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National Report on Sustainable Forests—2003

Prologue

A new century has dawned. With it has come increased demand for goods, services, and amenities from the private and public forests of the United States. Increasing population and increasing urban centers are creating demands on our forests that were not envisioned a century ago. Today, 270 percent more U.S. citizens are being supported by essentially the same forest land area—749 million acres—as existed in 1900. Certainly we are closer to the limits of our forests' capability to provide the things people want today than we were in 1900.

Since 1900, a few national assessments and reports have made critical contributions to the development of U.S. forests. By informing public discussion about U.S. forests, the reports shaped the policy choices and pathways taken to manage American forests. One such example is *Forest Taxation in the United States*, which provided new options for forest taxation that eliminated the confiscatory nature of previous tax laws and made it possible for private landowners to invest in reforestation and stand management activities.[1] More recently, the *2000 RPA Assessment of Forests and Rangelands*[2] and the *Southern Forest Resource Assessment*[3] influenced public discussion of domestic forest management policies from a national and a regional perspective.

This report presents a fresh analysis of the available data on the condition of forests in the United States. It uses the criteria and indicators of sustainable forest management endorsed by the Montreal Process, of which the United States is a member country.[4] The report also identifies data gaps and makes recommendations for next steps to move forward the state of the art for analysis of sustainable forest management in the United States. A supporting document, "Data Report—Technical Document Supporting the 2003 National Report on Sustainable Forests," is available at http://www.fs.fed.us/research/sustain/. Thus, this report represents a significant step forward in providing an analysis of data that is consistent and comparable with analysis of data by other Montreal Process countries.

The collective hope of the team of experts who assembled this report is that the reader will gain a better understanding of what available data can tell us about the status, condition, and trends in U.S. forests. The further identification of data gaps and analysis possibilities will better equip the reader to participate in the public dialog about America's forests and to help shape future policies.

"Better data leads to better dialog, which leads to better decisions"—it has been our mantra.

Richard W. Guldin and H. Fred Kaiser

[1] F.R. Fairchild et al. 1935. Forest taxation in the United States. USDA Miscellaneous Publication No. 218, U.S. Department of Agriculture.
[2] USDA Forest Service. 2001. 2000 RPA assessment of forest and ranglands. FS-687. Washington: USDA Forest Service.
[3] Wear, D.N., and J.G. Greis.. 2002. The southern forest resource assessment. Asheville, NC: USDA Forest Service, Southern Research Station.

[4] Visit the Montreal Process Web site for more information: http://www.mpci.org.

Acknowledgments

A team of experts is required to prepare a report of this scope and depth.

The national report was prepared by a core team composed of Brian Czech (U.S. Fish and Wildlife Service), Paul Geissler (U.S. Geological Survey), and the following individuals from the USDA Forest Service—David Darr, Mark Delfs, Richard Guldin, Robert Hendricks, William Lange, Ruth McWilliams, Steverson Moffat, and David Radloff.

Criterion team leaders each provided leadership to a team of indicator specialists in preparing the individual indicator reports and criteria summaries:

- Biological Diversity: Curtis H. Flather and Kurt Riitters
- Productive Capacity: W. Brad Smith
- Forest Health: Ken Stolte
- Soil and Water: Ken Stolte
- Carbon Cycles: Linda Heath
- Socioeconomic Benefits: Ken Skog
- Legal, Institutional, and Economic Framework: Paul Ellefson and Jim Granskog

In addition to the work of the criterion team leaders, the following individuals (including some criterion team leaders) authored or coauthored one or more supporting technical documents for the indicators and the 1-page summaries:

- Biological diversity: Curtis H. Flather, Kurt Riitters, W. Brad Smith, Taylor Ricketts, Carolyn Hull Sieg, Michael S. Knowles, John P. Fay, Noah Barstatis, and Jason McNees
- Productive capacity: W. Brad Smith and Susan J. Alexander
- Forest health: William M. Ceisela, John Coulston, and Mark J. Ambrose
- Soil and water: Katherine P. O'Neill, Ken Stolte, Michael C. Amacher, and David Chojnacky
- Carbon cycles: Linda Heath, Ken Skog, and Jim Smith
- Socio-economic benefits: Ken Skog, Susan J. Alexander, James Howard, Ken Cordell, Carter Betz, Susan Kocis, Michael Tarrent, Alan Pierce, Robert Schroeder, Joseph O' Leary, Joseph Tainter, David Wear, Karen Abt, Richard Haynes, and Marla Emery
- Legal, institutional, and economic framework: Paul V. Ellefson, Calder M. Hibbard, Michael A. Kilgore, C. Denise Ingram, Michael Hicks, W. Brad Smith, David Darr, Margaret Connelly, Rob Hendricks, Linda Langner, Steve McNulty, Sharon Friedman, and Clark Baldwin.

Although each indicator is limited to a single page in this report, extensive technical supporting documentation was developed for most indicators. That detail is contained in the Data Report and the contributions of the criteria team leaders and individual indicator authors are recognized there.

A host of other individuals provided support and encouragement along the way, several of whom retired mid-stream. Phil Janik's enthusiasm was largely responsible for initiating the Roundtable on Sustainable Forests, and together with the Roundtable Core Group, he provided leadership early in the report development process. Following Janik, first Pete Roussopoulos and then Joel Holtrop provided continuity of USDA Forest Service contributions to the Roundtable Core Group. As coleader of the Roundtable representing the National Association of State Foresters, Gerry Rose has supported this project from the outset.

H. Fred Kaiser was the initial leader of the core team preparing the report. He was a pioneer in recognizing how the criteria and indicators could be used to improve national reports on the condition of U.S. forests.

In a memorandum of understanding, the following Federal agencies agreed to a process for helping the Federal agencies develop a national report by 2003 for the Montreal Process on the state of the Nation's forests and progress toward sustainable forest management in the United States: USDA's Cooperative State Research, Education, and Extension Service, Forest Service, National Agricultural Statistics Service, and Natural Resources Conservation Service; the U.S. Department of Defense; the U.S. Department of Interior's Bureau of Indian Affairs, U.S. Geological Survey, U.S. Fish and Wildlife Service, and the Office of Policy Analysis; and the National Aeronautics and Space Administration.

The Meridian Institute, long-term facilitator for the Roundtable on Sustainable Forests, significantly improved the process for obtaining public review and comment on successive drafts of the report by organizing and hosting public workshops in April, May, and November of 2002. Their assistance in synthesizing public comments is greatly appreciated.

Richard W. Guldin

Contents

Introduction

Purpose of the National Report

This is a report on the state of the forests in the United States of America and the indicators of national progress toward the goal of sustainable forest management. Our goal is to provide information that will improve public dialog and decisionmaking on what outcomes are desired and what actions are needed to move the Nation toward this goal. We also intend to establish a baseline for future measurement of our progress. The indicators used reflect many of the environmental, social, and economic concerns of the American public regarding forests. While the report presents data primarily at a national or regional scale, it also provides a valuable context for related efforts to use the indicators to measure progress at such other geographic and/or political scales as ecoregions, States, watersheds, and communities. Scale represents the geographic area in which stakeholders operate. Action at all levels is vital to achieving sustainable forest management in the United States. Unless people at all geographical and political levels across the country conserve, protect, and use forest resources in sustainable ways, then what is said or done at the national level means little.

Origin of the Report

To achieve success in advancing forest sustainability throughout the United States across different ownerships, geographic settings, and political jurisdictions, it is essential to have cooperation among public and private owners, managers of forest lands, and other stakeholders. In 1994, the U.S. Department of Agriculture (USDA) Forest Service and the U.S. Department of State conducted an extensive national outreach effort, including a Federal Register notice, to assemble a group of forest stakeholders to provide an ongoing forum for sharing information and perspectives on sustainable forest management. The initial focus of discussion for the stakeholder group concerned development of a set of criteria and indicators (C&I) that would describe the basic elements of sustainable forest management and be used to measure national progress toward this goal.

The U.S. Departments of State and Agriculture used the results of stakeholder discussions in international deliberations on C&I. In 1995, these discussions resulted in the adoption of a set of C&I by the United States and several other countries with temperate and boreal forests.[5] These countries are participants in what is known as the Montreal Process Working Group on C&I (described later in greater detail). The C&I are intended to provide a common understanding of the essential components of sustainable forest management, and a common framework for describing, assessing, and evaluating a country's progress toward this goal at the national level. The C&I have also been adapted for use at other levels in the United States, including by some State agencies, regional planning groups, and others.

Participants in the stakeholder forum endorsed the C&I, and they have continued to meet periodically to review progress in the use of the C&I. The forum evolved into what is known as the Roundtable on Sustainable Forests, which first convened in 1998.[6] Participants in this forum have included representatives of Federal and State government agencies, tribal governments, conservation and environmental groups, private forest landowner organizations, forest products companies, regional and community-based organizations, professional societies, and academic institutions, as well as scientists and other citizens. The initial focus of the roundtable was to advance the use of the C&I and share other opportunities for sustainable forest management. This report had its impetus in the commitment made by the roundtable participants to help produce, by 2003, a national report based on the C&I, describing the current status and conditions of forests in the United States, including trends in their health, productivity, and use. The report also fulfills a commitment made by the United States and other Montreal Process countries to develop and share, by 2003, individual national reports based on C&I for sustainable forest management.[7]

The preparation of this report started with a series of three workshops for technical experts to assess potential sources of data, which was organized by the Roundtable on Sustainable Forests.[8] The authors used the results of those workshops to gather and analyze data for the report. After a draft report was available, the roundtable convened additional stakeholder workshops to review the draft and provide comments on how to improve it.[9] The draft was also made available on the Internet to enable other members of the public to offer suggestions. The USDA Forest Service and other members of a working group of Federal agencies and offices (known as the Sustainable Forest Data Working Group) assumed responsibility for preparing the report, which was initiated by the Federal participants in the

[5] See Analyses of the Indicators for a complete list of the C&I.

[6] See http://www.sustainableforests.net.

[7] The Montreal Process now involves 12 countries on 5 continents, which together contain 90 percent of the world's temperate and boreal forests and 60 percent of the world's total forests—See http://www.mpci.org/home_e.html.

[8] See http://www.sustainableforests.net/C&I_workshops/ci_workshops.html.

[9] See http://www.sustainableforests.net/C&I_workshops/Summary_Review_WS_DC_020626.pdf, http ://www.sustainableforests.net/C&I_workshops/Summary_Review_WS_Portland_0206.PDF, and http://www.sustainableforests.net/C&I_workshops/Summary_Final_Review_WS_021219.pdf.

Roundtable on Sustainable Forests.[10] Those participants are also signatories to a Federal Memorandum of Understanding on Sustainable Forest Management Data.[11]

Scope of the Report

Overview

The report—
- Addresses individually each of the 67 Montreal Process indicators. For most indicators, the presentation includes a graphical display of the data, an explanation of what the indicator is and why it is important, a narrative description of what the data shows, and, in some cases, an explanation of current limitations in reporting on the indicators. The presentation of each indicator is limited to one page. Supporting technical documents for each of the indicators are available on the report Web site.[12 & 13]
- Contains a summary discussion of each of the seven criteria, explores relationships among the C&I, and presents some approaches to interpreting the information.
- Profiles examples of actions that public and private forest managers and stakeholders at all scales are currently implementing to improve forest management and forest conditions in the United States.
- Describes some possible next steps for improving the understanding and reporting of the C&I for sustainable forest management. It highlights critical issues and provides links to more detailed information on the issues that arose during the preparation of the report.

State of the Data

This is the most comprehensive national report ever prepared using indicators for sustainable forest management in the United States. Work on the report revealed, however, that data on some indicators is lacking. The C&I were derived from a multistakeholder process and reflect contemporary notions of sustainability that require information beyond what has been traditionally collected and reported. Over time, the United States will make progress in reporting on these indicators. For example, the concluding section of this report identifies proposed steps for resolving some of the most critical data and analysis issues.

Interpreting Results

Our approach to interpreting data in this report is to present the best available information on the indicators, along with sound scientific analysis of that information. We highlight trends, where possible, and identify areas in which additional data or research is needed. We later suggest some possible methods for further interpreting the results, including exploring the interrelationships among the C&I. Environmental, social, and economic systems are diverse and dynamic, and our understanding of these systems and their interactions is limited. Although good historical data is available on some of the indicators, the required baseline data for determining trends for many other indicators is lacking. Reference conditions linked to desired future conditions are absent for most indicators. For all these reasons, the report does not state a conclusion on whether the combination of environmental, social, and economic conditions and trends documented here constitute overall progress toward achieving sustainable forest management.

For those who are interested in the future of forests in the United States, this report provides the basis for a broad public discourse concerning the interpretations of conditions and trends reported for the indicators and the actions needed to assure progress in sustainable forest management. For example, interested parties can use the information in this report to develop modifications to inventory systems and research programs and to improve the ability to measure progress in future reports. It will also provide an important data source for future planning and decisionmaking, as well as a baseline for future monitoring of the indicators to reveal whether plans and decisions are leading to better outcomes.

Relationship to Other Reports

This report builds upon a recent national resource assessment, the *2000 RPA Assessment of Forest and Range Lands*, that used the C&I as a framework. It was prepared by the USDA Forest Service, under the mandate of the Renewable Resources Planning Act (RPA).[14]

The work done for this report also contributed to other efforts regarding indicators of forest condition. For example, information developed by Federal agency scientists for this report was shared with the Heinz Center for use in its recently released report, *The State of the Nation's Ecosystems: Measuring the Lands,*

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[10] See http://www.pwrc.usgs.gov/brd/sfd.htm for further information on the Sustainable Forest Data Working Group, which is chartered under the Federal Geographic Data Committee. Participating agencies and offices include Department of Agriculture (Cooperative State Research, Education, and Extension Service; Forest Service; National Agricultural Statistical Service; Natural Resources Conservation Service), Department of Defense (Office of Deputy Undersecretary for Environmental Security), Department of the Interior (Bureau of Indian Affairs, Bureau of Land Management, National Park Service, Office of Policy Analysis, U.S. Fish & Wildlife Service, U.S. Geological Survey), and National Aeronautics and Space Administration (Earth Science).

[11] See http://www.fs.fed.us/sustained.

[12] See http://www.fs.fed.us/research/sustain/.

[13] Indicator 61 summarizes the data status for each of the 67 indicators in terms of coverage, currency, and frequency. The indicators having the most complete coverage are primarily those monitored through the Forest Inventory and Analysis Program (see http://www.fia.fs.fed.us).

[14] See http://www.fs.fed.us/pl/rpa/.

