Assessing and Forecasting Change in Northern Forests

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Introduction

THE PURPOSE OF this report is to describe how yesterday's trends and today's choices might change the future forest landscape of the Northern United States from 2010 (the baseline year) to 2060. Its results are intended to help resource managers and policy makers identify actions that will sustain the health, productivity, diversity, and resilience of these forests, which provide for the well-being of the 125 million people who currently live in the 20 Northern States (Fig. 1.1) and for 32 million additional people expected by 2060.

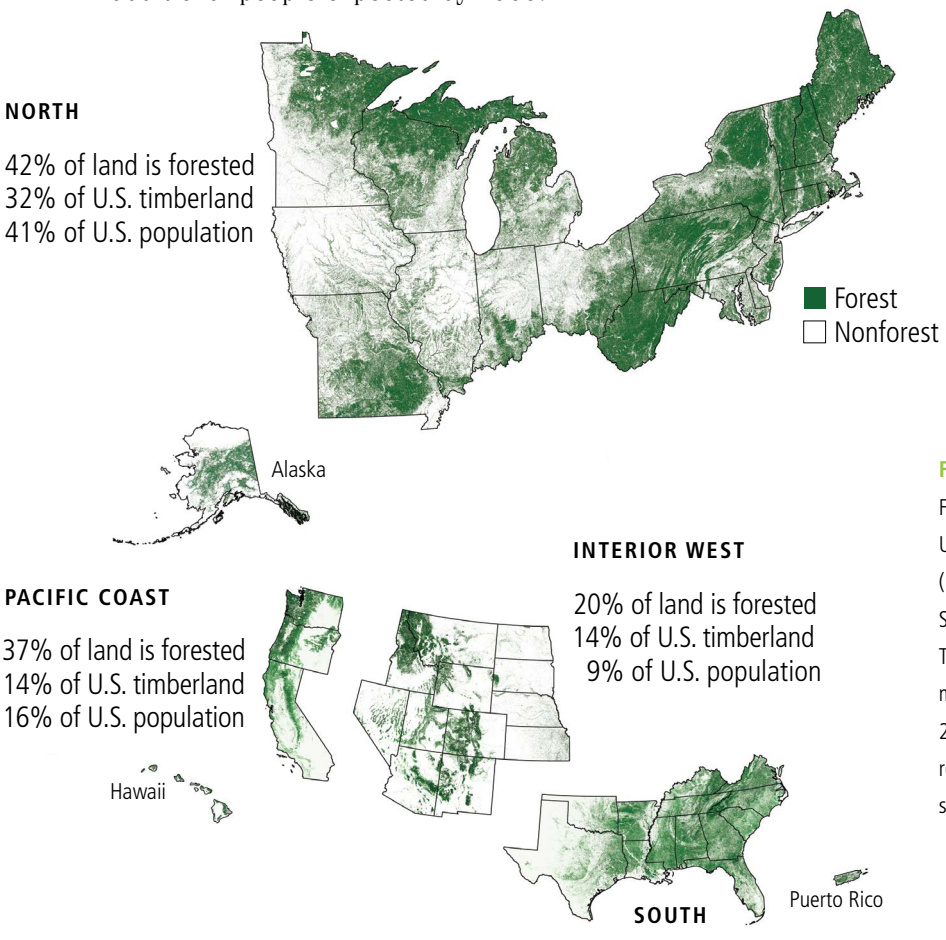


FIGURE 1.1
Forested area and population of the Northern United States compared with other U.S. regions (Homer et al. 2004, Shifley et al. 2012, Smith et al. 2009, U.S. Census Bureau 2010). Timberland is defined as forest land that maintains a minimum potential for growth of 20 cubic feet per acre per year and is not restricted from active forest management by statute or regulation.

Our attention is on issues that affect forest resources in the broadest sense, including urban and rural trees and forests; forest-associated plants and animals; tree and forest health; water and soil conservation; carbon sequestration; timber and nontimber forest products; forest-based employment; attitudes, laws, and policies affecting forest use and management; land-use change; and forest fragmentation.

