrelated indicators.

We used the framework of the Montréal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 2010) to assess current conditions and recent trends in northern forests. The structured format of the Montréal Process provided a convenient way to organize and summarize information related to forest sustainability.

The assessment identified similarities and differences among the 20 Northern States and compared the region with other regions of the United States.

The many indicators of forest conditions are interrelated, and this assessment cannot render a single, definitive judgment about the sustainability of northern forests. As noted earlier, one of the most significant contributions an assessment such as this can make is to provide the context and data needed to facilitate discussions about forest sustainability.

Ultimately it is the work of society to choose among options, make tradeoffs among desirable outcomes, and select the most effective or most equitable solutions. Those choices are implemented through discourse, legislative and rule-making processes, purchases made and forgone, opinions expressed, and investments made.

To foster additional discussion, Table 31 presents 36 indicators of forest sustainability from Chapter 5 and adds condition ratings for each of them, based on analysis of current conditions and recent trends. These ratings subjectively classify the various indicators as highly positive, positive, neutral, negative, or highly negative with respect to forest sustainability. The ratings are based on the assessment for the entire 20-State region. They do not capture local conditions that can be highly variable across the region, nor do they specifically account for the variation observed among individual Northern States. Rather, they help provide a larger spatial context that can be used to evaluate State and local forests. It is important to emphasize that these subjective ratings represent our best judgment. Other people may arrive at different conclusions or even propose alternative rating systems.

No forest resource issue exists in isolation. Forest policies and management practices intended to increase forest sustainability are likely to generate broader support if they simultaneously address multiple issues. For example, a future scenario using more woody biomass for energy might simultaneously decrease net atmospheric carbon emissions, increase renewable energy production, increase early successional habitat for dependent wildlife species, decrease the out-of-pocket costs for woodland habitat restoration, increase forest-based employment, and increase the total area covered by forest management plans. Or landscape-scale planning within priority conservation areas with mixed ownerships might identify opportunities for public-private partnerships to jointly address biodiversity issues and invasive species issues that cross ownership boundaries. Given limited time and money, management practices designed to pursue a single objective are often harder to justify than those designed to provide multiple conservation benefits simultaneously.

The remainder of this chapter discusses some of the interrelationships, interactions, and drivers of change that affect northern forests. The content addresses some of the threats and opportunities identified by Dietzman et al. (2011), and it also addresses findings that emerged from the analysis of conditions and trends. The many issues affecting northern forests are interrelated and so are approaches to achieving desired outcomes.

Table 31—Summary of northern forest sustainability condition ratings for forest sustainability indicators described in Chapter 5. Current conditions and recent trends are rated separately (when possible). Condition ratings represent the best judgment of the authors based on evaluations of each indicator with respect to forest sustainability for the region as a whole. People with different perspectives or people examining different areas within the region are likely to differ in the condition ratings they would assign to a given indicator.