Waters, and Living Resources of the United States.[15] The report presents a synopsis of the best available national data on indicators for six different ecosystem sectors, including a list of 15 indicators for forest ecosystems. The information has also been shared with the U.S. Environmental Protection Agency (EPA) for a report being prepared from its perspective on national environmental indicators. In addition, some of the data and analysis used to prepare this report also contributed to the recent Southern Forest Resource Assessment.[16]

Concepts of Sustainable Development and Sustainable Forest Management

The Idea of Sustainability

While many ideas about sustainability have been put forward during the last two decades, almost all are consistent with the basic concept of sustainable development found in the 1987 Brundtland Commission Report (WCED 1987). The Brundtland Commission defined sustainable development as—

> *…development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

The concept of sustainable development links the environment, society, and the economy. These three basic components or spheres of sustainable development are often stated as three interdependent goals of environmental protection, social well-being, and economic prosperity. The essential idea is that environmental, social, and economic issues and values must be integrated into our decisionmaking and actions, while accounting for future as well as present needs. In all decisions, the long-term effects on resources and capital, as well as the capacity for the future creation of benefits, should be considered (Anderson et al. 2002). In its 1999 report, *Our Common Journey: A Transition toward Sustainability*, the National Research Council's Board on Sustainable Development described sustainable development as "t*he reconciliation of society's developmental goals with its environmental limits over the long term.*" The board also noted that "*any successful quest for sustainability will necessarily be a collective, uncertain, and adaptive endeavor in which society's discovering of where it wants to go and how it might try to get there will be inextricably intertwined.*"

Thus, this report presumes that sustainability should be viewed as more of a journey than a destination. It is not a fixed target, and the pathway to sustainability may involve a range of acceptable outcomes, as well as a range of feasible courses to reaching those outcomes determined by carefully weighing environmental, social, and economic criteria (Fedkiw 2001). The Brundtland Commission describes the journey this way: "*…in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs*" (WCED 1987).

Recognizing that sustainability is a global concern and a common goal for human development, the United States and 177 other nations of the world came together at the Rio Earth Summit in 1992, and agreed to take concrete steps to advance sustainable development.[17] Forest issues were a major focus of discussion at the Earth Summit, and sustainable forest management was recognized as a key part of the global goal of sustainable development. A Statement of Forest Principles, declaring the importance of managing all forests in a sustainable manner, was adopted as the first global agreement on forests.[18] In the United States, during the decade following the Earth Summit, various national dialogs about sustainable development and sustainable forest management were initiated, such as the President's Council on Sustainable Development and the Seventh American Forest Congress. These dialogs resulted in the adoption of goals and policy recommendations for the United States.

At the 2002 World Summit on Sustainable Development (WSSD), the United States and other nations reaffirmed their commitment to the Rio principles, adopting a plan of implementation designed to build on the achievements made since 1992 and to expedite the realization of remaining goals, including more integrated and cross-sectoral solutions. As a result of WSSD, the understanding of sustainable development was broadened and strengthened, particularly the important linkages between poverty, the environment, and the use of natural resources. For example, the WSSD plan of implementation makes this statement regarding forests:[19]

> *Sustainable forest management . . . is essential to achieving sustainable development and is a critical means to eradicate poverty, significantly reduce deforestation and halt the loss of forest biodiversity and land and resource degradation, and improve food security and access to safe drinking water and affordable energy; highlights the multiple benefits of both natural and planted forests and trees; and contributes to the well-being of the planet and humanity.*

[15] See http://www.heinzctr.org/ecosystems/.
[16] See http://www.srs.fs.fed.us/sustain.

[17] See http://www.un.org/esa/sustdev/agenda21.htm (Agenda 21, the Rio Declaration on Environment and Development).
[18] See http://www.un.org/documents/ga/conf151/aconf15126-3annex3.htm.
[19] See http://www.johannesburgsummit.org/html/documents/summit_docs/2309_planfinal.htm.

Defining Sustainable Forest Management

In the book *Forest Sustainability: the History, the Challenge, the Promise*, Donald Floyd (2002) observes that—

> *…trying to define sustainability and sustainable forestry is like trying to define "justice" or "democracy." There are many definitions and some consensus, but agreement over the specifics is elusive. If sustainability cannot be specifically defined, does that mean it is of little value? Foresters know there are many useful yet ambiguous terms, like "multiple use," "forest health" and "ecosystem." We come to grips with any new idea through discussion and debate, and we are still in the process of debating and defining the meanings of sustainability.*

The terms **forest sustainability** and **sustainable forest management** are sometimes used interchangeably, and refer to the same basic concept. The concept has been given specific meaning through the development of criteria and indicators for sustainable forest management. The *Dictionary of Forestry* (Helms 1998) offers this description of forest sustainability:

> *….the capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity, in the long run, in the context of human activity and use.*

The *Dictionary of Forestry* also states that sustainable forest management is an evolving concept that has several definitions. It offers two, the second of which specifically incorporates the seven criteria from the Montreal Process:

1. *The practice of meeting the forest resource needs and values of the present without compromising the similar capability of future generations – note sustainable forest management involves practicing a land stewardship ethic that integrates the reforestation, managing, growing, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water quality, wildlife and fish habitat, and aesthetics.*
2. *The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and potential to fulfill, now and in the future, relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems–note criteria for sustainable forestry include (a) conservation of biological diversity, (b) maintenance of productive capacity of forest ecosystems, (c) maintenance of forest ecosystem health and vitality, (d) conservation and maintenance of soil and water resources, (e) maintenance of forest contribution to global carbon cycles, (f) maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies, and (g) legal, institutional, and economic framework for forest conservation and sustainable management.*

The Society of American Foresters adopted the following statement defining the concept of sustainable forest management:[20]

> *"Sustainability as applied to forestry is the enhancement of human wellbeing by using, developing, and protecting resources at a rate and in a manner that enables people to meet their current needs while also providing future generations with the means to meet their needs as well; it requires simultaneously meeting environmental, economic, and community aspirations."*[21]

Other definitions particularly stress the importance of recognizing environmental limits. One example is the following statement (Noss 1993) from the book *Defining Sustainable Forestry*:

> *Since sustainable forest management is only possible within the ultimate constraints and limits imposed by the ecosystem, sustainability should be viewed as the degree of overlap between ecological possibilities and socially desired benefits of forests.*

The *Sourcebook on Criteria and Indicators of Forest Sustainability in the Northeastern Area* (USDA Forest Service 2002) sums up the key features of most definitions in this statement about forest sustainability:

> *...it involves the continued existence and use of forests to meet human physical, economic, and social needs; the desire to preserve the health of forest ecosystems in perpetuity; and the ethical choice of preserving options for future generations while meeting the needs of the present.*

The concept of sustainable forest management is related to but different in significant ways from an earlier concept of sustained yield—the amount of wood that a forest can produce on a continual basis. The concept of sustained yield, dating back to the Middle Ages in Europe, was brought to the United States in the late 1800s by early forestry leaders such as Bernhard Fernow and Gifford Pinchot. It was expanded over time to include the perpetual production of other forest outputs in addition to timber supply, including water, recreation, fish and wildlife, and livestock forage—the expanded concept is often referred to as the "multiple-use sustained-yield" principle. This principle was enshrined in law in 1960 for national forests.[22] The concept of sustainable forest management, however, includes managing the forest for more than outputs; it focuses on maintaining processes and seeking to sustain communities, economies, and all the elements of a forest (Floyd 2002).[23]

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[20] See http://www.safnet.org.
[21] Statement issued by the Society of American Foresters Council, 2001.
[22] The Multiple-Use Sustained-Yield Act (P.L. 86-517) was signed into law on June 12, 1960.
[23] See Floyd (2002) for a fuller description of the evolution of concepts of forest sustainability in the United States.

Sustainable forest management also denotes maintaining capacities for future generations to meet their needs. Because we cannot predict what they will value most, future citizens should not be denied the opportunity to make their own choices. We need to ensure that the environmental, social, and economic systems that provide what people value from forests endure so that future generations can enjoy the benefits that they choose to value.

One of the keys to sustainability is having a suite of values that recognizes the interrelationships among all three spheres. For example, if the society values both economic growth and the environmental qualities required to sustain the economy, then it is more likely to develop the traditions and institutions necessary for sustainability. In the United States, there are signs that citizens care about the environment. Tarrent, et. al. (2003), found that the public "favors a balance of environmental protection and economic development in public and private forests, but with a very strong tilt in favor of the environment." Czech and Krausman (1999) found that Americans value the availability of resources for posterity more than either current environmental or economic welfare. As expressed in survey responses, Americans have developed key aspects of a long-term social perspective in favor of protecting the environmental and economic spheres of sustainability.

Sustaining the full range of services and benefits (environmental, social, and economic) that people desire from forests will usually require a diverse mosaic of ownerships, forest conditions, and capacities across the landscape, as well as a variety of management emphases. Though our society has some core shared goals for what forest management should sustain (the criteria for sustainable forest management from the C&I depict these in a general sense) specific resource management objectives will still vary among different types of landowners and among other stakeholders. Given the necessary information and incentives, the various landowners can manage their forests in light of their individual, private objectives and their shared community goals, while providing a mix of different products, services, and other benefits that, in combination, meet the broad range of objectives that society has for forests.

What Are Indicators?

"Indicators are repeated observations of natural and social phenomena that represent systematic feedback. They generally provide quantitative measures of the economy, human well-being, and impacts of human activities on the natural world. The signals they produce sound alarms, define challenges, and measure progress . . . Generally, indicators are most useful when obtained over many intervals of observation so that they illustrate trends and changes. Their calculation requires concerted efforts and financial investments by governments, firms, nongovernmental organizations, and the scientific community." The National Research Council, *Our Common Journey: a Transition toward Sustainability*, 1999.

Using Indicators To Monitor Change

Indicators provide "gauges" to monitor how a system operates or functions. Any single indicator by itself provides limited information about the system as a whole. Information from a suite of indicators provides a clearer picture. A complex system requires many different indicators to monitor the system.

Forests are very complex systems. Further, the many different values held by people about the environmental, social, and economic spheres of forests require a large and diverse set of indicators to depict the many facets of forests and forest management. The set of indicators used in this report was designed to be meaningful to the public and decisionmakers.

The breadth of indicators used for this report helps us appreciate the complexities that are part of resource management decisions. Thus, the information derived from monitoring change in indicators can contribute to better public understanding of America's forests and promote better dialog about forest management options. This better dialog, founded on better data, should lead to better decisions about the sustainable management of forests and improve the understanding of the consequences of earlier decisions. "*Indicators are essential to inform society over the coming decades how, and to what extent, progress is being made in navigating a transition toward sustainability.*" (National Research Council 1999)

Criteria and Indicators for Sustainable Forest Management

In the United States, the commitment by the Federal Government and others to using the C&I as a framework for sustainable forest management has resulted from a combination of international and domestic interactions. In 1993, following the Rio Earth Summit, the United States became one of the first countries to commit to a national goal of sustainable forest management.[24] At the time, however, there was little agreement on how to characterize or assess sustainability. Building on the Forest Principles adopted at the Earth Summit, different groups of countries joined together to discuss and reach consensus on ways to assess national progress toward the sustainable management of forest resources. Nine international C&I processes are now ongoing, involving approximately 150 countries and covering nearly all the world's forested area.[25]

The United States participates in one of these processes—the Montreal Process.[26] The member countries reached a nonbinding agreement in 1995 on a set of C&I for the conservation and sustainable management of temperate and boreal forests.[27] Representatives of the USDA

[24] Presidential Decision Directive/NSC-16, November 1993.
[25] For information on what nations are included in each of the C&I processes, see Table 9 at http://www.fao.org/forestry/fo/fra/index_tables.jsp.
[26] See http://www.mpci.org/.
[27] See http://www.mpci.org/whatis/criteria_e.html..

Forest Service, the National Association of State Foresters, and many domestic nongovernmental organizations participated with the U.S. Department of State in discussions that led to the agreement. Similar collaboration occurred in other Montreal Process countries.

Today, member countries in the Montreal Process include the United States, Canada, Japan, New Zealand, Australia, Republic of Korea, Chile, Mexico, China, the Russian Federation, Uruguay, and Argentina. These countries encompass more than 90 percent of the world's temperate and boreal forests and 60 percent of all forests. Each nation assumes individual responsibility for assessing its own forests. This report affirms the commitment of the United States to use the Montreal Process C&I in such national assessments.

The C&I—7 criteria and 67 indicators—characterize essential components of sustainable forest management. They provide an accepted framework for gathering data necessary for discussing the importance, status, and sustainability of forest management.

Milestones in the U.S. Government's Commitment to the Criteria and Indicators

1992—United Nations Conference on Environment and Development recognized the sustainable management of forests as a key component to sustainable development, resulting in a nonbinding Statement of Forest Principles.
1993—Presidential Decision Directive committed the United States to a national goal of sustainable management of forests.
1995—Santiago Declaration, a statement of political commitment now endorsed by 12 countries, included criteria and indicators for the conservation and sustainable management of temperate and boreal forests.
1996—President's Council on Sustainable Development released U.S. report that includes policy recommendation on sustainable forest management.
1996—Seventh American Forest Congress in the United States developed vision elements and principles, many of which focus on 'sustainability.'
1998—Roundtable on Sustainable Forests convened in the United States to serve as a multistakeholder forum to share information and perspectives regarding sustainable forests in the United States.
2000—Federal Memorandum of Understanding on Sustainable Forest Management Data signed in the United States now includes 12 Federal agencies committed to resolving data issues related to the C&I and to developing national reports using the C&I.

The criteria define categories of capacities or processes that are essential to sustainable forest management, while the indicators provide the means for measuring or describing various aspects of the criteria. Criteria 1 through 6 address biological diversity, the productive capacity of the forest, the health of the ecosystem, soil and water resources, global carbon cycles, and social and economic benefits that come from the forests. Criterion 7 addresses the legal, institutional, and economic framework for supporting forest conservation and sustainable management. Half of the indicators measure economic, social, or institutional concerns. It is important to emphasize that no single criterion or indicator alone is an adequate measure of sustainability. All criteria should be considered together to provide a more complete picture of the status of forests and their management.

The C&I will change over time. They will be reviewed and refined, collectively by all the Montreal Process countries, to reflect experience gained with their use, new research findings, advances in technology, and public understanding of forests.

Sharing Responsibility in the United States

In the United States, the quest for sustainable forest management is shared by many government agencies, nongovernmental organizations, private businesses, and literally millions of individuals who own and/or manage forests in rural and urban areas. Sustainability as a concept helps connect each of us upward, inward, and outward. We represent diverse interests, backgrounds, and responsibilities for managing public and private lands. And, as described later, we care in many ways for the Nation's forests.

We are at a historic point in time. At the turn of the century and the beginning of a new millennium, we are confronted with new resource issues. As we move forward, the USDA Forest Service, in collaboration with others, seeks to broaden and deepen the commitment of the United States to sustainable forest management through shared learning and responsibility.

The hope and desire of the many agencies, organizations, and individuals involved in developing and reviewing the report is that it will be used to inform future dialog about sustainable forest management in the United States. The report and the companion documents contain the best and most comprehensive information about sustainable forest management in the United States that we have available at this time.

Drivers Affecting the Measures of Resource Condition Reported by the Montreal Process Criteria and Indicators

The current situation for U.S. forests has evolved as an outcome of the interactions of many driving forces, some within the forest sector, and many outside the sector. This section of the report briefly describes some of the more obvious drivers of resource condition in the United States. The discussion is not exhaustive, but is indicative of the complex interactions of domestic and international forces driving forest resource conditions in the United States.

The criteria and indicators used in this report largely overlook these forces, but they are antecedent to the forest conditions depicted by the criteria and indicators. These forces are important in understanding changes over time in the data for indicators.

Domestic Forces

Population and Income

Among the strongest drivers of forestry condition in the United States are population and income. The U.S. population increased from 122 million people in 1929 to 285 million in 2001 (figure 1). Especially after World War II, gross domestic product (GDP) and disposable income increased in the United States (figure 2). The increased income, coupled with the increasing population, increased demands for all outputs of the forest, including water, timber and nontimber products, scenic beauty, fish and wildlife, and a place to recreate. These increasing demands affected timber harvesting and other uses of the forest, and thus affected forest growth and other measures of resource condition reflected in the criteria and indicators of sustainable forest management in the Santiago Declaration.