A large component of forest change will be the result of normal forest growth, aging, natural regeneration, and species succession. In addition, we expect that a range of external forces will also drive forest change:

- Population increases will cause millions of acres of forest land to be converted to urban and other land uses.
- Economic conditions will affect forest products consumption, production, and harvesting rates.
- The spread of invasive species will exacerbate the effects of other disturbances on forest ecosystems.
- Changes in population, economic activity, energy consumption, and energy production will affect future climate change.
- Climate change will, in turn, affect dynamics within forested ecosystems, including patterns of vegetation growth and species succession.

Because we cannot know with certainty how the economy, population, or climate will change in the future, this report presents several alternative scenarios that cover a range of different assumptions about these and other driving forces. The assumptions were incorporated into analytical models that were used to estimate how northern forests are likely to change under each alternative scenario.

NORTHERN FORESTS IN CONTEXT

The U.S. North consists of 20 Central and Northeastern States (Fig. 1.1) that together constitute the most heavily forested and most densely populated quadrant of the Nation (Shifley et al. 2012). Maintaining diverse, healthy, productive forests requires managers and policy makers to anticipate future changes and respond proactively to avert negative consequences of those changes.

Past and current forest conditions and forest management issues for the North are presented in detail in previous products of the Northern Forest Futures Project. Northern forests today bear the imprint of land-use practices over prior centuries (Thompson et al. 2013). As European settlers migrated westward into forested areas in the 1700s and 1800s, they set in motion the following general sequence of processes that shaped the current condition of northern forests:

- Exploitive timber harvesting
- Forest clearing for agriculture
- Burning forests to open the understory and benefit livestock grazing

- Gradual abandonment of marginal agricultural lands with reversion to forest cover
- Aggressive forest fire suppression
- Urbanization
- Forest fragmentation
- Maturing timber resources
- Aging private forest owners
- Low management intensity among family forest owners

The cumulative consequences of human activities on northern forests have been dramatic over the past 50 years. Some changes have been remarkably positive—an increase of 11 million acres of forest land (7 percent) and an increase of 144 million cubic feet of timber (240 percent), both despite a population increase of 26 million people (27 percent). Other changes have been of great concern—the expanding impact of invasive species, loss of species diversity, increasing numbers of areas in which urban expansion is shrinking forest acreage, fragmentation of forest land, parcellation of forest ownerships, loss of forest-based employment, effects of burgeoning white-tailed deer (*Odocoileus virginianus*) populations on tree regeneration and forest composition, and increasing atmospheric carbon emissions.

We expect equally dramatic changes in northern forests over the next 50 years. Some will be the consequences of the natural forest processes that over time affect every forest acre.

Other changes will be determined by human activities including:

- Conversion of forests to other land uses
- Introduction and continued spread of invasive species
- Emphasis on management practices that focus on forest health and species diversity
- Consumption of forest products
- Production of wood-based bioenergy
- Extraction of gas and minerals beneath forest land
- Competing pressures and changing preferences among outdoor recreation enthusiasts
- Valuation of forest ecosystem services and commodities
- Federal and State policy and legislation
- Effectiveness of hunting as a tool for controlling white-tailed deer populations

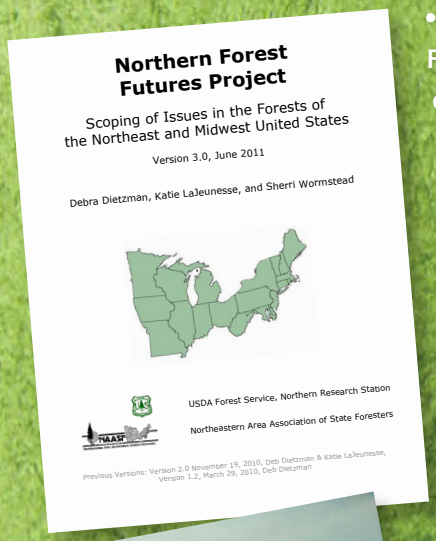
Still other changes will be determined by emerging global-scale phenomena. An example is climate change, which is expected to gradually increase in impact over the next 50 years and beyond. It is a phenomenon that we have limited ability to control locally and for which mitigation through forest management is still in early stages.