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
1	Forest area			Forests cover 42 percent of the land, an increase of 38 million acres over the past 100 years, despite population growth and urban expansion. In recent decades forest area has ceased to increase in many States and has declined in some.
2	Forest ownership			Public forest lands constitute a small share of the region as whole, but individual States vary greatly in their proportion of public land. A mix of public and private ownerships is usually considered desirable because public and private forest land managers often (but not always) differ in their management objectives and their capacity to provide forest products, amenities, and ecosystem services. (See also Parcelization, item 7.)
3	Protected forest			About 16 percent of forests (27 million acres) are under some category of protection. Compared to the rest of the United States, protected northern forests are concentrated in the least restrictive protected categories. Most protected areas are on public land, but conservation easements and similar instruments are increasingly used to expand the area of protected private forest land. Some habitats of high conservation interest (e.g., floodplains or migration corridors) are underrepresented in current protected areas.
4	Forest cover types			Forest cover types are the result of past disturbances and management activities. Changing the mix is a long-term endeavor. Loss of pine forest acreage relative to historical levels has reduced forest biodiversity in some areas. The ongoing transition of oak dominated forest to maple-dominated forest continues, at the expense of wildlife habitat quality. As long as native forest cover types are widely distributed across the landscape within their historic ranges there is little basis to judge the condition positive or negative.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
5	Forest age classes			Past patterns of harvesting and wildfire suppression have left the North with relatively little young (early successional) forest or old forest, but with relatively abundant forest in the 40- to 80-year age classes. Lack of age class diversity indicates a lack of forest biodiversity. With current rates of disturbance, the area of old forests is increasing over time, but the area of young forests is not.
6	Fragmentation			Northern forests continue a decades-long trend of fragmentation. However, interpretation of this metric differs with timeframe and scale; for example, over the past century unproductive farms abandoned in the first half of the 20th century have reverted back to forest via natural succession—a process that has contributed substantially to maintaining a stable forest area. (See also Forest area, item 1.) In recent decades, however, expansion of urban, suburban, and exurban areas has fragmented millions of acres of forest land.
7	Parcelization			The average size of family forest ownerships continues to decrease, reaching a regionwide average of 26 acres in 2006. As forest ownerships become smaller, the economic viability of forest management decreases, and addressing large-scale forest management issues becomes more difficult.
8	Number and status of native forest-associated species			Many forest-associated species are at risk or have been previously extirpated. Tools to inventory and monitor forest associated species are improving, but a full inventory of forest associated species is lacking. Ongoing trends in forest fragmentation and conversion of forest to other uses are usually considered detrimental to native forest-associated species. (See also Fragmentation and Urban and community land, items 6 and 34.)
9	Timberland			The region has a high proportion of timberland relative to total forest land, and that has changed little in recent decades.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
10	Wood volume			Wood volume is abundant and has increased substantially in the past 50 years. Invasive species have greatly reduced the wood volume of targeted tree species in some locations.
11	Wood growth and removals			Wood growth far exceeds removals and has done so for decades. This is locally sustainable but it may represent lost opportunities for forest-associated employment or may result in transfer of harvesting impacts to forests outside the region.
12	Planted forests			Compared to the rest of the United States, the area of planted forest is low. Planted forests often have greater productivity per acre than native forests, but converting native forests to plantations generally decreases biodiversity.
13	Tree mortality			The current rate of tree mortality across the region is relatively low. However, increasing mortality associated with invasive species is a concern. (See also Insect and disease incidence and risk, item 15.)
14	Indicators of forest damage on standing timber		N/A	Only a small percentage of trees have damage or defects. Temporal trends in damage indicators are not available.
15	Insect and disease incidence and risk			Old and new invasive species are causing severe localized mortality for some tree species and widespread chronic defoliation or mortality for others. Controlling insects and diseases or managing forests to adapt to them is often a costly, long-term endeavor.
16	Soil quality		N/A	Regional inventories show the proportion of bare forest soil and compacted forest soil to be relatively low. Excess aluminum can be toxic to trees and other plants under certain conditions. Many other soil characteristics (such as percent soil organic matter) are now routinely quantified for forest inventory plots, but whether levels are beneficial or detrimental to forest sustainability is debatable. For conserving soil, managing land for forest cover is generally considered preferable to other land uses. Trends in forest soil characteristics are poorly documented.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
17	Water supply and quality			Nearly half of the region's surface water supply originates from forest lands and most drinking water comes from surface water sources. Most rainfall and snowmelt in forests moves into streams through subsurface flows, accelerating nutrient uptake and contaminant absorption processes. Increasing forest area in the last century has benefited water quality, but the more-recent losses of forest land to urban development have not.
18	Carbon sequestered in forests			The quantity of sequestered carbon in forests generally increases as the volume of live trees increases. The volume of timber in the region has increased substantially in the past 50 years. (See also Wood volume, item 10.)
19	Carbon sequestered in forest products			Carbon is sequestered in forest products. Regionally about 1.5 billion cubic feet of wood is converted annually to long-lived products. Another 0.9 billion cubic feet is used to produce pulp and paper products. This is a substantial quantity of wood products and associated sequestered carbon, but it is below the region's capacity. Since 1986, the annual volume of roundwood products has decreased. (See also Wood volume and Wood growth and removals, items 10 and 11.)
20	Using woody biomass for energy			Annually about 0.6 billion cubic feet of wood harvested in the region is used for fuelwood (including residential heating). This is a small part of the region's energy needs, but utilization of woody biomass for energy is increasing. Use of fuelwood often offsets consumption of fossil fuels that would be used instead.
21	Consumption of wood and wood products			Consumption of wood products is about 71 cubic feet per capita. Per capita consumption is expected to remain stable or decrease slightly, but increases in population have and will continue to increase total wood products consumption.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
22	Value and volume of wood and wood products			The total value of primary wood product shipments from the region was $112 billion in 2006, and associated wood products manufacturing provided $52 billion of added value. But based on the rate of increase in total forest volume, the value and volume of wood products production appears to be below potential. (See also Wood volume, item 10.) Roundwood harvesting increased from 1952 to 1986, but has remained flat since.
23	Recovery or recycling of wood products			The national paper recovery rate is about 50 percent and has gradually increased in past years. Paper recovery is not tracked separately for the Northern States.
24	Nontimber forest products			Increased attention is being given to quantifying the value of nontimber forest products. Utilization appears to be below potential. Edible and decorative nontimber products are collected by about 10 percent of family forest owners. Sales of maple syrup produced in the region have increased sharply in recent years and now exceed $91 million, annually.
25	Revenues from forest-based environmental services			Values for forest-based environmental services have been difficult to quantify, but are the focus of increased attention as potential sources of income.
26	Investments and expenditures in forest management, industries, services, and research			Investments in forest management are substantial in terms of total dollars, but stewardship plans only cover about 16 percent of private forest area not owned by the forest products industry. The largest industrial investments were in the pulp and paper sector. Active forest industries can increase understanding of and support for forest management. When adjusted for inflation, the combined U.S. Forest Service expenditures on management, State and private programs, and research in the region have declined slightly since 2005. Investments in management and certification by nongovernmental organizations are increasing in impact.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
27	Employment in forest products industries			The region employs 441,000 workers in the forestry and logging, wood products, and pulp and paper industries, a steady decline since 2001. Total employment is probably less than the region's forest resources are capable of supporting. Stable employment opportunities in logging and forest products industries often benefit rural communities economically.
28	Wages, income, and injury rates in forest industries			Total wages in the forestry and logging, wood products, and pulp and paper industries are about $19 billion annually. Since 2001, average wages have been flat. Injury rates are comparable to the national average and have been decreasing.
29	Recreation and tourism			Northern forests provide the equivalent of nearly 15 billion activity days of recreation. The number of activity days increases with the increasing population in the region. This creates opportunities for more people to interact with forests, but can result in conflicts over competing uses.
30	The importance of forests to people		N/A	The importance of forests to people extends beyond what can be extracted from forests to what they are. This can become a source of controversy if natural resource management actions threaten to change the character of places where people have formed strong attachments. There is a growing body of knowledge on this topic, but no basis for rating an overall trend.
31	Forest-related planning, assessment, and policy review; and opportunities for public involvement and participation in public policy and decisionmaking			All Northern States recently completed Forest Action Plans. States differ in many forest planning and public involvement policies, but coordination is increasing on regional forest planning and policy issues. (See also Investments and expenditures in forest management, industries, services, and research, item 26.)