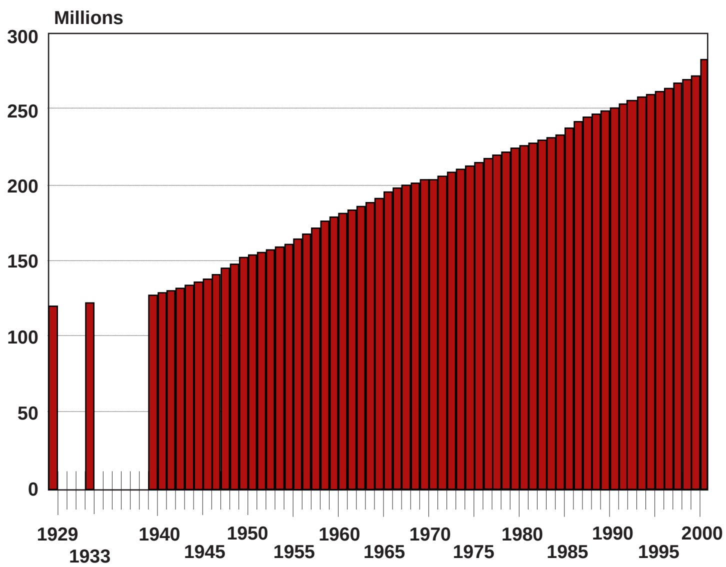
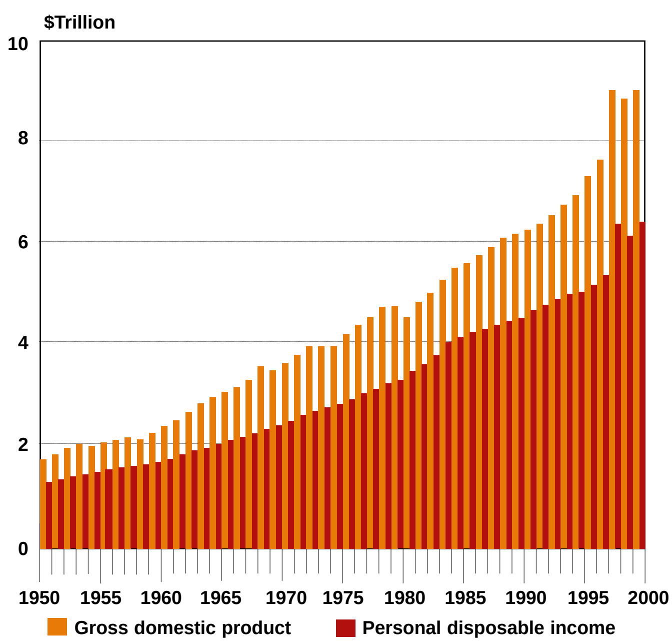


Figure 1. U.S. population.



Source: Howard 2001

Figure 2. Gross domestic product and personal disposable income (1992 $s).

After World War II, increasing population and income increased demand for and made possible a greatly enhanced transportation infrastructure. Better transportation for automobiles enabled suburbanization and led to land use change around existing cities. Better roads also enabled people to get to what had formerly been remote forests. Increasing populations and incomes around the world increased demands for U.S. agricultural products, such as soybeans, that led to large-scale clearing of forest land for growing crops.

Change in Land Use

In the evolution of the current U.S. forest resource situation, forestry and agriculture have a history of competing land use, but the competition has in a sense been benign in that the use of land for either purpose has not foreclosed its later use for the other purpose. Agricultural land, therefore, reverted to forest land in the Northeast in the 1800s (MacCleery 1992), and forest land was cleared for agricultural crops in the Mississippi River valley in the 1970s. Other competing uses of forest land are more likely to be irreversible. Between 1982 and 1997, 11.7 million acres of forest land were converted to developed land, while 7.9 million acres were converted to crop, pasture, or rangeland (USDA Natural Resources Conservation Service 2000). While urbanization and fragmentation of forest land may end the use of the land for timber production, some land may remain in forest cover as urban forest.

In the humid East, forests are the natural land cover. Losses of forest land to agriculture and development were offset by natural reversion of abandoned agricultural lands to forests in the East and special tree-planting incentives in the 1960s and 1990s (figure 3). Abandonment of pasture lands was especially important in the early 20th century as animals were replaced with machines for tilling the soil (MacCleery 1992).

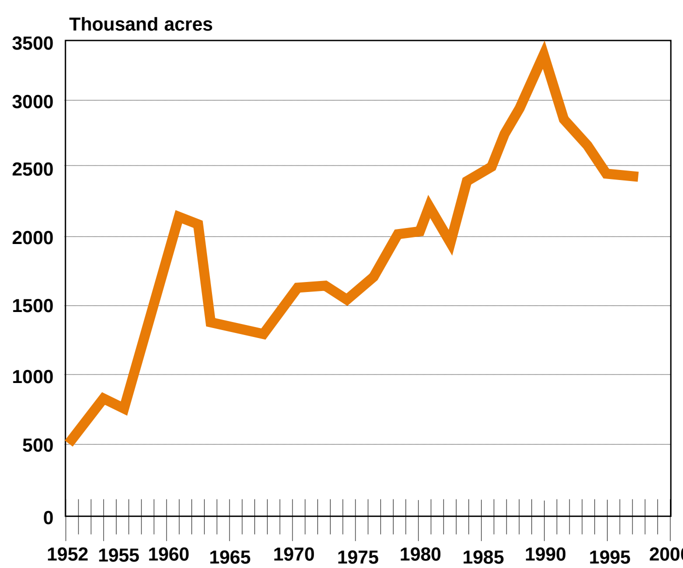


Figure 3. Tree planting in the United States.

Recycling

Recovery of paper and paperboard in the United States is both an outcome and a driving force affecting measures of the U.S. forest resource situation. It is the outcome of interactions of voluntary and mandatory recycling programs and fiber markets. In the 1980s through the 1990s, there was recognition of a solid waste disposal problem. During this time, the acronym NIMBY (not in my backyard) was coined. Increased recycling was perceived to be an alternative to more landfills and incinerators.

As recycled material leads to decreased timber harvest, recycling is a driver of the condition of U.S. forests. Recovery of paper and paperboard in the United States is approaching 50 percent, which is probably close to the economic maximum (Ince 1998). Of this 50 percent, 38 percent is recycled domestically and most of the remainder is exported. Recycling is increasingly part of the U.S. culture, and the forest situation will evolve with recycling as a continuing feature of the U.S. fiber supply situation. This will continue to affect indicators of sustainable forest management as depicted in the Santiago Declaration.

Technology in the Growing, Processing, and Use of Wood

The technology of wood fiber growing, processing, and use has evolved to the point where wood can be processed into fiber and reconstituted as just about any product desired. As a result, wood of just about any species can be used in the manufacture of oriented strand board, fiber board, and other engineered wood products such as fiber-based I-beams to replace large timbers used for supporting floors. More and more housing components, such as roof trusses, are pre-manufactured and moved to the home site, reducing wood waste at the building site. According to Ince (2000), the quantity of industrial wood output produced per unit of industrial roundwood input increased in the United States by 39 percent from 1900 to 1998. Much of the gain occurred since 1950 and was the result of increased use of wood residues and paper recycling.

Cloning and other changes in the management of forests can nearly double the rate of growth of plantations (Siry 2002). Continued success in growing plantations may lead to a much larger share of U.S. production of timber products coming from plantations.

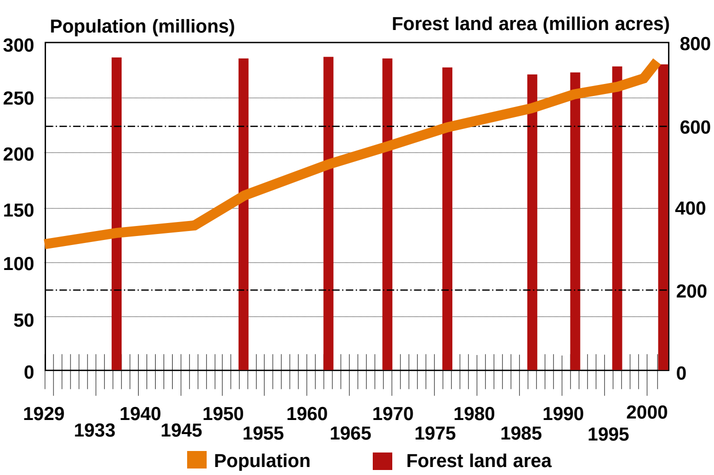
Technological changes in a variety of sectors have influenced forest management and use. For example, the move from DDT to more targeted pesticides has much changed the thinking about how to control pests. Not only has technological change influenced the way that we grow and use wood fiber, it has affected other ways that the forest is used. Snowmobiles, better skis, and snowshoes have opened the forest to more winter-based recreation. Gear for adventure sports such as rock climbing have enabled new uses for parts of the landscape not previously used.

Regardless of the sources of technological changes, over time the changes have affected many of the indicators used as measures of sustainable forest management in the Santiago Declaration. Such changes should be considered when evaluating changes in the indicators over time.

Efforts to control water and air pollution: The evolution of the U.S. forest situation has been affected by Federal and State laws that corrected many serious problems with water and air pollution that existed in the 1950s and 1960s. Legislation, such as the Clean Water Act of 1977 and the Clean Air Act of 1963, has largely eliminated point sources of pollution such as sewage discharge into streams. On a more local scale, codes mandating best management practices and other proscriptions have affected the evolution of current U.S. forest conditions and affected air and water quality. In evaluating changes in data regarding indicators of sustainable forest management, it should be recognized that the legal and institutional framework is not constant over time but changes in response to society's values. Similar progression of the legal and institutional framework will likely continue to affect the evolution of future U.S. forest resource conditions.

Need to Consider Interactions of Drivers

While some domestic drivers of resource condition, such as population, are obviously important to consider, the United States' experience with the relationship between population and forest area is an example of why individual drivers of resource condition should not be considered in isolation of other forces. While the population of the United States more than doubled between 1929 and 2000, the area of forest land remained relatively stable (figure 4). This relationship is counter-intuitive in that increased population drives demands for living space, food production, and so forth. The simple relationship between population and forest land area does not include consideration of the many other forces that affect the area of forest land.



Source: Council of Economic Advisers annual report 2002 and Smith, et. al. 2003

Figure 4. U.S. population and forest land area.

International Forces

U.S. Forests in a World Context

The United States has 6 percent of the forest land area in the world and 8 percent of the total volume (United Nations Food and Agriculture Organization 2001). The United States accounts for 27 percent of the wood used to make products. In part, this pattern reflects a history of wood use in the United States; relatively inexpensive wood-based products; technological innovations that enhance the growing, processing, and use of timber products; and growing U.S. populations and incomes.

Imports and Exports Relative to Consumption and Production

From a small net export situation at the start of the 20th century, U.S. trade in timber products evolved into a deficit situation in volume terms (Hair and Ulrich 1964). Imports as a percent of consumption increased from 13.1 percent in 1965 to 27.2 percent in 2002 (figure 5). Because imports have increased, U.S. harvest has been lower than it would have been without imports. Lower harvest could affect biological diversity, productive capacity, forest ecosystem health and vitality, soil and water resources, forest contribution to global carbon cycles, and long-term multiple socioeconomic benefits. Imports may be judged to be injurious to domestic industry to the point that they trigger changes in the legal, institutional, and economic framework. Canada remains by far the biggest source of U.S. imports (more than 75 percent of the total in 2000), but other countries increased shipments to the United States in the last decade of the 20th century.

In recent years up through much of 2002, the strong value of the U.S. dollar relative to the value of other currencies stimulated imports from Finland, Brazil, and other nontraditional sources. This same strength of the dollar contributed to a near collapse of U.S. exports to some countries, such as Japan (figure 6). Even these relatively short-term external influences on the U.S. forest sector can affect the measured condition of U.S. forests. Exports of timber products as a percent of production varied between a low of 4.9 percent in 1965 and a high of 15.9 percent in 1991 during the last half of the 20th century (figure 5). The lower the percent of production that is exported, the less the direct influence of exports on measures of domestic resource condition.

In the last 10 years, imports have increased in part because of decreased harvest on Federal lands in the United States, which also led to increased harvest on private lands in the South. Because of this shift in priorities on the management of Federal lands, measures of forest resource condition have been affected on all ownerships due to the changes in harvest patterns.

Because the roles of imports and exports in determining domestic resource conditions are largely overlooked in the criteria and indicators of the Santiago Declaration, we are not in as strong a place conceptually to discuss whether current forest resource management is sustainable. Nevertheless, the reader should keep in mind that international trade has been a driving force in determining forest resource conditions in the United States.

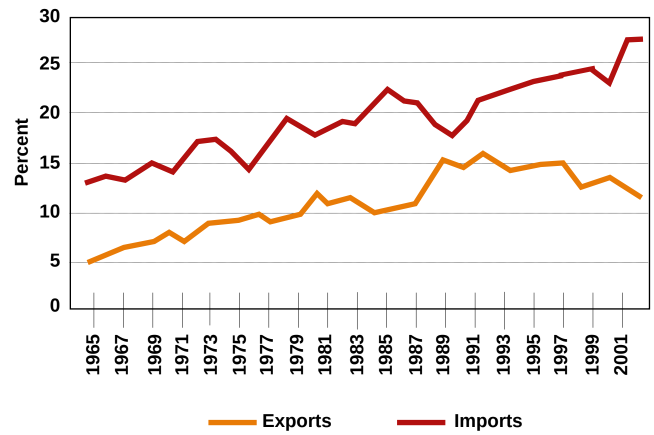
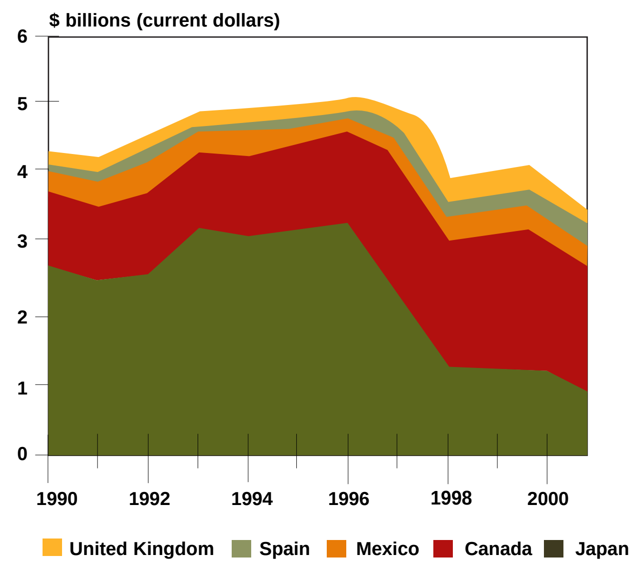


Figure 5. U.S. exports of timber products as a percent of production and U.S. imports of timber products as a percent of consumption.



Source: U.S. Department of Agriculture Foreign Agricultural Service 2002

Figure 6. Value of U.S. exports of solid wood products to the top five markets.