The processes of natural regeneration, species succession, growth, inter-tree competition, aging, senescence, and weather-related disturbances—when coupled with vast forest acreage—result in gradual forest changes at a landscape scale that is measured in thousands or millions of acres. The cumulative effects of human activities, when combined with normal forest dynamics, can take decades to unfold at State and regional scales.

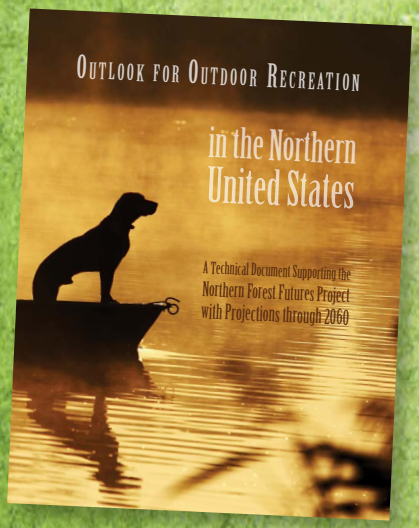
Northern Forest Futures Project

The Northern Forest Futures Project is a multi-year, collaborative undertaking by the Northern Research Station of the U.S. Forest Service to provide a window on tomorrow's forests, demonstrating how today's trends and choices might change tomorrow's landscapes. The intent of this research is to provide forest owners, managers, and other decisionmakers with information to guide sustainable management of the public and private forests in the Northern United States.

Some previous outputs from the Northern Forest Futures Project include:

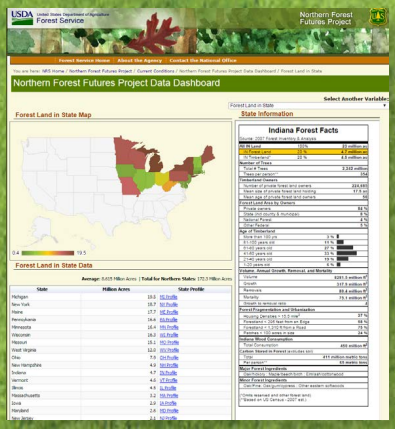


- "Northern Forest Futures Project: Scoping of Issues in the Forests of the Northeast and Midwest United States," by Debra Dietzman et al. (2011), offers a broad-scale summary and analysis of widespread issues affecting northern forests.

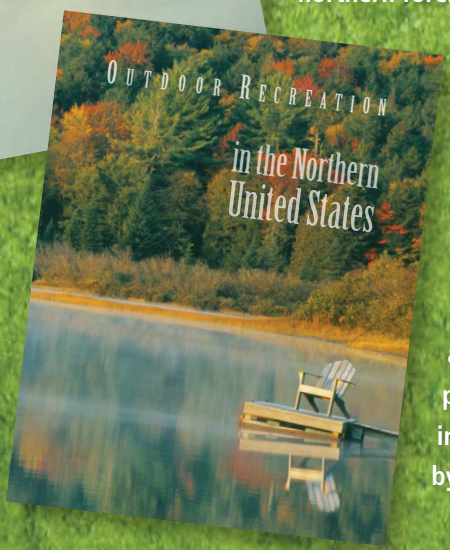


- "Outlook for Outdoor Recreation in the Northern United States…," by Bowker and Askew (2013), is a technical document supporting the Northern Forest Futures Project with recreation projections through 2060.

- "Forests of the Northern United States," by Stephen R. Shifley et al. (2012), reports on current baseline (2010) conditions of northern forests.



- Web-based tools for an interactive summary, mapping, and graphical visualization of forest-associated data for the North are available at http://www.nrs.fs.fed.us/futures/dashboard/.



- Detailed trends and projections for participation in dozens of outdoor recreation activities in the North are published in "Outdoor Recreation in the Northern United States," by H. Ken Cordell et al. (2012).