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

Table 31 continued

No.	Indicator	Current condition rating[a]	Recent trend condition rating[a]	Rating explanation
32	Best practice codes for forest management			Most States have some form of best practice codes or best management practices (BMPs) that address silviculture, water and soils, and wildlife or biodiversity. BMPs are optional in some States, but attention to BMPs and associated forest management issues has increased over the last decade. BMPs require ongoing revision to address emerging issues such as invasive species management or biomass harvesting.
33	Management of forests to conserve environmental, cultural, social, and/or scientific values			One forested acre in six is afforded some sort of protected status, a proportion similar to the national average. In addition to widespread conservation of these values on public lands, easements and trusts are increasingly being used on private lands. (See also Protected forest, item 3.)
34	Urban and community land			Eighty percent of the population in the North lives in urban areas, which comprise about 6 percent of the region's land area. The area of urban land increased by nearly 4 million acres or 0.9 percent from 1990 to 2000, and roughly 37 percent of the new urban area came from forests. (See also Population and urbanization, item 35.)
35	Population and urbanization, projected to 2050			Losses of forest land to urbanization are expected to continue. By 2050, Rhode Island (71 percent), New Jersey (64 percent), Massachusetts (61 percent), and Connecticut (61 percent) are expected to be more than half urban land.
36	Tree and impervious cover in urban and community areas			Northern urban or community areas have about 20 percent impervious surface and about 39 percent tree cover. By comparison, rural forest cover across the region is about 42 percent. As they expand, urban and community lands reduce the area of rural forest land but retain some tree cover.