Planted Forests

During the last 20 years of the 20th century, forest plantations were established in many parts of the world (United Nations Food and Agriculture Organization 2001). These plantations are reaching the size to be suitable for timber products. In Chile, Indonesia, Myanmar, and South Africa, supplementing wood supplies from natural forests has been a primary objective of plantation establishment. In Chile and New Zealand, the establishment of plantations has enabled these countries to meet all their domestic wood needs and also support a significant export industry with supplies from plantations. The United States has about 14 percent of the total world area of 279 million acres of plantations. Especially in the U.S. South, pine plantations are becoming increasingly important as a source of fiber supply and most of the expected increase in softwood harvest in the United States will be from plantations (Haynes 2003). Increased reliance on plantations for timber supplies will affect measures of resource condition on the plantation lands as well as in the rest of the Nation's forests.

Globalization

Globalization will continue to affect the evolution of the U.S. forest sector. The evolution will be reflected in changes in trade patterns for timber products that can affect domestic resource condition through changes in timber harvest. For example, for at least the next decade or two, the U.S. forest situation will likely evolve within an environment of relatively inexpensive fiber worldwide because of the maturing of the many millions of acres of plantations. Globalization will also affect worldwide distribution of forest insects and diseases that could prove devastating for forest health in the United States and elsewhere. The American chestnut blight and Dutch elm disease are but two examples of exotic pathogens that have had lasting effects on measures of U.S. forest condition.

Climate Change

There is evolving understanding of climate change and its possible effects on the U.S. forest sector (Joyce and Birdsey 2000). The current U.S. forest situation has evolved within the context of the climate of past centuries, such as in the so-called "mini ice age" of the 17th century. Changes in forest resource condition will continue to reflect in part past and current climatic conditions that may be influenced by forestry and other activities worldwide.

Availability of Data

Indicator 61 describes the scope, frequency, and statistical reliability of forest inventories, assessments, monitoring, and other relevant information. Findings for this indicator are highlighted here because of the significance of the condition of the data for reporting on each of the 67 indicators at a national scale. It is possible to report on all indicators because we know something about each of them. The analysis for indicator 61, however, describes the state of the data in terms of being able to report fully at a national scale.

The data for 8 of the 67 indicators is current and consistent across the entire Nation and come from ongoing programs whose funding and longevity are reasonably assured. Six of the eight indicators are from the USDA Forest Service Forest Inventory and Monitoring Program and the other two are from the U.S. Bureau of the Census. Data for 40 of the 67 indicators was judged to be inconsistent nationally, slightly dated, and not measured frequently enough. Eleven of the 67 indicators have data judged to be from inconsistent or nonexistent sources, sources that have no consistent plan for remeasurement, or data at less than a national scale or are more than 15 years old and, therefore, of questionable usefulness. The remaining eight indicators are based on modeling efforts rather than on direct measurement. The analysis for indicator 61 shows similar shortcomings in the data pertaining to currency and frequency.

Both the Heinz Foundation (H. John Heinz III Center for Science, Economics, and the Environment 2002) and the Environmental Protection Agency (EPA's report on the environment at http://www.EPA.gov/indicate) identified similar data issues in their recent reports. As we will discuss in the Transition Towards Sustainability Section, the next key steps in evaluating the sustainability of forests in the United States should be a review and possible modification of indicators of resource condition and strategies for the collection of data. Shortcomings in the existing data affect our understanding of the current state of forests and our capability to interpret the existing information.

Lack of Reference Conditions and Relative Weights for the Indicators

Along with a need to review and possibly revise indicators, there is a need to further develop the concept of reference conditions (also commonly termed reference values, desired future condition, or natural condition) for each indicator. Without reference conditions, interpretation of point values, or even trends for data, in terms of movement toward or away from sustainable forest management, is difficult. One of the concepts of the criteria and indicators is that data should be interpreted for the whole package and not on an indicator-by-indicator basis. Thus, as the reader progresses through the analysis of the indicators, issues with data availability and reference conditions should be kept in mind when evaluating the significance of the findings.

While a reference condition can help with interpreting trends in the data for an indicator, it does not provide insight into the relative importance of the indicator in evaluating sustainable forest management. For example, with 67 indicators, are all of them of equal importance in evaluating sustainable forest management, or do some carry more "weight" than others? There is currently no weighting scheme for the indicators in the Santiago Declaration. This weighting should be the provenance of stakeholders for any set of indicators being used to evaluate sustainable forest management.

Analyses of the Indicators

This section of the report presents summary 1-page analyses of the 67 indicators. The summaries provide analyses for almost all the indicators; however, as noted before, comprehensive data on a continuing basis is not available for all the indicators. Many of the summaries present ad hoc analyses of existing data, rather than analyses of data from a comprehensive monitoring program, and were conducted especially for this report.

Most of the summaries have supporting technical documents that detail data and analysis methods. When a supporting technical document is available, the summary refers the reader to that document at http://www.fs.fed.us/research/sustain/. The collection of supporting technical documents is titled the Data Report and is available online at that address.

The following listing of the criteria and indicators and explanation of why the criteria are important are provided for convenience in referencing the indicators' wide-ranging nature while reading the analyses.

Criterion 1: Conservation of Biological Diversity

Why Is This Criterion Important?

Biological diversity ("biodiversity") spans a spectrum from genetics to species to the ecosystem. In general, the biodiversity conservation criterion reflects the knowledge that biodiversity is a form of natural capital (along with other stocks of natural capital such as water, soil, timber, and minerals) that provides environmental services essential to the human economy. Each ecosystem has a capacity for biodiversity, and tropical forests typically have greater biodiversity capacity than boreal ecosystems. When the biodiversity capacity of a forest ecosystem is diminished, the forest's underlying ecosystem components and processes are threatened, as are the dependent economic sectors and communities.

Ecosystem Diversity

- Indicator 1. Extent of area by forest type relative to total forest area
- Indicator 2. Extent of area by forest type and by age-class or successional stage
- Indicator 3. Extent of area by forest type in protected area categories as defined by IUCN or other classification systems
- Indicator 4. Extent of areas by forest type in protected areas as defined by age-class or successional stage
- Indicator 5. Fragmentation of forest types

Species Diversity

- Indicator 6. Number of forest-dependent species
- Indicator 7. The status (threatened, rare, vulnerable, endangered, or extinct) of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

Genetic Diversity

- Indicator 8. Number of forest-dependent species that occupy a small portion of their former range
- Indicator 9. Population levels of representative species from diverse habitats monitored across their range

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Why Is This Criterion Important?

Because "productive capacity" refers to the ability of forests to produce goods and services for humans, this criterion overlaps the environmental and economic spheres of sustainability. The productive capacity criterion is one of the most straightforward, as are its constituent indicators. Essentially, productive capacity is maintained as long as the harvesting of forest products does not exceed growth rates. If harvesting exceeds growth rates, then the natural capital stocks become depleted or "liquidated," and the amount of products flowing from these stocks must decline. For example, if timber or deer are harvested at too rapid a pace, then lumber or venison production will not be sustained.

- Indicator 10. Area of forest land and net area of forest land available for timber production
- Indicator 11. Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production
- Indicator 12. The area and growing stock of plantations of native and exotic species
- Indicator 13. Annual removal of wood products compared to the volume determined to be sustainable
- Indicator 14. Annual removal of nontimber forest products (e.g., fur bearers, berries, mushrooms, game) compared to the level determined to be sustainable

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

Why Is This Criterion Important?

Ecosystem health depends on the functionality of natural, nondegraded ecosystem components and processes. The underlying premise is that forest species and ecosystems have evolved to function within particular environmental conditions determined largely by geological and climatic forces. Humans, meanwhile, have historically (and prehistorically) adapted their economic and social activities to environmental conditions and to the resulting ecological processes. Substantial modification of environmental conditions therefore threatens species' adaptive capacities, ecosystems' functional capacities, and that of the associated human economies and societies. For example, many local and regional U.S. economies depend on forests. To the extent that exotic species, air pollution, or diseases threaten the forests, the associated economies and communities are likewise threatened.

- Indicator 15. Area and percent of forest affected by processes or agents beyond the range of historic variation (e.g., by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals)
- Indicator 16. Area and percent of forest land subjected to levels of specific air pollutants (e.g., sulfates, nitrate, ozone) or ultraviolet that may cause negative impacts on the forest ecosystem.
- Indicator 17. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g., soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species, such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc.)

Criterion 4: Conservation and Maintenance of Soil and Water Resources

Why Is This Criterion Important?

Soil and water are primary stocks of natural capital in all terrestrial ecosystems. They constitute the foundation for the human economy and for the "economy of nature" with its birds, mammals, fish, reptiles, amphibians, invertebrates, and plants. Forest ecosystems differ from other types of ecosystems in that the soil and water resources support the growth of trees (which themselves constitute a form of natural capital). The amount of soil and water and their characteristics determine the capacity of ecosystems to sustain forests, forest economies, and forest-dependent societies.

- Indicator 18. Area and percent of forest land with significant soil erosion
- Indicator 19. Area and percent of forest land managed primarily for protective functions (e.g., watersheds, flood protection, avalanche protection, riparian zones)
- Indicator 20. Percent of stream kilometers in forested catchments in which stream flow and timing have deviated significantly from the historic range of variation
- Indicator 21. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties
- Indicator 22. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities
- Indicator 23. Percent of water bodies in forest areas (e.g., stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability
- Indicator 24. Percent of water bodies in forest areas (e.g., stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation, or temperature change
- Indicator 25. Area and percent of forest land experiencing an accumulation of persistent toxic substances

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

Why Is This Criterion Important?

More than any other criterion, this one reflects the fact that forests exist within a context of the global environment and the world's economic and social activities. Criterion 5 embodies a direct link between the environment and the economy, because carbon cycling concerns result from the fossil fuel combustion that powers the human economy. The capacity of forests to sequester carbon may be—or may become—a primary factor for determining the capacity of fossil-fueled economies. The global economy, in other words, may be a function not only of the global environment, but particularly of the forested environment.

- Indicator 26. Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age-class, and successional stages
- Indicator 27. Contribution of forest ecosystems to the total global carbon budget (standing biomass, coarse woody debris, peat, and soil carbon)
- Indicator 28. Contribution of forest products to the global carbon budget

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits To Meet the Needs of Societies

Why Is This Criterion Important?

While the first five criteria are centered in the environmental sphere of sustainability (with the exception of criterion 2, which clearly overlaps the economic sphere), criterion 6 is centered firmly in the economic sphere. As the sole criterion with an economic focus, it has more (19) indicators than any of the environmental criteria. Its first two subcategories reflect the basic economic breakdown of goods (e.g., wood products) and services (e.g., tourism). The investment subcategory provides indicators of society's attention to forest maintenance. The cultural subcategory includes the most social of the socioeconomic indicators, and the employment subcategory provides indicators of the forests' capacity to provide work, wages, and subsistence.

Production and Consumption

Indicator 29. Value and volume of wood and wood products production, including value added through downstream processing
Indicator 30. Value and quantities of production of nonwood forest products
Indicator 31. Supply and consumption of wood and wood products, including consumption per capita
Indicator 32. Value of wood and nonwood products production as a percentage of GDP
Indicator 33. Degree of recycling of forest products
Indicator 34. Supply and consumption/use of nonwood products

Recreation and Tourism

Indicator 35. Area and percent of forest land managed for general recreation and tourism in relation to the total area of forest land
Indicator 36. Number and type of facilities available for general recreation and tourism in relation to population and forest area
Indicator 37. Number of visitor days attributed to recreation and tourism in relation to population and forest area

Investment in the Forest Sector

Indicator 38. Value of investment, including investment in forest growing, forest health management, planted forests, wood processing, recreation, and tourism
Indicator 39. Level of expenditure on research and development and on education
Indicator 40. Extension and use of new and improved technologies
Indicator 41. Rates of return on investment

Cultural, Social, and Spiritual Needs and Values

Indicator 42. Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social, and spiritual needs and values
Indicator 43. Nonconsumptive use forest values

Employment and Community Needs

Indicator 44. Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment
Indicator 45. Average wage rates and injury rates in major employment categories within the forest sector
Indicator 46. The viability and adaptability to changing economic conditions of forest-dependent communities, including indigenous communities
Indicator 47. Area and percent of forest land used for subsistence purposes

Criterion 7: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management

Why Is This Criterion Important?

Although it overlaps with the economic sphere, this criterion is centered in the social sphere of sustainability. Its first three subcategories provide for the assessment of laws, regulations, policies, planning, and public involvement pertaining to sustainable forest management. The last two subcategories address the nature and levels of forest research, monitoring, and reporting. Together, they reflect society's propensity and capacity to sustain forested ecosystems and associated economies.

Extent to Which the Legal Framework (Laws, Regulations, and Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It:

Indicator 48. Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides a means of resolving property disputes by due process
Indicator 49. Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors
Indicator 50. Provides opportunities for public participation in public policy and decisionmaking related to forests and public access to information
Indicator 51. Encourages best practice codes for forest management
Indicator 52. Provides for the management of forests to conserve special environmental, cultural, social, and/or scientific values

Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity to:

Indicator 53. Provide for public involvement activities and public education, awareness, and extension programs, and make available forest-related information
Indicator 54. Undertake and implement periodic forest-related planning, assessment, and policy review, including cross-sectoral planning and coordination
Indicator 55. Develop and maintain human resource skills across relevant disciplines
Indicator 56. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and to support forest management
Indicator 57. Enforce laws, regulations, and guidelines

Extent to Which the Economic Framework (Economic Policies and Measures) Supports the Conservation and Sustainable Management of Forests Through:

Indicator 58. Investment and taxation policies and a regulatory environment that recognizes the long-term nature of investments and permits the flow of capital in and out of the forest sector in response to market signals, nonmarket economic valuations, and public policy decisions in order to meet long-term demands for forest products and services

Indicator 59. Nondiscriminatory trade policies for forest products

Capacity To Measure and Monitor Changes in the Conservation and Sustainable Management of Forests

Indicator 60. Availability of up-to-date data, statistics, and other information important to measuring or describing indicators associated with criteria 1through 7.

Indicator 61. Scope, frequency, and statistical reliability of forest inventories, assessments, monitoring, and other relevant information

Indicator 62. Compatibility with other countries in measuring, monitoring, and reporting on indicators

Capacity To Conduct and Apply Research and Development Aimed at Improving Forest Management and Delivery of Forest Goods and Services

Indicator 63. Development of scientific understanding of forest ecosystem characteristics and functions

Indicator 64. Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest-related depletion or replenishment in national accounting systems

Indicator 65. New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies.

Indicator 66. Enhancement of the ability to predict impacts of human intervention on forests

Indicator 67. Ability to predict effects on forests of possible climate change

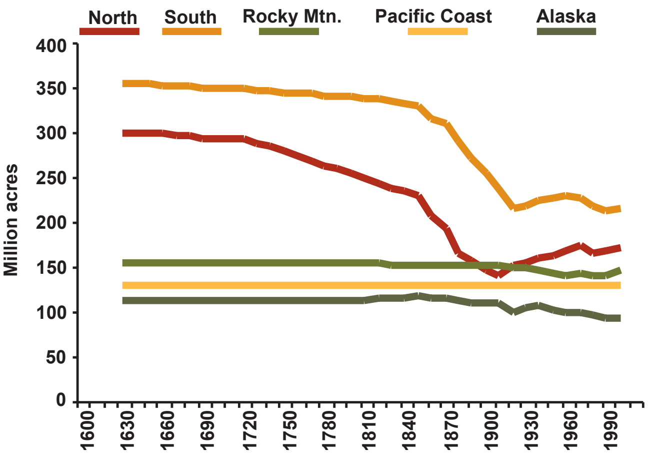


Figure 1-1. Area of forest land by region, 1630–2002.