For example, local disturbances, such as forest clearing resulting from urban development or violent weather, can produce obvious changes in forest conditions at a particular location. However, such disturbances need to cumulatively affect millions of acres to represent a significant change in the collective condition of 174 million acres of northern forest land. Consequently this report takes a long-term, large-scale perspective in describing how scenario analysis and other forward-looking analytical tools will help society understand the magnitude of cumulative forest changes anticipated over the next 50 years.

SCENARIO ANALYSES

Subsequent chapters of this report present a methodology for and results of our efforts to describe how the conditions represented by the alternative scenarios would change northern forests over the next 50 years. The scenarios all start with forest conditions as of 2010, and they all incorporate predictable patterns of forest growth, mortality, aging, and species succession. Scenarios differ in assumptions about land-use changes, population growth, forest product output levels, invasive species impacts, and climate change.

For each scenario, a system of models was applied to make detailed, quantitative projections of forest area, age structure, volume, biomass, and forest-type group; and of characteristics that are linked to changes in forest condition, land use, and human demographics including measures of biodiversity, surface water quality, forest fragmentation, insect and disease impacts, and demand for outdoor recreation.

The analyses presented in this report drew on data and methods that had been developed for other national and regional analyses. Those prior efforts provided a context, data, and analytical techniques that helped us compare alternative scenarios. Collectively, the results of prior analyses and those described in later chapters of this report provide a window on future forest conditions in the North and insight into the choices that will be available for directing forest conditions along a path that society considers desirable. Ultimately it is the work of society to choose among options, make tradeoffs among desirable outcomes, and find effective and equitable solutions. We hope that our analyses provide society with a better understanding of possible futures for northern forests and therefore serve as a basis for making wise choices.

Related National and Regional Reports

The Northern Forest Futures Project benefited from several national and regional analyses, which provided guidance, data, and analytical methods that could sometimes be modified and applied to similar analyses for individual Northern States. Throughout the course of the project, prior publications helped set the ecological and socioeconomic context for the North.

The 2010 national report on sustainable forests (USDA FS 2011) is the most recent synthesis of U.S. forest resources for each of the seven Montréal Process criteria and their associated indicators. It provided the framework both for this report and for the report on past and current forest conditions (Shifley et al. 2012). Some of the data sources compiled for the national report were also used here.

The scenario analysis methods developed for the 2010 Resources Planning Act (RPA) assessment (USDA FS 2012c, Wear et al. 2013) provided a quantitative framework that was modified for the northern state-scale scenario analyses of forest change. Dozens of RPA technical reports document the estimation methods and underlying climate and socioeconomic assumptions used in the national scenario analyses of future forest conditions (USDA FS 2012d). To the extent possible, the Northern Forest Futures Project followed the assumptions and analytical methods for scenario analysis that were used for the national RPA analyses.

Individual State forest action plans (NAASF 2012), a regional collective summary of all the State action plans (Wormstead et al. 2011), and output from the Forest Sustainability Indicators Information System (USDA FS 2012b) provided detailed, state-scale information about forest resources, issues, and management priorities. This information sets the context for projecting conditions of individual Northern States.

State forest inventories repeated through time by the Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service (USDA FS 2012a) provided the core descriptive forest data for individual States and for the region as a whole. The scenario analysis methods used in this report projected conditions for each FIA inventory plot forward in time, subject to the assumptions and conditions of each scenario. The highly refined FIA database summary and analysis tools simplified additional efforts to analyze and interpret the projection results (Miles 2013, USDA FS 2013).

The Southern Forest Futures Project (USDA FS 2012e, Wear and Greis 2013) is the forerunner of and inspiration for the Northern Forest Futures Project. Although the two projects differed somewhat in approach, the basic projection methodology that was used for the Northern States was developed as part of Southern Forest Futures Project and the national RPA.

As detailed in Chapter 2, the scenarios analyzed are closely tied to those used nationally for the Resources Planning Act assessment (USDA FS 2012c, 2012d). Moreover the format of the Montréal Process Criteria and Indicators (described on page 8) was followed when reporting results. The approach and methodology can provide a context for landscape-scale conservation and land-use planning across various scales, including national forest plans and State forest action plans. The projections of future forest conditions for the North and for the 20 individual States it encompasses are provided for use in the preparation of a range of assessment and planning documents.