[a] *Highly positive* *Positive* *Neutral* *Negative* *Highly negative*

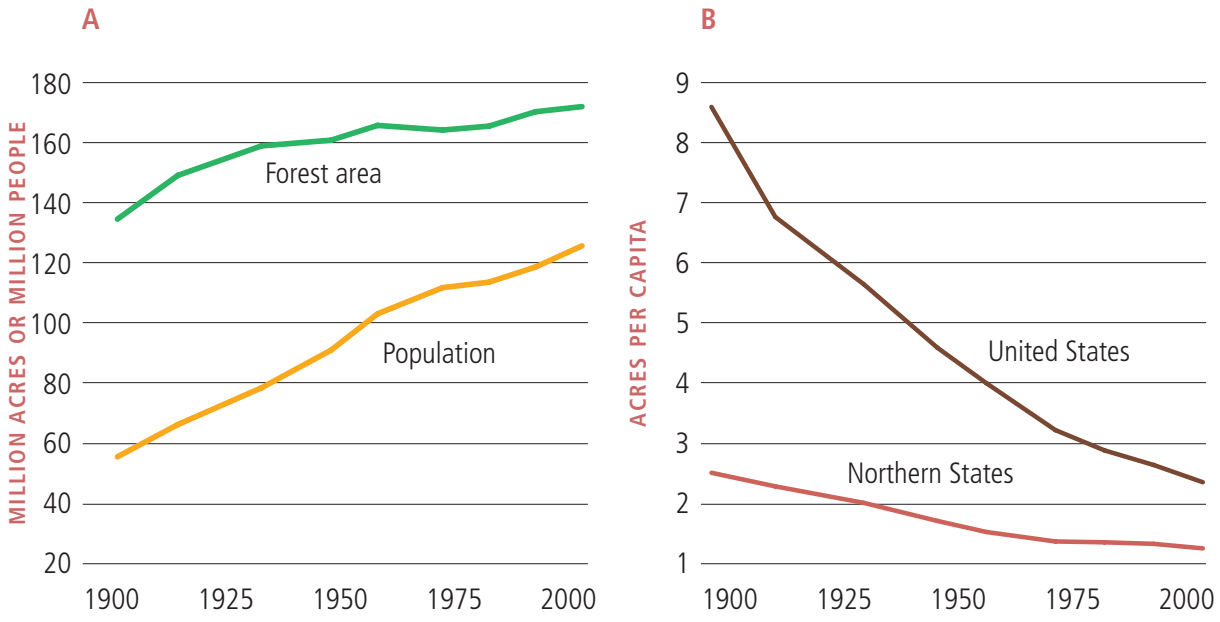
FORESTS AND PEOPLE TOGETHER

The 20 Northern States comprise the most heavily forested and most heavily populated quadrant of the United States. Although the forests of the West and especially the South are recognized centers for U.S. wood and paper production, the proportion of the North that is forested (42 percent) is slightly greater than the South (40 percent) and the Pacific Coast (37 percent) and far greater than the Interior West (20 percent) or the overall U.S. average (33 percent).

The abundance of northern forests comes with an abundance of people. A broad based measure of population pressures on forests is forest acreage per capita, which declines if forest area decreases relative to population or population increases relative to forest area. Over the past century, population increased at a faster rate than forest land in the North; this resulted in a gradual decline in forest area per capita from 2.6 to 1.4 acres (Fig. 67). Because the North has 41 percent of the U.S. population (124 million people) but only 23 percent of U.S. forest land, forest area per capita is substantially lower than in other regions (3.3 acres per capita, combined) and well below the U.S. average of 2.5 acres. However, over the last century, changes in forest area per capita have been much greater for the rest of the United States, and this has substantially closed the gap in forest area per capita between the North and the country as a whole.

FIGURE 67

Forest area and population in the Northern States (A), and forest area per capita in the Northern States and the United States (B) (Smith et al. 2009, and U.S. Census Bureau 2010).



What we find utterly remarkable about northern forests is that their total area has increased over the last century, despite a 56 percent increase in population (Fig. 2). Reversion of abandoned farmland back to tree cover is responsible for much of that increase. However, the area of forest land appears to have peaked, or nearly so.

The location and character of northern forests has also changed over the last century. Conversion of forests to residential and other developed uses has had localized impacts on aesthetics, biodiversity, water quality, carbon sequestration, quality of life, and ability to practice forest management. Pressures to fragment forests, subdivide forest ownerships, and convert forests to developed uses have been substantial and are expected to continue. From 1990 to 2000, expanding urban development in the North subsumed 4 million acres of land, of which 37 percent was forested (Table 28, Fig. 68). From 2000 to 2050 the urban area in the United States is expected to more than double to 8 percent of the total land area, at the cost of about 12 million additional acres of forest land.

Some negative consequences of population pressure on forests notwithstanding, the proximity of people to forests creates some unique opportunities in the North. Urban trees and forests are especially important to quality of life for the 80 percent of residents who live in northern urban areas. The North's rural forests are accessible to and serve many people. And energy or biofuels produced from wood are close to large numbers of energy consumers.

The region's extensive forest cover enables 5 million private woodland owners—almost half of all private woodland owners in the Nation—to have a piece of the region's forest. But 3 million of those northern owners have fewer than 10 acres of forest land. Private forest owner objectives are varied and timber production is often a low priority. A consequence of this ownership pattern is that the majority of forested acres lack forest management plans (Butler 2008).