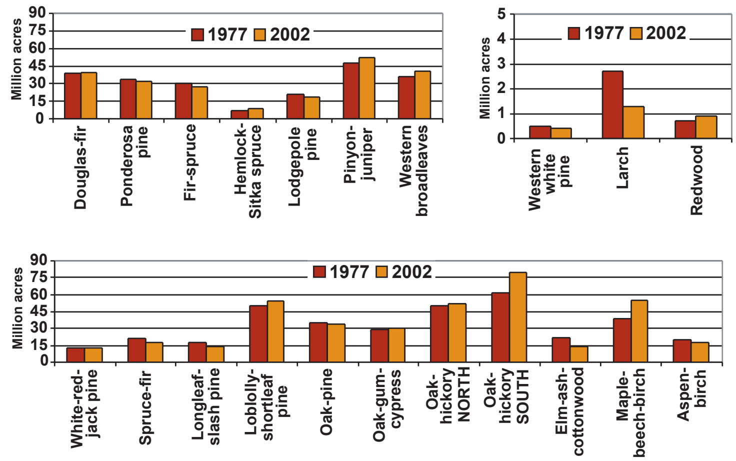


Figure 1-2. Forest by major type in the United States, 1977 and 2002 (excluding Alaska).

What Is the Indicator and Why Is It Important?

Forest type is a coarse representation of land cover based on major tree species associations. As individual trees respond to natural or human-induced change, forest composition and structure change. Monitoring changes in the location and distribution of forest types is useful for resource managers and analysts interested in forest resources to track the sustainability and diversity of the Nation's forest cover and the desired future condition of that forest cover.

The current forest area in the United States is 749 million acres, or about one-third of the Nation's land area. The U.S. forest area was about 1 billion acres at the time of European settlement. Of the total forest land loss of 300 million acres, most (nearly 200 million acres) occurred in the East (North and South regions) between 1850 and 1900, with the loss consisting predominantly of broadleaf forest cleared for agriculture. For the last 100 years, the total forest area has been relatively stable, while the U.S. population has more than doubled. Today, conifer forests cover 412 million acres in the United States and are found predominantly in the West (315 million acres) and South (67 million acres). Broadleaf forests cover 273 million acres, and are located predominantly in the North and South (223 million acres).

Broadleaf forests. At 132 million acres, oak-hickory (*Quercus/Carya spp.*) is the largest single forest cover type. It constitutes more than 17 percent of all forest land in the Nation and nearly half of all broadleaf forests. Covering 55 million acres, maple-beech-birch forests (*Acer/Fagus/Betula spp.*), are also dominant in the Eastern United States. Combined, these two upland forest types constitute nearly two-thirds of all broadleaf forests, which have increased 18 and 42 percent, respectively, since 1977.

Conifer forests. Pines (*Pinus spp.*) are the single-most dominant group of conifer forests. Loblolly-shortleaf pine (*P. taeda, echuinata*) and longleaf-slash pine (*P. palustris, elliotii*) types in the South and ponderosa and lodgepole pine types (*P. ponderosa and contorta*) in the West combine to cover 115 million acres, or more than one-fourth of all conifer forest types. The largest single conifer type, with 61 million acres in interior Alaska, is the spruce-birch (*Picea/Betula spp.*) type. Douglas-fir (*Pseudotsuga menzezii*) follows closely, with 40 million acres found predominantly in the Pacific Coast Region.

Mixed forests. Virtually all mixed forests of oak-pine (*Quercus/Pinus spp.*) and oak-gum-cypress (*Quercus/Nyssa/Taxodium spp.*), with 59 of the 64 million total acres, are found in the South. While oak-gum-cypress is found in the wet lowlands of the South, oak-pine is usually found on the drier uplands.

Indicator 2. Extent of Area by Forest Type and by Age-Class or Successional Stage

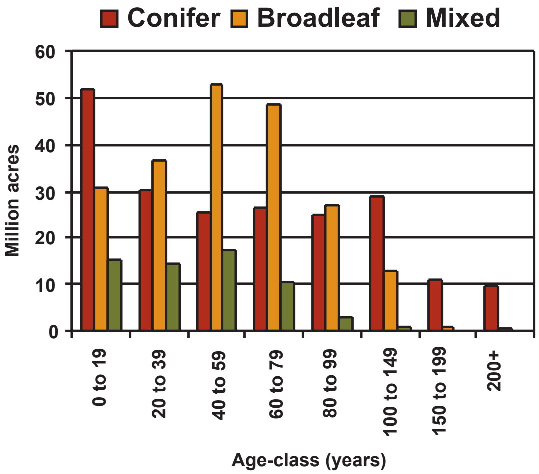


Figure 2-1. Distribution of timber land in the United States by stand-age-class and major forest type, 2002.

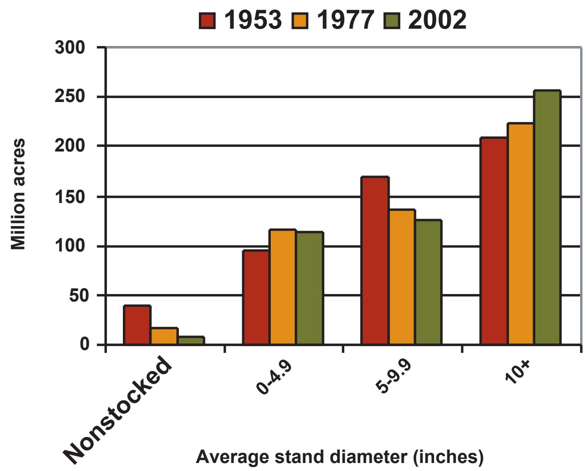


Figure 2-2. Area of timber land by average stand diameter class, 1953, 1977, 2002.

What Is the Indicator and Why Is It Important?

This indicator uses age-class distribution by broad forest type as a coarse measure of the landscape-scale structure of the Nation's forests, where many species wholly or partly depend on a particular successional stage. A diverse distribution of forest lands across forest types and age-classes is an indicator of tree-size diversity and is important for determining timber growth and yield, the occurrence of specific guilds of wildlife, the presence of other nontimber forest products, and the forest's aesthetic and recreational values.

What Does the Indicator Show?

Currently, age-class data is available only for timber land (about two-thirds of all forest land) and show a diversity of age-classes in all major forest types with conifer types skewed slightly to younger age-classes because of more intensive management for timber. Broadleaf types have a more normal distribution, showing a bulge in the 40- to 79-year age-class, as second- and third-growth forests in the East continue to mature. Preliminary inventory data on the remaining forests (primarily parks, wilderness, and low wood-productivity forests) are skewed toward older age-classes.

While trend data on age-class is sparse, historic data is available for average tree size in forest stands. Whether stands become more structurally diverse as they age depends on many factors, such as management and disturbance histories, adequate seed sources for regeneration, site conditions, climatic factors, and geophysical factors. The occurrence of insects and disease, whether endemic or epidemic, also plays a role in defining the forest's diversity.

Trends also show a steady decline in nonstocked areas over the past 50 years as poorly stocked stands are regenerated or converted to other uses. Stands averaging 0 to 5 inches in diameter increased as older stands were harvested and regenerated. Nearly 3 million acres of nonforest land were planted in the South as part of the Conservation Reserve Program in the 1980s and 1990s. Intermediate stands in the 6- to 10-inch diameter range have been declining, while stands averaging more than 11 inches in diameter have been rising. This latter trend is indicative of the dominant use in the United States of selective harvesting, which accounts for nearly two-thirds of all harvesting. Additionally, shifts in management policy, which have reduced harvesting on public forests in the West, are increasing the acreage of larger diameter stands in that region.

Indicator 3. Extent of Area by Forest Type in Protected Area Categories as Defined by IUCN or Other Classification Systems

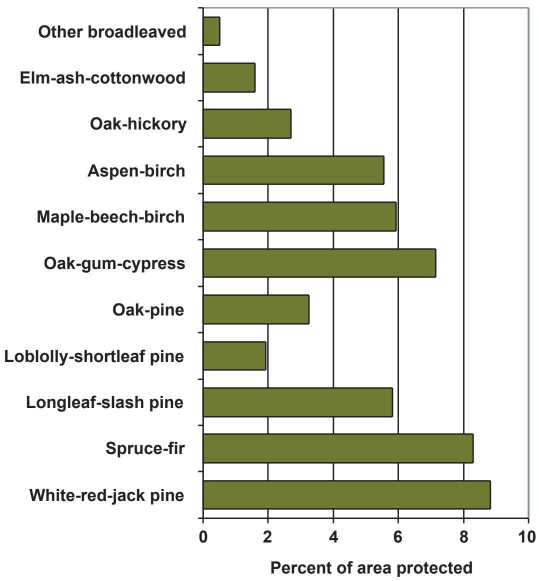


Figure 3-1. Percentage of forests protected in the East by forest type, 2001.

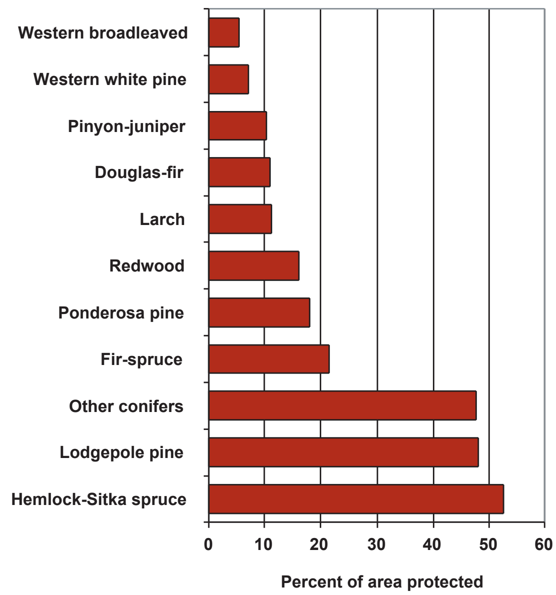


Figure 3-2. Percentage of forests protected in the West by forest type, 2001.

What Is the Indicator and Why Is It Important?

In the broadest sense, the area and proportion of forest ecosystems reserved in some form of protected condition provide some indication of the emphasis a society places on preserving representative ecosystems as a biodiversity conservation strategy. Important forest management questions also can be addressed by maintaining information on a network of comprehensive, adequate, and representative forest types within protected areas. Traditionally, protected areas have been set aside, in part, for their conservation, scenic, and recreational values, and might not represent the full range of biodiversity. Over time, forest types within protected areas will change. Adequate protection of the ecosystems and species in reserved areas may provide more management flexibility in forests under management for timber production and other extractive purposes.

What Does the Indicator Show?

The United States has a long history of forest protection, with Yellowstone, the world's first national park, set aside in 1872. Protected areas of IUCN[28] categories I-VI are estimated to cover about 154 million acres (7 percent of all land in the United States), of which an estimated 106 million acres (14 percent of all forest land) is forested. Conifer forests, particularly those on public lands in the West (Rocky Mountain, Pacific Coast, and Alaska regions), occupy a larger percentage of protected area in the United States. A smaller proportion of broadleaf forest types is currently protected. Broadleaf forests occur predominantly on private lands in the East (north and south regions).

[28] Category I is an area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring or a large area of unmodified or slightly modified land and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition. Category II is a natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area, and (c) provide a foundation for spiritual, educational, recreational, and visitor opportunities, all of which must be environmentally and culturally comparable. Category III is an area of land and/or sea containing one or more specific natural or natural/cultural features of outstanding or unique value because of their inherent rarity, representative or aesthetic qualities, or cultural significance. Category IV is an area of land and/or sea subject to active intervention for management purposes to ensure the maintenance of habitats and/or to meet the requirements of specific species. Category V is an area of land with coast and sea, as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological, and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance, and evolution of such an area. Category VI is an area of land and/or sea containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while providing, at the same time, a sustainable flow of natural products and services to meet community needs.

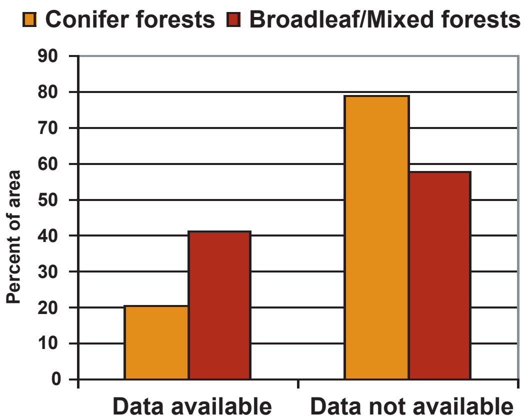


Figure 4-1. Availability of descriptive data for protected forests in the United States, 2001.

Figure 4-2. Location of protected forests in the United States, 2001.

What Is the Indicator and Why Is It Important?

In the broadest sense, the area and proportion of forest ecosystems reserved in some form of protected condition provides some indication of the emphasis a society places on preserving representative ecosystems as a strategy to conserve biodiversity.

Important forest management questions also can be addressed by maintaining information on a network of representative forest types within protected areas. Traditionally, protected areas have been set aside, in part, for their conservation, scenic, and recreational values. The ecosystems they contain might not represent the full range of biodiversity. If protected areas are part of a national conservation strategy (including rare and endangered species), then some indication of what is protected is required. Over time, forest types within protected areas will change. This change must be be monitored as part of an overall sustainability strategy.

What Does the Indicator Show?

Currently, descriptive data is available for only about 25 percent (26 out of 106 million acres) of the forest area designated as protected in indicator 3. The largest areas of protected forest thus far inventoried are in conifer types. Although they constitute a smaller portion of the total protected area, broadleaf/mixed types have nearly half of their total forest area inventoried.

Protected broadleaf/mixed forests inventoried thus far have a fairly even distribution of ages. By contrast, protected conifer forests inventoried thus far are heavily skewed to the stands more than 100 years old. As stands continue to remain in protected status, their age distribution primarily will be determined by natural disturbances such as fire, weather, and insect or disease outbreaks.

Currently, data on age or successional class of U.S. forests in protected areas is sparse. Changes in inventory protocols are being established to rectify this situation, and new field inventory data is being collected in these areas.

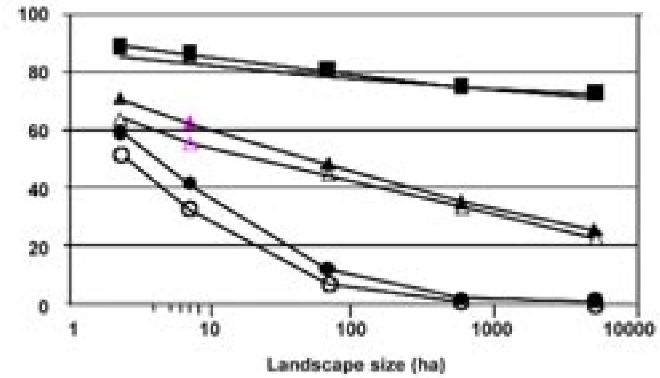


Figure 5-1. Forest land fragmentation from national land-cover maps. The chart shows the percentage of forest land in the coterminous United States located in landscapes of different sizes meeting the criteria for "core" (●, completely forested landscape), "interior" (▲, >90 percent forested), and "dominant" (■, >60 percent forested). Open and closed symbols represent western and eastern Resources Planning Act (RPA) regions, respectively.