Although the focus here is on forest conditions within the U.S. North, there are related ecological, social, and economic flows with the U.S. South and Canada. Those are not addressed in this report, but complimentary material for those regions is available from many sources including the Southern Forest Futures Project (Wear and Greis 2013) and Natural Resources Canada (2015).

Montréal Process Criteria and Indicators

As part of the Montréal Process Working Group the United States has joined with 11 other member nations to define seven criteria (essential components) that are described by 54 indicators (measures)—these collectively provide a structured approach for assembling and organizing information relevant to an assessment of sustainable management of temperate and boreal forests (Montréal Process Working Group, n.d.). This report is organized around the seven Montréal Process criteria plus an eighth that describes urban forest resources.

Individual indicators address resource conditions such as forest area, canopy cover, wood volume, forest health, and biodiversity as well as processes such as land-use change, tree growth, tree removals, and recreation. The Montréal Process Criteria and Indicators are scalable and have been the foundation for national (USDA FS 2011), regional (USDA FS 2012b), State (USDA FS 2011, Wormstead et al. 2011) and county assessments (Baltimore County Maryland Department of Environmental Protection and Resource Management 2007).

Criterion name[a]	Number of Montréal Process indicators used to describe the criterion	Corresponding chapters of this publication
1 Conservation of biological diversity	9	3
2 Maintenance of productive capacity of forest ecosystems	5	4
3 Maintenance of ecosystem health and vitality	2	5
4 Conservation and maintenance of soil and water resources	5	6
5 Maintenance of forest contribution to global carbon cycles	3	7
6 Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies	20	8
7 Legal, institutional, and economic framework for forest conservation and sustainable management	10	9
8 Urban forests	n/a	10

[a]*The first seven criteria are taken from the Montréal Process Working Group (2013).*

CRITERIA AND INDICATORS

We use the format of the Montréal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 2013) to organize information about the expected future condition of northern forests.

This organization matches the format used in the report on current conditions of northern forests (Shifley et al. 2012), a choice intended to simplify comparison of current and anticipated future forest conditions. The format is based on seven criteria that characterize the essential components of sustainable forest management and 54 indicators (metrics) that describe the criteria in terms of forest conditions.

Some of the 54 indicators of forest conditions included in the Montréal Process are well defined and readily quantified, but others are not. For example, indicators that report on forest area, wood volume, carbon, insects, diseases, species diversity, fragmentation, products, employment, recreation, or best management guidelines can be quantified with existing information and can sometimes be projected forward in time. Other indicators are ambiguously defined, or they lack the metrics needed for quantitative—or even qualitative—definition. Examples include measures of resilience in forest-dependent communities, the importance of forests to people, whether trade policies for forest products are discriminatory, or the success of efforts to conserve genetic diversity. Chapters 3 through 9 address the seven Montréal Process criteria, focusing on indicators that can be described quantitatively and offer some capacity for examining past trends and future expectations.

In addition to the seven Montréal Process criteria, our analysis included one additional criterion—urban forests—which addresses a forest component that is relatively small in area but expanding. Urban trees and forests are of high impact because they affect the quality of life of urban dwellers that constitute the majority of the North's population.

REPORT ORGANIZATION

Chapter 2 provides detailed descriptions of the scenarios, assumptions, and forecasting methods used to project future forest conditions from 2010 to 2060. Chapters 3 through 9 describe current trends and anticipated future changes for selected indicators that are associated with each Montréal Process criterion. Chapter 10 gives additional focus to urban trees and forests. Finally, Chapter 11 summarizes the major drivers of northern forest change and offers some of the associated implications. The appendices provide additional quantitative details for individual Northern States.

The Northern Forest Futures Project Web site (http://www.nrs.fs.fed.us/futures/) and the Northern Forest Futures database (online and included with the printed version of this report) provide an opportunity for users to interactively explore data and results related to these analyses.

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