For Discussion

- **Given their changing character, what is the desirable mix of commodities, amenities, and ecosystem services from the 172 million acres of northern forest land?**
- **To what extent can producing that mix simultaneously help sustain forest health and diversity?**
- **Given the spatial distribution of forests and people across the region and the importance of forests to human well-being, where are focal points of forest and human interaction, and what, if anything, can be done to improve the frequency and quality of these interactions?**

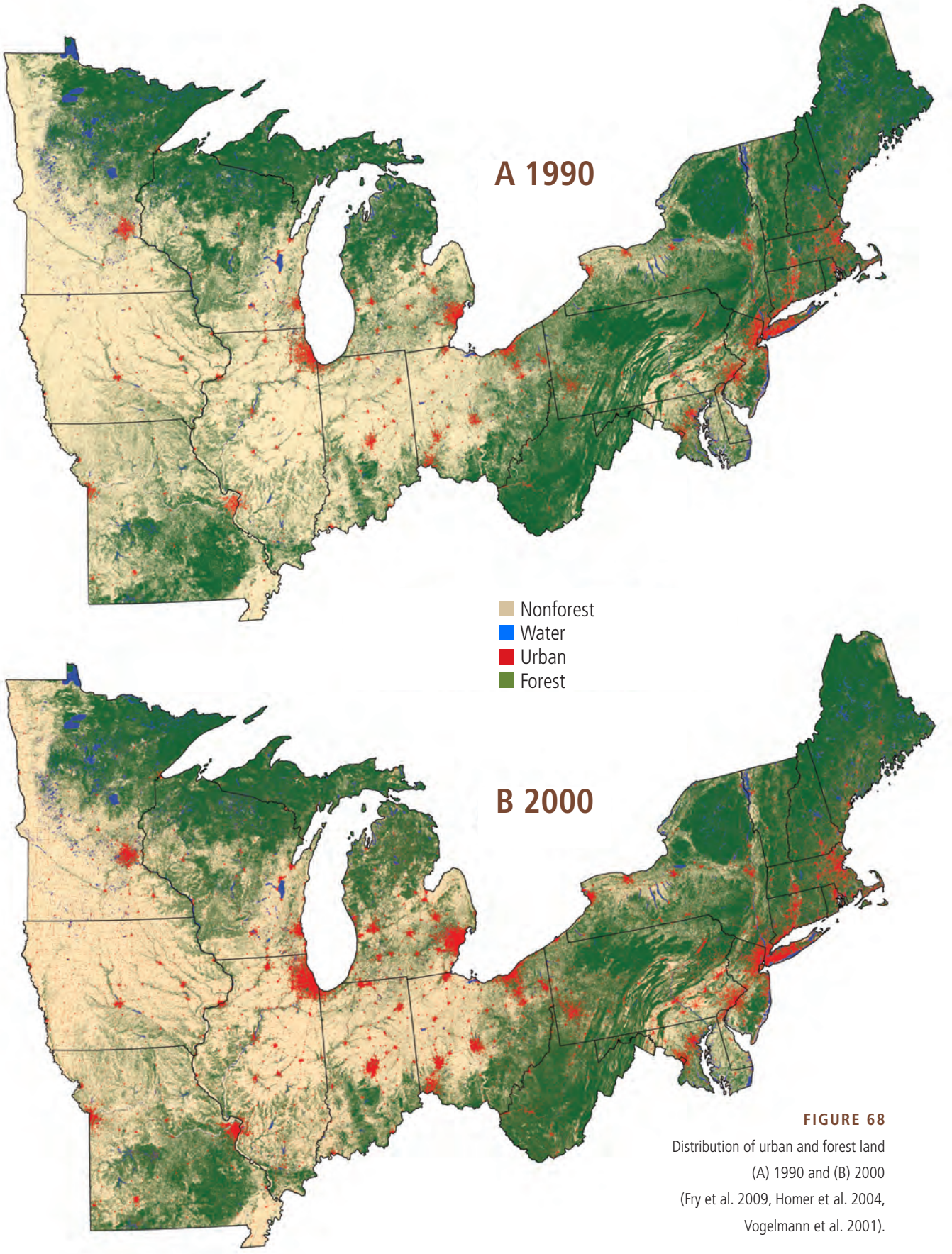


FIGURE 68
Distribution of urban and forest land (A) 1990 and (B) 2000 (Fry et al. 2009, Homer et al. 2004, Vogelmann et al. 2001).

INVASIVE SPECIES

Invasive plants and animals are a problem throughout the North. Some invasives drastically reduce the diversity of the forest. They also can have a huge economic impact in terms of lost commodities and ecosystem services. The high costs of invasive species eradication/control and removal/replacement of affected trees saps funds that could be used for other purposes.