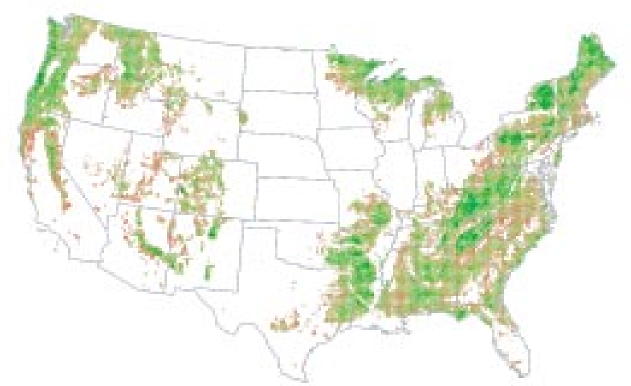


Figure 5-2. The map shows the relative amount of "interior" forest at 7-ha scale (corresponding to the pink symbols in the chart), shaded from low (red) to high (green) for areas containing >60 percent forest overall. The large green areas contain the major areas of less-fragmented forest land.

What Is the Indicator and Why Is It Important?

The fragmentation of forest area into small pieces may change ecological processes and reduce biological diversity. This indicator includes several measures of the extent to which forests are distributed as large blocks.

What Does the Indicator Show?

Maps of forest land derived from satellite imagery at 0.09-ha resolution (circa 1992) show that about three-fourths of all forest land is found in or near the boundaries of large (>5,000 ha), yet heavily fragmented, forest land patches, and the rest exists as smaller patches in mostly nonforested regions. Fragmentation is scale-dependent; while 57 percent of all forest land is "core" in 2-ha landscapes, the proportion decreases rapidly with landscape size, and <1 percent of forest land is "core" in 590-ha or larger landscapes. Similarly, while 69 percent of all forest land is "interior" in 2-ha landscapes, less than half is "interior" in landscapes larger than 66 ha. Overall, 44 percent of forest land is within 90 meters of forest land edge, 62 percent is within 150 meters of forest land edge, and less than 1 percent is more than 1,230 meters from forest land edge. Nevertheless, where forest land exists, it usually is "dominant"—at least 72 percent of all forest land is in landscapes that are at least 60 percent forested for landscapes up to ~5,000 ha in size.

Why Can't the Entire Indicator Be Reported at This Time?

The available data does not permit an analysis of forest type fragmentation, only overall forest land fragmentation, and does not reflect land ownership ("parcelization") or small roads. Regional baseline conditions and the specific ecological implications of observed levels of fragmentation are mostly unknown.

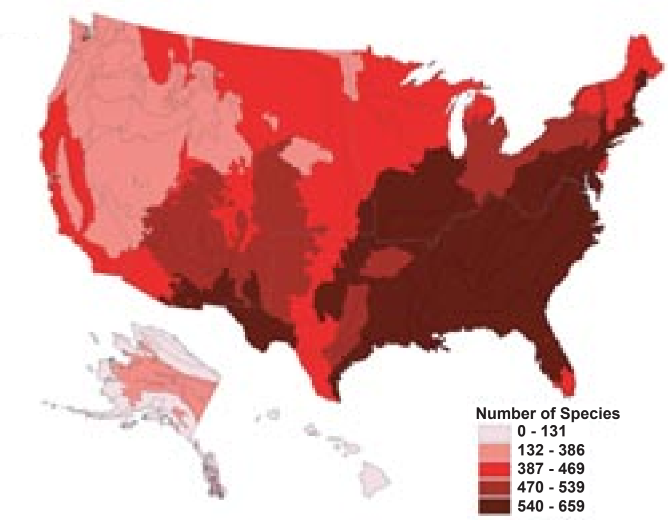


Figure 6-1. The number of tree and terrestrial animal species associated with forest habitats. (Data provided by NatureServe and World Wildlife Fund.)

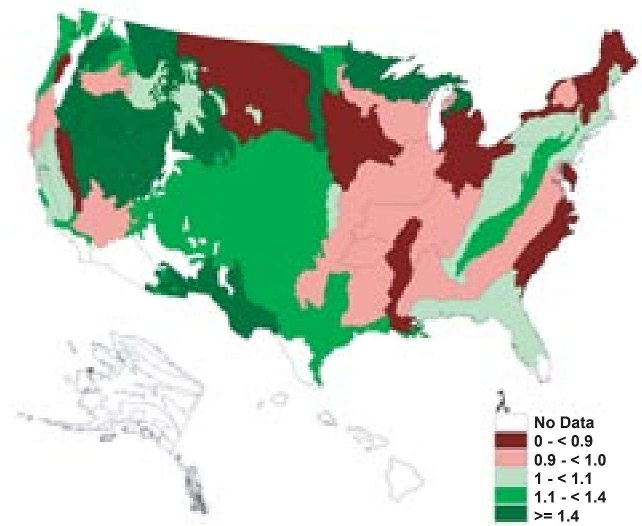


Figure 6-2. The estimated change in the number of forest-associated bird species from 1975 to 1999. Change is measured as λ (1999 richness/1975 richness). Values of $\lambda>1.0$ indicate increasing richness (green shades); values of $\lambda<1.0$ indicate declining richness (red shades). (Data provided by NatureServe and the U.S. Geological Survey Biological Resources Division.)

What Is the Indicator and Why Is It Important?

This indicator monitors the number of native species that are associated with forest habitats. Because one of the more general signs of ecosystem stress is a reduction in the variety of organisms inhabiting a given locale, species counts are often used in assessing ecosystem wellbeing. The count of forest-associated species can change under two conditions: native species can become extinct or new species can colonize and become established in the species pool. In either case, ecological processes such as productivity or trophic relationships can be altered, leading to possible changes in the way humans derive goods and services from ecosystems.

What Does the Indicator Show?

Data on the distribution of 689 tree and 1,486 terrestrial animal species associated with forest habitats (including 227 mammals, 417 birds, 176 amphibians, 191 reptiles, and 475 butterflies) were analyzed. Species richness (number of species) is highest in the Southeast and in the arid ecoregions of the Southwest (figure 6-1). Since the mid-1970s, trends in forest bird richness have been mixed (figure 6-2). Ecoregions where forest bird richness has increased the greatest are found in the West and include the Great Basin, northern Rocky Mountains, northern mixed grasslands, and southwestern deserts. Declining forest bird richness has primarily occurred in the East, with notable areas of decline in the Mississippi lowland forests, southeastern coastal plain, northern New England, southern and eastern Great Lakes forests, and central tallgrass prairie.

Why Can't the Entire Indicator Be Reported at This Time?

Monitoring species richness over large geographic areas is logistically very difficult. For this reason, systematic inventories that permit the estimation of species richness over time are lacking for most taxonomic groups. Although some data does exist, most represent a convenience sample that limits their use in estimating scientifically tenable trends in species richness. The most fundamental need is to develop economically feasible monitoring programs that address a broad spectrum of taxonomic groups.

Indicator 7. The Status (Threatened, Rare, Vulnerable, Endangered, or Extinct) of Forest-Dependent Species at Risk of Not Maintaining Viable Breeding Populations, as Determined by Legislation or Scientific Assessment

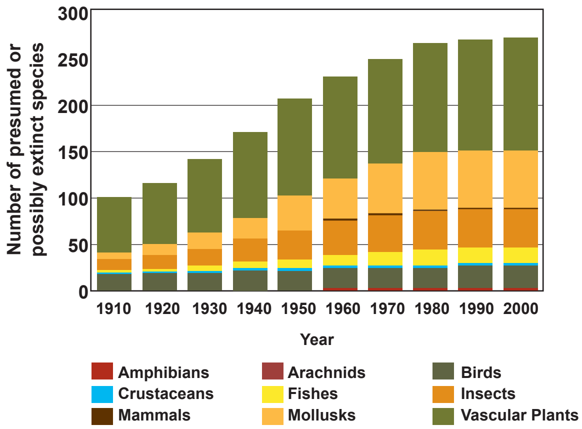


Figure 7-1. Cumulative number of species that are considered to have become extinct since 1900 by taxonomic group.[29]

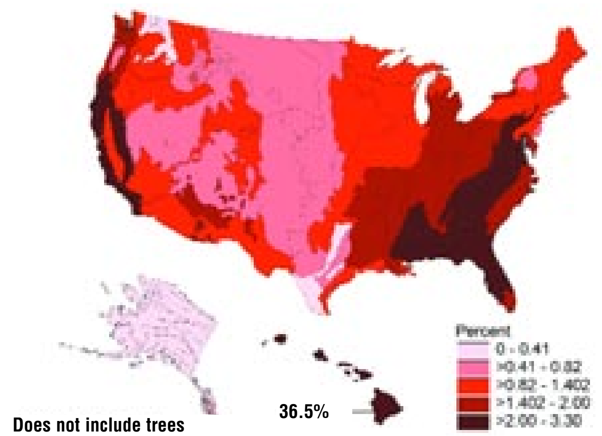


Figure 7-2. The percentage of tree and terrestrial animal species associated with forest habitats that are at risk of extinction. (Data from NatureServe and World Wildlife Fund.)

What Is the Indicator and Why Is It Important?

As the number of species considered rare increases, the likelihood of species extinction increases. This indicator focuses on species that have the greatest chance of being lost from the biotic community, and therefore presages potential declines in species richness. Because the goods and services that humans derive from ecological systems can be affected by the loss of species, tracking the number of species at risk of extinction can potentially indicate whether the use or management of forest resources is eroding or conserving biological diversity.

What Does the Indicator Show?

The trend in species extinction since the turn of the 20th century varies by taxonomic group (figure 7-1). Very few species of crustaceans, amphibians, or mammals, and no reptiles, have become extinct in the last 100 years. Although birds are prominent on the list of extinct species, their numbers have remained fairly constant since the early 1900s. In contrast, the number of insects, mollusks, fish, and vascular plants considered extinct has increased over time. When considering only trees and terrestrial animals associated with forests, 15 percent are currently at risk of extinction. Proportionately, most of those at-risk, forest-associated species are amphibians, butterflies, and grasshoppers. The at-risk species associated with forest habitats are concentrated geographically in Hawaii, in the Southeast, and on the west coast (figure 7-2).

Why Can't the Entire Indicator Be Reported at This Time?

Information on the conservation status of obscure species is lacking in many cases. Among all species (not just forest-associated ones), nearly 30 percent of insects, 11 percent of grasshoppers, and nearly 9 percent of fish species have not been assigned a conservation status category yet. In addition to dealing with this data limitation, we also are unable to examine trends in the number of at-risk species across all conservation status categories, in large part, because of the absence of periodic evaluations of species status from which trend information can be developed.

[29] The number of extinct species is for all species (not just forest-associated ones). The trend is based on only those species for which a "date of last observation" is reported.

Indicator 8. Number of Forest-Dependent Species That Occupy a Small Portion of Their Former Range

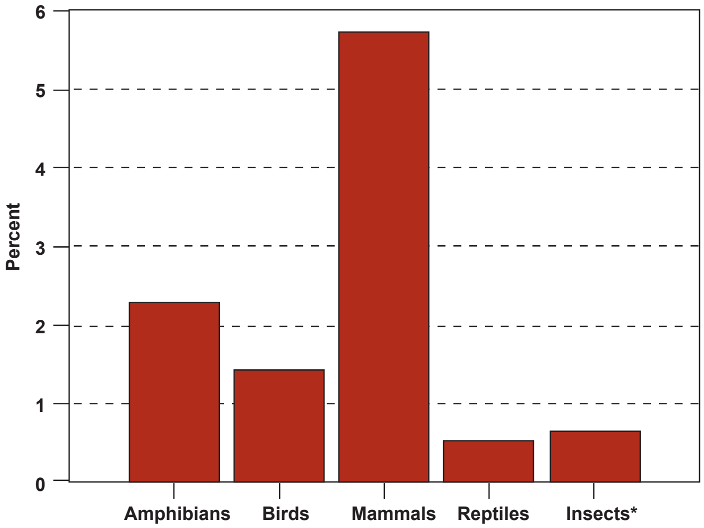


Figure 8-1. The percentage of terrestrial animal species associated with forests that now occupy ≤ 80 percent of their former geographic range (based on State-level occurrence data). * Insects includes butterflies and grasshoppers only.

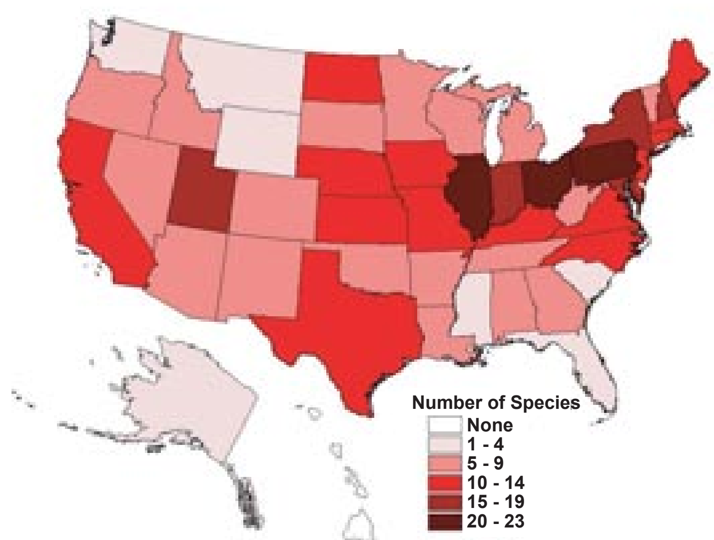


Figure 8-2. The number of terrestrial animal species associated with forests that have been extirpated within each State. (Data provided by NatureServe.)

What Is the Indicator and Why Is It Important?

This indicator compares a species' current geographic distribution with its historic distribution as a means of identifying those species whose ranges have contracted significantly. Through land-use conversions and resource management, human activity is accelerating changes in species' ranges though the alteration of native habitats, the introduction of exotic species, and direct exploitation. The size of a species' range is often related to the number of genetically distinct populations that exist. Consequently, genetic diversity is expected to decrease as species populations are lost through reductions in range size.

What Does the Indicator Show?

The geographic ranges of most species have not been appreciably reduced. Geographic range data for 1,642 terrestrial animals associated with forests show that 88 percent of species fully occupy their former range as estimated by State-level occurrence. Of the 193 species that have been extirpated from at least one State, 72 percent still occupy ≥ 90 percent of their former range. The number of species that now occupy ≤ 80 percent of their range varies by taxonomic group (figure 8-1). Range contraction of this magnitude is most commonly observed among mammals (5.7 percent), followed by amphibians (2.3 percent) and birds (1.4 percent). Geographically, States that have lost the greatest number of terrestrial animal species associated with forests are concentrated in the Northeast (figure 8-2).

Why Can't the Entire Indicator Be Reported at This Time?

Estimates of species' geographic ranges are basic to conservation planning. Unfortunately, for most species, data from which to quantify changes in range occupancy is lacking. In particular, reconstruction of former ranges is hampered by the absence of historic records. Although efforts are under way to comprehensively document species distributions, these compilations are often based on expert opinion that provides an estimate of the current range only. Because a species' geographic range is dynamic, a statistically designed inventory that permits an objective and temporally systematic assessment of range occupancy is needed.