For Discussion

- **What additional opportunities exist for coordinated approaches to invasive species management?**
- **How can these approaches converge with other objectives such as maintaining forest health (urban and rural), maintaining native species diversity, managing forests to increase resilience to future forest disturbances, and utilizing wood harvested in the process?**

The impacts of invasive species, especially nonnatives, are enduring. More than 140 years after its introduction, the gypsy moth is firmly established in the North; it is being managed—at a cost—along a slowly advancing front. After more than a century since the introduction of chestnut blight, scientists have bred a blight-resistant American chestnut. Since its introduction in the United States 70 years ago, Dutch elm disease is thoroughly established in northern forests. The emerald ash borer, Asian longhorned beetle, hemlock woolly adelgid, and thousand cankers disease of walnut are spreading. Autumn olive, multiflora rose, garlic mustard, and bush honeysuckle are well entrenched. Past experience suggests that (1) despite their best efforts, forest managers will lose battles with some current invasive species and with others yet to arrive, and (2) when a new invasive species gets a foothold, management and mitigation efforts will be long, costly affairs.

Ongoing, active management of urban, community, and rural forests is one method of identifying, resisting, mitigating, and managing invasive species. The fact that a small proportion of rural forest acreage is actively managed limits opportunities to counteract the threat of invasive species through early identification, preemptive actions to reduce risk, or rapid response to treat affected trees and forests.

BIODIVERSITY

Almost 15 percent of forest-associated species in the North are considered at some risk of extinction or extirpation. When a forest-associated species become nationally threatened or endangered, legislative remedies are activated to help its population recover. And some populations do recover. However, such mandated species recovery plans are a remedy of last resort; they are often accompanied by great expense, disruption, and uncertain outcome. Preferably, collective forest management (public and private) across the region would maintain species diversity by supporting a shifting mosaic of diverse forest habitats.

For Discussion

- **How would management aimed at increasing forest age-class diversity affect wildlife diversity?**
- **How would management to increase biodiversity affect recreation, water quality and quantity, commodity production, and bioenergy production?**
- **How might multiple management objectives converge to sustain or increase forest biodiversity while simultaneously providing other benefits?**

One approach to maintaining forest biodiversity is to create diverse, healthy forests that support many species, monitor species of conservation concern, and adapt management practices as necessary to sustain rare habitats and rare or declining species. This is done in a systematic way on many public forests and some private forests. State forest action plans (USDA and NAASF 2011) and wildlife action plans (Association of Fish and Wildlife Agencies 2011) address biodiversity issues in multiple ways, including management emphasis on priority conservation areas. On a regional level, analyses of biodiversity require additional emphasis. For example, as an artifact of past management and disturbance across the region, northern forests are clustered in the 40- to 80-year old age classes (Fig. 10), with relatively few forests younger than 20 years or older than 100 years. Given current rates of forest disturbance and regeneration, old forests will likely increase in abundance as forests across the region increase in age, but the area of young (early successional) forests—and associated habitats—will likely remain small. This has far-reaching implications for the abundance of wildlife species that depend on early- or late-successional forest habitats and, thus, for forest biodiversity in general. Forest age-class diversity is among the simplest measures of forest structural diversity and habitat diversity, and it is a measure for which there are excellent data at local, State, and regional scales. Yet the lack of forest age class diversity has received relatively little attention in discussions of forest sustainability across the North.

CONSUMPTION AND PRODUCTION OF WOOD AND PULP PRODUCTS IN THE NORTH

Consumption of wood and pulp products in the form of lumber, paper, plywood, composite panels, and pallets is about 71 cubic feet of wood per person annually, or roughly 8.8 billion cubic feet for the 124 million people who live in the Northern States. The proportion of U.S. wood products that come from net imports has been steadily increasing (Fig. 42). In 2005, U.S. net imports amounted to 6 billion of 21 billion cubic feet of total U.S. wood and pulp products consumption. The largest component of wood imports is softwood lumber, and most softwood lumber imports come from Canada. The United States is also a net exporter of some types of wood products such as hardwood lumber, but for all wood products in combination, annual imports greatly exceed exports.

In 2006, about 3 billion cubic feet of wood and pulp products were produced in the North (Table 9). This is a relatively small proportion of the total U.S. wood and pulp products production (20 percent) or consumption (15 percent) given that the North includes 32 percent of U.S. timberland (Fig. 1). However, as noted earlier, the North also has a high population and low forest per capita compared to the rest of the United States.

Timber is harvested and processed to meet demand generated by consumers. Where timber harvesting occurs—be it the North, elsewhere in the United States, or elsewhere in the World—it has impacts. It changes forest structure, species composition, habitat characteristics, the quantity of sequestered carbon, water and soil characteristics, recreation opportunities and other conditions. Timber harvesting in conjunction with a management plan can create opportunities to simultaneously address perceived problems with insects, diseases, invasive species, or biodiversity. A viable forest products industry can be an important source of employment and economic support for rural communities. Declines in forest products output can remove those opportunities.