Indicator 9. Population Levels of Representative Species from Diverse Habitats Monitored Across Their Range

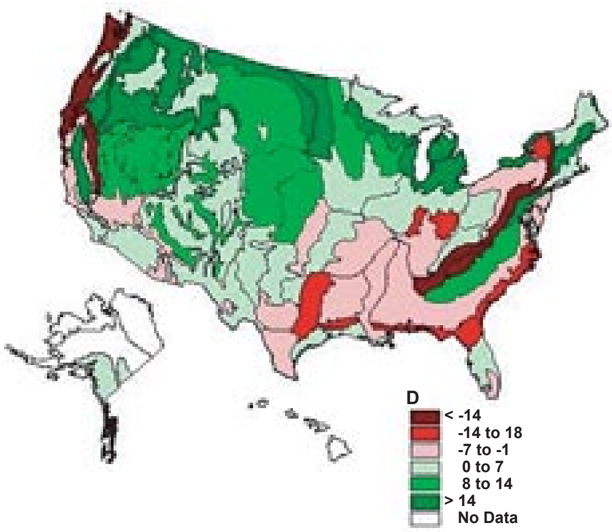


Figure 9-1. Difference (D) between the number of forest birds with significantly (P< 0.1) increasing and decreasing population trends, by physiographic region, between 1966 and 2000, calculated from the Breeding Bird Survey (BBS) database.

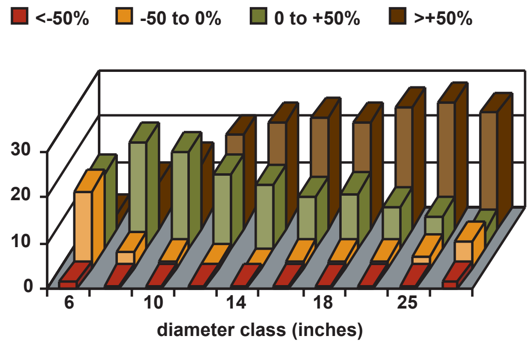


Figure 9-2. Number of tree species or groups of species in the Forest Inventory and Analysis database with decreasing and increasing stem numbers (a measure of tree population size), by diameter class, for trees >5 inches diameter breast height, between 1970 and 2002.

What Is the Indicator and Why Is It Important?

This indicator estimates population trends of selected species as a surrogate measure of genetic diversity. Decreases in genetic diversity as populations decline, particularly if associated with small populations, contribute to increased risk of extinction. This indicator also provides an important measure of general biodiversity, since changes in species abundance are a more sensitive measure of environmental stress than are species richness alone.

What Does the Indicator Show?

Between 1966 and 2000, about 26 percent of bird species associated with forests increased and 27 percent decreased; for nearly half the species, no strong evidence existed for an increasing or decreasing trend. Physiographic regions with higher numbers of bird species with significantly decreasing trends compared to bird species with significantly increasing trends are clustered on the coastal regions and eastern third of the United States (figure 9-1). Most tree species or groups of species tracked by the Forest Inventory and Analysis program show increases of >50 percent in numbers of stems > 12 inches in diameter between 1970 and 2002 (figure 9-2). State agency data indicate that populations of many big-game species increased in the last 25 years, but forest-dependent small-game species showed mixed trends.

Why Can't the Entire Indicator Be Reported at This Time?

Although it is not surprising that systematic inventories of obscure taxa (e.g., nonvascular plants, fungi, bacteria, nematodes, and arachnids) that would permit estimates of population trends over time are lacking, it is surprising that spatially and temporally extensive data for most other taxa are generally lacking as well. The paucity of population data for taxa other than bird species and a small subset of mostly big-game species points out the need to develop systematic strategies for monitoring population levels of other vertebrate, invertebrate, and plant taxa.

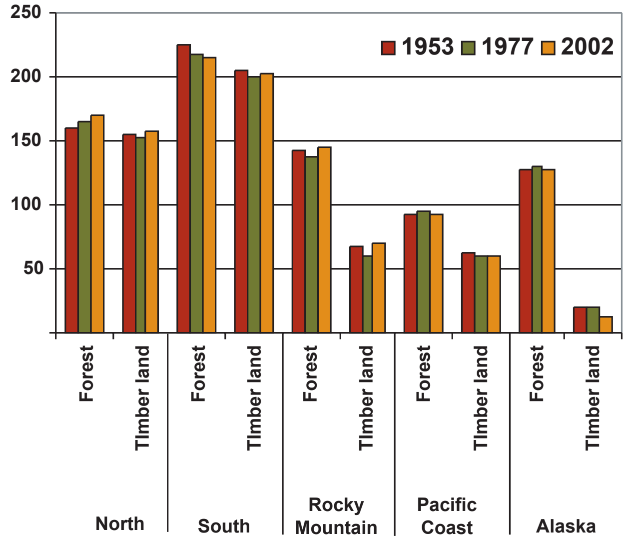


Figure 10-1. Historic forest and timber land areas by region and year

What Is the Indicator and Why Is It Important?

This indicator provides information fundamental to calculating the timber productive capacity of existing forests and shows how much forest is potentially available for timber production, compared with total forest area. Knowledge of the availability and capability of forest land to provide desired goods and services is a critical indicator of the balance of forest ecosystems relative to potential end uses. The multitemporal nature of the management objectives and planning guidelines for the diverse owners of the Nation's forests, however, makes it difficult to summarize the area of forest available for timber production in a single value at a single point in time, much less consistently over time. Within the context of this report, forest available for timber production will be defined as forest land not precluded by law or regulation from commercial harvesting of trees, or "timber land." In practice, the area available for timber production at any given time will always be a value less than total timber land. The amount of the area adjustment required to determine the actual availability of timber land will depend on the ownership mix and the management constraints in place at the time of analysis. This adjustment will also affect all other indicators in this criterion.

What Does the Indicator Show?

Total forest area available for timber production, or timber land, provides an aggregate view of the management/capability status of the Nation's forests. While the 749 million acres of U.S. forest land are about equally distributed between the East (North and South regions; 384 million total acres of forest land) and the West (Rocky Mountain, Pacific Coast, and Alaska regions; 365 million total acres of forest land), timber lands make up 504 million acres (67 percent) of this total, with 361 million acres (72 percent) in the East and 143 million acres in the West. The largest areas of forest not classified as timber land are predominantly in the West. They are composed of low-density, slow-growing pinyon-juniper forests in the Rocky Mountain Region and the slow-growing mixed spruce-and-birch forests of interior Alaska. The total area of U.S. timber land has been stable over the past 50 years, with an overall loss of only 1 percent.

Indicator 11. Total Growing Stock of Both Merchantable and Nonmerchantable Tree Species on Forest Land Available for Timber Production

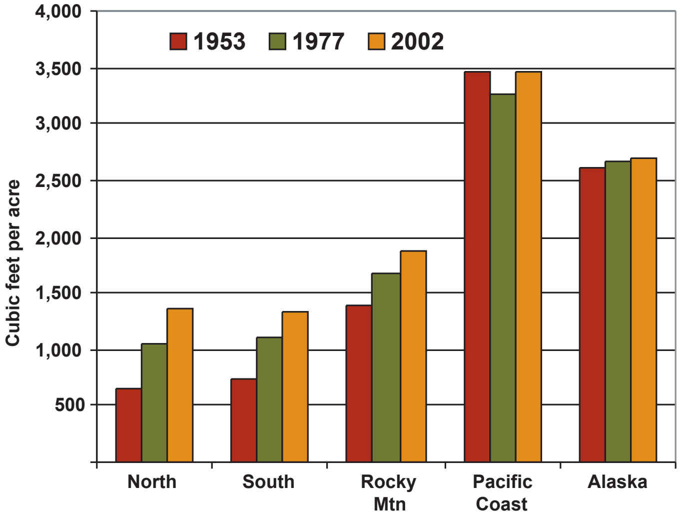


Figure 11-1. Growing stock volume per acre on timber land by region, 1953-2002.

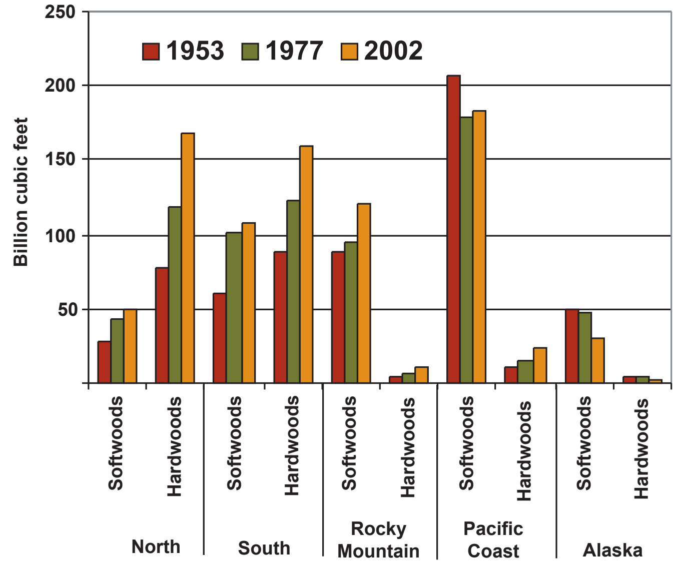


Figure 11-2. Growing stock volume on timber land by region and species group 1953–2002.

What Is the Indicator and Why Is It Important?

Growing stock is a fundamental element in determining the productive capacity of the area identified as forest available for timber production. Knowledge of growing stock of the various species that make up the forest and how growing stock changes over time is central to considerations of a sustainable supply of wood for products and the sustainability of the ecosystems that provide them.

What Does the Indicator Show?

The Nation's timber lands contain more than 800 species of trees. Variability in the condition of the size and quality of those trees has considerable bearing on their value in wood products. Generally speaking, about 94 percent of all live tree volume on U.S. timber land is considered to be growing stock, or wood capable of being used for commercial products. The remaining 6 percent is considered to be trees of poor form and/or small stature, or that are otherwise unsuited for wood products. With the relatively stable base of forest land available for timber production or timber land (indicator 10) and a historic pattern of growth exceeding removals (indicator 13), the volume of growing stock in the United States has been rising steadily for more than 50 years. The current growing stock of 856 billion feet is 39 percent higher than the volume in 1953. The Nation's conifer-growing stock volume totals 492 billion cubic feet, or 57 percent of all growing stock. Conifer-growing stock volume is concentrated in the West. At 364 billion cubic feet, broadleaf species account for 43 percent of all growing stock timber volume in the United States. Broadleaf volume has risen 98 percent as second- and third-growth forests in the North and South continue to mature.

Ownership of timber land has a direct effect on the availability of timber for products. As public policy responds to increasing demand for using public forest land for recreation, wildlife habitats, and biodiversity conservation, the area and corresponding volume of timber available for harvest from public timber lands has been declining, which places additional pressure on private timber land and imports. This pressure is further heightened by improved technologies that enable a shift to broadleaf species, which are dominant on private timber lands, for many previously conifer-dominated products such as paper and composite products. Overall, per-acre volume on private timber land is increasing but has slowed in response to increasing demand caused by shifts in public policy and wood product-processing technology.

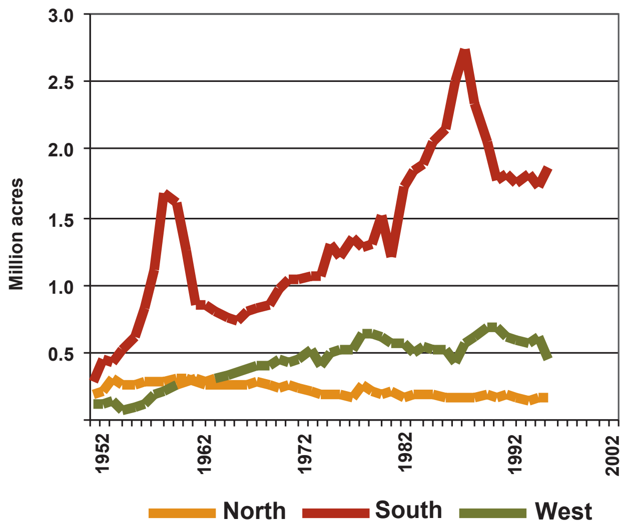


Figure 12-1. Tree planting in the United States by year and region, 1952–1996.

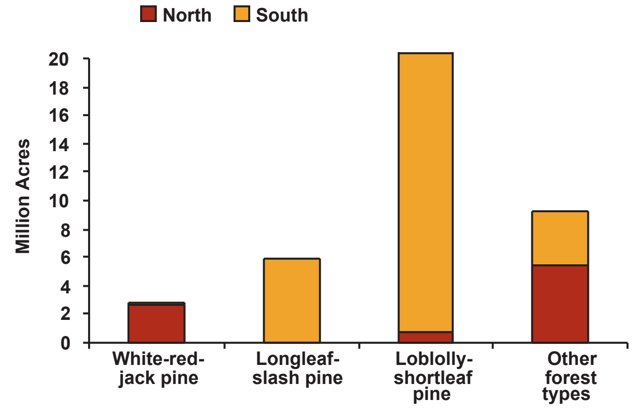


Figure 12-2. Area of timber land plantations in the North and South, 2002.

What Is the Indicator and Why Is It Important?

This indicator is a measure of the degree to which forest plantations are being established in response to increasing demand for forest products and competing nontimber uses for forest land. The provision of forest products from intensively managed plantations can enhance the potential range and quantity of goods and services available from the remaining forest.

What Does the Indicator Show?

Since 1926, forest planting has risen steadily in the United States. By 2001, it was taking place on more than 2 million acres per year throughout the Nation. Two types of planting can be identified: (1) traditional planting of intensively managed trees in which other native tree species are actively suppressed, and (2) planting to augment stocking of naturally regenerating forests. The latter type of planting, which occurs predominantly in the West, seeks to improve stocking of desired native species and to improve the forest's capacity to produce timber products. This indicator will focus on plantation timber land in the North and South regions, which generally use silvicultural practices that fully or partially suppress existing vegetation at the time of planting and/or during stand rotation to improve yields and shorten rotations.

In 2002, plantation timber land totaled 46 million acres (9 percent of all timber land) in the United States and was predominately composed of conifer species. Most plantations are in the South, which has 38 million acres, or about 82 percent of all timber land plantations. In the United States, 70 percent of all plantations are composed of southern pines—longleaf, slash, loblolly, or shortleaf pines. Plantation acreage continues to rise in the United States, particularly in the South, where it currently constitutes 19 percent of all timberlands. Growing stock volume on plantation timber land totaled 30 billion cubic feet in 2002, or 9 percent of total growing stock in the combined North and South regions and 4 percent of all growing stock in the United States.

In contrast to planting practices in many other countries, virtually all tree planting in the United States is of native species. About a dozen exotic species are planted in the United States, but the acreage of these plantings constitutes less than 1 percent of the forest area planted each year.

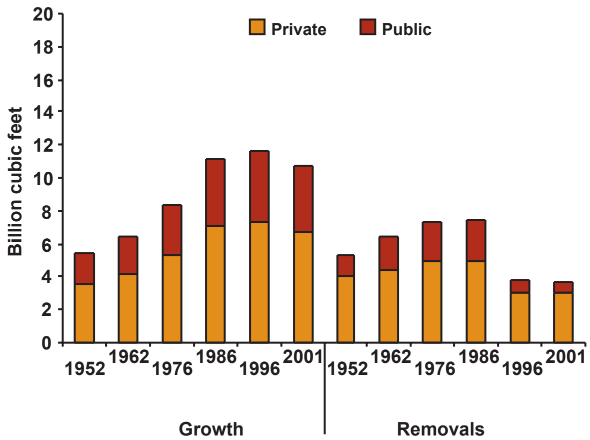


Figure 13-1. Growth and removals of growing stock on timber land in the West, 1952–2001.