For Discussion

- **How does consumption of forest products affect forest sustainability in the North and elsewhere?**
- **To what extent could the North's forests sustainably meet demand for wood and pulp products by people living in the North and elsewhere?**
- **To what extent can production of wood and pulp products in the North enhance opportunities to achieve other conservation goals such as improved forest health, increased biodiversity, increased employment, or increased access to renewable energy?**

CARBON SEQUESTRATION AND CLIMATE CHANGE

Concerns about climate change focus on the concentration of atmospheric carbon dioxide and other greenhouse gases, which in turn is affected by the amount carbon that is sequestered in forest ecosystems. Northern forests contain vast quantities of sequestered carbon in soils, live trees, dead trees, and down logs. As forests grow, they accumulate woody biomass, about half which is carbon (Fig. 37). The quantity of carbon annually sequestered from the atmosphere by all U.S. forests is only about 10 percent of the quantity of U.S. carbon emissions from burning fossil fuels and other sources. Forest management can increase the quantity of biomass and the amount of carbon sequestered, but carbon accounting is complicated by many variables including the number of years considered in the analysis, what happens to wood that is harvested, and anticipated tree mortality due to fire, insects, and disease. Management practices that enable forests to sequester more carbon annually are likely beneficial, but their impact will be relatively small compared to total carbon emissions from all sources. Some have suggested that a more effective way of reducing atmospheric carbon would be to use wood for energy (heat, electricity, liquid fuels), thereby offsetting carbon released from the fossil fuels and creating opportunities for carbon sequestration in regenerating forests (Malmsheimer et al. 2008).

Other actions that improve the carbon balance by increasing carbon sequestration or decreasing carbon emissions include:

- Keeping forests as forests
- Planting nonforested areas with trees (afforestation)
- Opting for durable wood products that sequester carbon during their useful life, and at the same time regenerating new trees after timber harvesting
- Conserving energy

These and other actions can help reduce new carbon emissions and/or sequester more carbon from the atmosphere. Most can be pursued simultaneously. Such actions are important components of a strategy to reduce net greenhouse gas emissions, but it appears that the annual quantity of carbon sequestered by all forest associated activities in the North will be far less than current annual greenhouse gas emissions.

Climate change has been frequently cited as a management concern for the northern forests, and it has been a high priority for research. Potential effects of climate change on forest ecosystems continue to be studied, including research that forecasts how the spatial distributions of tree species and wildlife are likely to shift under alternative climate change scenarios (Iverson et al. 2008, Matthews et al. 2007), Prasad et al. 2007, Rodenhouse et al. 2008.

For Discussion

- Given the longevity of trees and forest communities compared to the expected rate of climate change, what proactive forest management might be taken in anticipation of altered climate conditions?
- How will forests respond to climate change?
- How and where do management tactics for addressing climate change converge with other complementary management objectives?

BIOENERGY

The motivation to increase utilization of woody biomass for energy is directly related to concerns about greenhouse gas emissions, carbon sequestration, climate change, and our dependence on fossil fuels. Using woody biomass instead of fossil fuels to produce energy has the potential to reduce net carbon emissions. The most efficient strategies for managing carbon may be those that never release it to the atmosphere in the first place—conservation and renewable alternatives to fossil fuels. Knowledge and technologies continue to evolve on efficient ways to convert woody biomass into energy while reducing net greenhouse gas emissions.

The total amount of forest biomass in northern forests is immense, and the annual rate of biomass accumulation is much higher than the current rate of harvesting. However, energy demand is even higher. If the total annual woody biomass growth in northern forests were converted to energy, it could not meet the energy demands of the people who live in the region. Nor could total annual U.S. woody biomass growth meet the Nation's current demand for energy.

For Discussion

- **What management interests and objectives align with producing forest-based bioenergy?**
- **How is bioenergy production in various quantities likely to affect forest employment, the North's renewable energy portfolio, the types and quantities of other forest products produced, revenue to forest owners, and options to simultaneously achieve other compatible conservation goals?**

Biomass harvesting for energy production presents opportunities to simultaneously meet (or hinder) other resource objectives. Many convergent interests can affect and be affected by large-scale biomass harvesting. For example, the lack of early successional habitats (Fig. 10) for wildlife in northern forests is a serious concern among wildlife biologists (Askins 2001, Trani et al. 2001). Biomass harvesting has the potential to alter the amount and location of early succession forest habitat. Likewise in the North, oak regeneration failures have been a persistent problem on millions of acres of productive sites that currently have oak overstories. Loss of oaks from the forest reduces tree species diversity and diminishes habitat quality for mast-dependent wildlife species. Biomass harvesting conducted with a joint objective of increasing oak regeneration could be effective on many sites. The high density of people and forests in the North places woody biomass in close proximity to energy users. Under some scenarios this proximity could facilitate bioenergy utilization, but it could also decrease the capacity of forests to provide other commodities or ecosystem services.

CAPACITY FOR FOREST MANAGEMENT

Active forest management with silvicultural treatments is essential to achieve many desired products and services from forests. Outputs of wood products and biomass obviously depend on forest management practices. Less obvious, perhaps, is the importance of active forest management in restoring savanna and woodland habitats, providing habitat for desirable wildlife species, sustaining forest biodiversity, increasing forest carbon sequestration, or sustaining forest health. Northern forests are persistently afflicted by severe weather, invasive species, native insects, diseases, wildfire, and climate change. The undesirable impacts of these disturbance agents can be partially mitigated through proactive management to promote forest health and increase resilience. Reactive management following large-scale disturbance events can speed forest recovery and salvage forest products. Forest management is virtually the only process available for reducing the undesirable impacts of forest disturbances or for increasing the output of desirable forest products, amenities, and ecosystem services.

Active forest management requires motivation and adequate resources on the part of forest owners as well as adequate numbers of skilled and equipped specialists to prescribe and implement treatments—both of which are lacking throughout much of the region. Only 4 percent family forest owners report that they have a written management plan, and they tend to be the owners with larger forest acreages; collectively they manage about 16 percent of the total family forest area in the region (Butler et al. 2010).

URBAN AND COMMUNITY FORESTS

Most people in the Northern States—80 percent—live within urban areas that cover only 6 percent of the region's land base. However, urban areas in the North are expanding at a rate of nearly 4 million acres per decade, and 1.5 million acres of that expansion spread into land that was formerly classified as forest. This expansion of housing and other development changes the character of forests in important ways. Compared to trees in rural forests, for example, trees in urban or community areas tend to have higher value for aesthetics, cooling, stormwater management, and cleansing the atmosphere; lower value for wood products; and different habitat suitability for wildlife.

For Discussion

- How can State and regional forest assessments be used to monitor the cumulative effects of stand-scale forest management actions?
- How can landscape-scale conservation and management be applied to pursue management objectives that operate at different spatial scales (for example, timber management applied to a 20-acre tract versus migrant songbird habitat management applied across a 1,000-acre landscape)?
- To what extent can forest management be more widely and regularly applied in the North to allow forest owners and managers to pursue multiple conservation objectives?
- To what extent can forest-associated jobs and rural economic stability be supported by forest management activities?

Trees cover nearly 40 percent of urban or community lands. Because of their proximity to people, such trees are highly valued and are relatively expensive to treat or replace if attacked by insects or diseases. Parks, preserves, riparian zones, and other forested areas can provide unique habitats and recreation opportunities within urban or community areas. However, expanding urban and community lands along with parcelization, fragmentation, and expansion of impervious surfaces can reduce tree cover, degrade air and water quality, and alter species composition and biodiversity.

For Discussion

- **How can forest inventory and monitoring be improved to measure the range of benefits associated along the continuum of urban to rural forests?**
- **What options are available to manage urban and community expansion so that desirable forest-associated benefits are maintained while sustaining the needs of a growing human population?**
- **What new forest monitoring and management approaches, if any, are needed for States that are on trajectory to become predominantly urban land?**

CONCLUDING REMARKS

This assessment puts information about the forest conditions for individual Northern States in a spatial context and describes trends that have shaped the region's forests. Efforts to address many of the pressing forest resource issues in the North can benefit from this regional perspective. It also complements State Forest Action Plans (USDA FS and NAASF 2011).

Development of policies and practices supportive of forest sustainability requires the capacity to view the consequences of management decisions (including no action) across multiple spatial scales and multiple timeframes. Most forest management is implemented on the ground an acre or a stand at a time. Views of the forest from larger spatial scales and longer temporal scales are necessary to understand the cumulative effects of thousands or millions of individual management actions. Relevant spatial scales include landscapes, ecoregions, watersheds, States, multi-State regions, nations, and the World. Relevant timeframes include a few decades to more than a century.

Other forest assessments at various spatial scales have been conducted using the same Montréal Process format that was followed in this assessment. Such standardization is beneficial because it facilitates comparisons within and across spatial scales (such as within and among States). It also provides opportunities to improve the efficiency of future assessment efforts by standardizing the types of data that are reported for all spatial scales and by coordinating data collection and reporting activities.

Although this assessment provides key information for those interested in forest sustainability, we intentionally avoid stating whether forests and forest management in the North are sustainable, primarily because all definitions of forest sustainability are partially subjective. Nevertheless the assessment identifies some specific conditions and trends that appear consistent with forest sustainability and some that do not. More importantly, it provides necessary facts, figures, and maps for ongoing, detailed discussions about the current and future sustainability of northern forests.