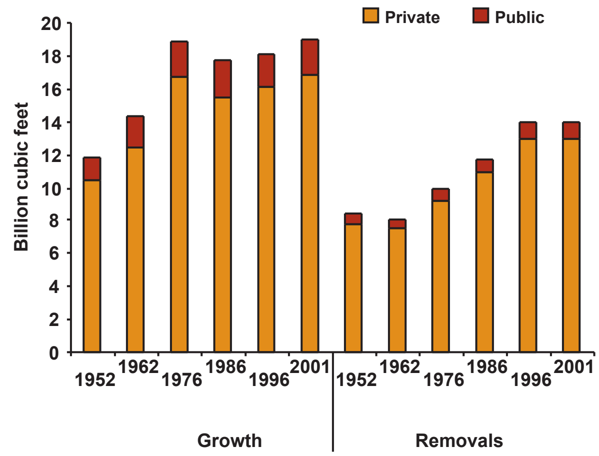


Figure 13-2. Growth and removals of growing stock on timber land in the East, 1952–2001.

What Is the Indicator and Why Is It Important?

This indicator compares net growth of growing stock with wood harvest (removals) of products on timber land. This method is frequently used to assess whether wood harvesting is reducing the total volume of trees on forest available for timber production. Growth is the net annual increase in the volume of growing stock between inventories after accounting for effects of mortality but before accounting for the effects of harvest. Removals measure the average annual volume of living trees harvested between inventories. Timber land is the subset of forest land on which some level of harvesting is potentially allowed. The volume of trees on timber land is considered sustainable as long as growth (net of mortality) exceeds removals.

What Does the Indicator Show?

Growth has exceeded removals on U.S. timber lands for several decades, while the area of timber land has remained relatively stable. The result has been a substantial increase in the volume of growing stock on U.S. timber lands. In the 1990s, growth continued to exceed removals for both publicly and privately owned timber lands in the East (North and South regions) and West (Rocky Mountain, Pacific Coast, and Alaska regions).

Trends in growth on timber land since 1952 are attributable to several factors. In general, positive growth trends reflect regrowth and maturation of forests on lands that had been harvested before 1952. Growth trends also reflect investments in fire protection, land owner education, and silviculture. Changes in harvest patterns in the 1990s resulted in shifts in growth and removals by ownership and region. Historically, most harvesting occurred on private timber lands in the East. Recent data shows a further shift of removals from public timber land in the West to private timber land in the East. Thus, growth has been exceeding removals by a wider margin in the West, while the gap has been decreasing in the East. Currently, total removals are 76 percent of net growth in the East and 45 percent of growth in the West.

Comparing net growth on timber land to removals conveys no information about quality, biodiversity, other attributes of ecology, or management objectives, and should be considered in conjunction with other indicators to monitor the overall sustainability of forest management.

Indicator 14. Annual Removal of Nontimber Forest Products (e.g., Fur Bearers, Berries, Mushrooms, Game) Compared to the Level Determined To Be Sustainable

What Is the Indicator and Why Is It Important?

This indicator shows removal of nontimber forest products (NTFPs). As demand for these products grows, it becomes more important to monitor the products' flow and the effect of their removal on the viability of current and future forest ecosystems. Information is not currently available to compare the growth and removals of NTFPs to evaluate sustainable levels.

What Does the Indicator Show?

NTFPs include medicinal plants, food and forage species, floral and horticultural species, resins and oils, materials used for arts and crafts, and game animals and fur bearers. The popular use of medicinal plants has experienced an expansion in the past 20 years, exceeding the use of any other nontimber native flora. Demand for medicinal plants has prompted protective measures. Foods from native species provide a very small share of the food species consumed by Americans, but are often culturally significant and are becoming increasingly popular in restaurants. Native plants used for decorating homes and workplaces are as diverse as the decorative forms invented. A tremendous variety of native plant, lichen, and moss species supplies commercial foliage, stems, branches, fruits, and other vegetation used in the winter holiday season and in the year-round floral industry. The use of NTFPs in arts and crafts is an integral part of innumerable traditions in the United States. Resins and oil products derived from native plant species fall into several broad categories. Industrial chemists use aromatic plant compounds in air fresheners, bath products, diffusers, hair- and skin-care products, inhalants, massage oils, and perfumes. "Big game" primarily denotes large mammal species taken for sport or subsistence. Over the past 20 years, harvests of common big-game species have generally paralleled population trends; the number of hunters and the time devoted to hunting has been increasing. The number of small-game hunters has declined at a nearly constant rate since the mid-1970s. From 1975 to 1996, there was also a steady decline in the number of migratory bird hunters. The national trend in fur harvests has declined from a peak of 20 million pelts in 1980 to a low of 3 million pelts in 1991. Despite the lack of national quantified information across many NTFP categories, removal of NTFPs from forest ecosystems is a significant and very important activity to many Americans for recreational, commercial, subsistence, and cultural uses.

Annual or periodic harvest of NTFPs is largely undocumented, particularly on private forest land, although it is understood that such activity has affected forest ecosystems. An immediate need exists for compiling existing life history information on key products and for developing life histories where information is missing; for choosing several key products based on ecological sensitivity or economic/social importance; and for developing pilot studies to measure biologically and socially sustainable harvest levels using the concepts of population biology, social science, economics, and ecology.

Indicator 15. Area and Percent of Forest Affected by Processes or Agents Beyond the Range of Historic Variation (e.g., By Insects, Disease, Competition from Exotic Species, Fire, Storm, Land Clearance, Permanent Flooding, Salinisation, and Domestic Animals)

What Is the Indicator and Why Is It Important?

This indicator analyzes and reports the effects of climate, fire, insects, disease, and invasive plants on ecological processes in forests. When these processes are altered beyond some critical threshold, they may produce significant changes to forest condition.

What Does the Indicator Show?

Depending on available data for each process agent, the effects on the forest between 1996 and 2000 were determined to be beyond the range of historic or recent variation. The range of historic variation is defined as the effects of the process or agent during the 1800 to 1850 (historic or baseline period). The range of recent variation is defined as the effects of the process or agent during the recent past (approximately 1920 to 2000). The analysis of historic variation was based primarily on anecdotal data while the analysis of recent variation relied on more quantitative data, particularly for the period 1979 to 1995.

Process, Agent, or Event	**Beyond Historic Range** (year)	**Beyond Recent Range** (year)
Climate		
El Nino and la Nina events of 1997–2000	--	1997-2000
Ice storm (Northeast)	--	1998
Fire		
Area burned (nationwide)	--	2000
Area burned (West)	--	1996, 1998, 2000
Indigenous insects		
Southern pine beetle (South)	1986, 1995	2000 (parts of AZ, FL, KY)
Mountain pine beetle	1981	--
Spruce beetle (AK)	1996	1996
Spruce budworm (ME)	1978	--
Spruce budworm (AK)	--	1997
Western spruce budworm (West)	1986	--
Douglas-fir tussock moth (ID, OR, WA, MT)	1973	--
Indigenous pathogens		
Dwarf mistletoes, western root diseases (West)	1950-2000	--
Fusiform rust (South), oak wilt (TX)	1950-2000	--
Oak decline (AR)	2000	--
White-tailed deer (North Region)	1950-2000	--
Exotic insects and diseases, diseases of unknown origin, and exotic invasive plants	All years since their introduction	

The behavior of many processes and agents has been altered due to human activities such as fire exclusion, intensive forest management, and introduction of exotic species. Although most indigenous insects were at lower levels during the 1996–2000 analysis period than in previous years, they still caused serious regional and local damage to forests despite management actions to control them. Further details on the processes, agents, and events affecting U.S. forests can be found in the supporting technical document in the Data Report (see http://www.fs.fed.us/research/sustain).

Indicator 16. Area and Percent of Forest Land Subjected to Levels of Specific Air Pollutants (e.g., Sulfates, Nitrate, Ozone) or Ultraviolet That May Cause Negative Impacts on the Forest Ecosystem

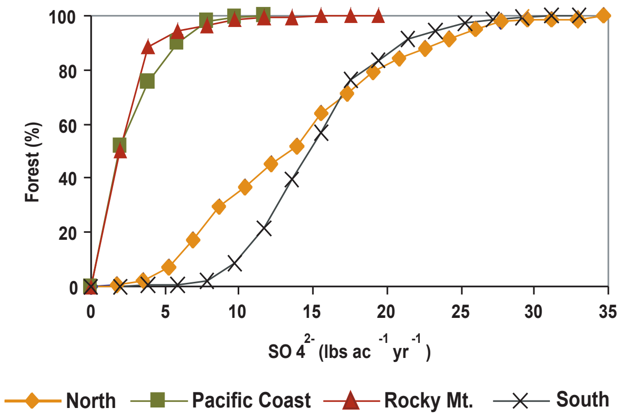


Figure 16-1. Cumulative distribution function of percent of forest subject to specific levels of wet SO_4^{2-} deposition (1994–2000).

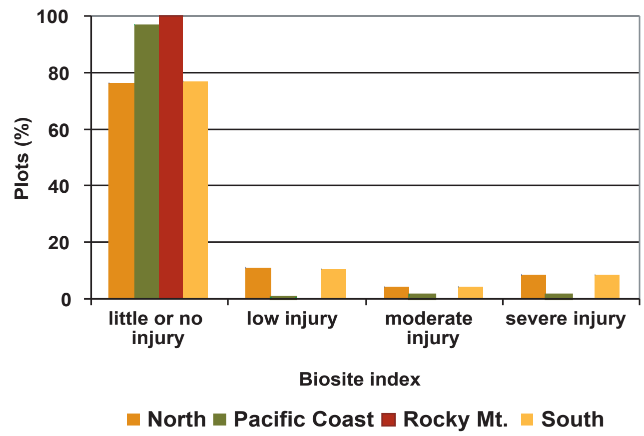


Figure 16-2. Histogram of percent of ozone biomonitoring plots with low, moderate, or severe foliar O_3 injury recorded.

What Is the Indicator and Why Is It Important?

Air pollutants are considered to have a significant cumulative effect on forest ecosystems. They affect regeneration, productivity, and species composition. In the United States, inputs of sulfur, nitrogen, and tropospheric ozone are of primary concern in forested ecosystems. Their effects include soil and water acidification, base cation depletion, and foliar injury.

What Does the Indicator Show?

Air pollution exposure was generally highest in the Eastern United States (North and South Resource Planning Act [RPA] regions). Annual estimates of sulfate deposition for forested areas decreased across RPA regions from 1994 through 2000. Those trends were statistically significant in the North and South RPA regions, where approximately 50 percent of the forest was exposed to sulfate deposition of more than 13.4 lbs ac^{-1} yr^{-1} for the period. Nitrate deposition rates were lowest in the Pacific Coast and Rocky Mountain RPA regions. In those areas, approximately 84 percent of the forest received less than 4.2 lbs ac^{-1} yr^{-1} from 1994 through 2000, as compared to the North and South RPA regions where only 2 percent of the forest received less than 4.2 lbs ac^{-1} yr^{-1} of nitrate deposition. Ozone exposure was highest across the South RPA Region and in southern California; however, little or no ozone injury to plants was recorded on most ozone biomonitoring plots across RPA regions. In the North and South RPA regions, approximately 77 percent of the biomonitoring plots received little or no ozone injury. In the Pacific Coast and Rocky Mountain RPA regions, 97 percent and 100 percent, respectively, of the biomonitoring plots had little or no injury from ambient levels of tropospheric ozone. Only a small portion of plots, mostly in the North and South RPA regions, had severe foliar injury. Results from multivariate analysis showed the oak-hickory and loblolly-shortleaf forest type groups were generally exposed to more air pollution than other forest types. Conversely, western white pine and larch forest type groups were exposed to less air pollution than all other forest types. Currently, it is not known if the specific levels of sulfate, nitrate, and ammonium deposition reported cause large-scale negative effects on forest ecosystems even though smaller-scale effects have been observed (e.g., high-elevation spruce-fir forests).

Indicator 17. Area and Percent of Forest Land with Diminished Biological Components Indicative of Changes in Fundamental Ecological Processes (e.g., Soil Nutrient Cycling, Seed Dispersion, Pollination) and/or Ecological Continuity (Monitoring of Functionally Important Species, such as Fungi, Arboreal, Epiphytes, Nematodes, Beetles, Wasps, etc.)

RPA Region	Diminished Biological Components? Yes	No	No or Insufficient Data
	---------------------Percent---------------------		
North	33.1	37.1	29.8
South	0.0	43.1	56.9
Rocky Mtn.	18.5	29.2	52.3
Pacific Coast	40.5	59.5	0.0
United States	20.3	40.9	38.8

Table 17-1. Percentages of forest area in coterminous 48 States with diminished biological components.

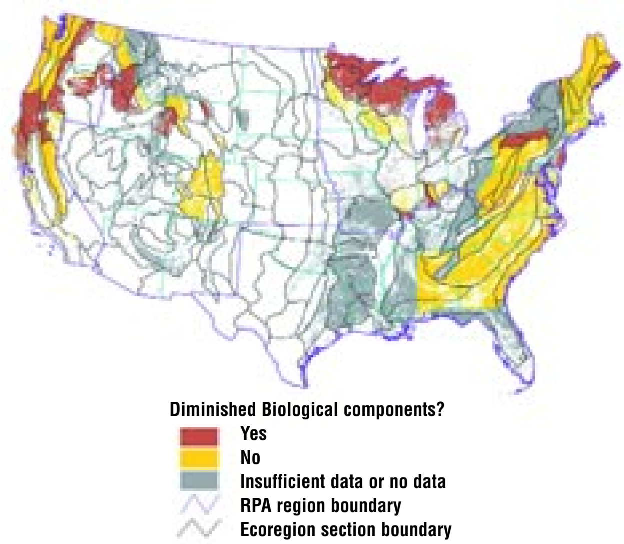


Figure 17-1. Forest area having diminished biological components that may indicate changes in fundamental ecological processes and/or ecological continuity.

What Is the Indicator and Why Is It Important?

The purpose of this indicator is to evaluate the status of fundamental ecological processes that are essential to continued ecosystem health and vitality. Because it is extremely difficult to measure most ecological processes directly, the indicator is framed in terms of biological components of the forest ecosystem that reflect the state of fundamental ecological processes. In some cases, measures of biological components that may be incorporated directly reflect a change in ecological processes or ecological continuity. In other cases, the relationship between the biological components measured and the underlying ecological processes is much less direct or less well understood.

Because forest ecosystems include the entire suite of forest biota, not just trees, data relating to the entire range of forest species could potentially be incorporated into this indicator. The available national scale data, however, relates almost exclusively to trees. In the future, information on other forest biota may be incorporated into this indicator.

What Does the Indicator Show?

At this time, it is possible to only partially evaluate this indicator because (1) national-scale data is lacking on many components of forest ecosystems, (2) available data coverage is incomplete, and (3) fundamental research linking biological components to ecological processes is lacking.

As a first approximation, this analysis used three metrics: tree mortality, tree crown condition, and fire condition class. The analysis was limited to States in which Forest Health Monitoring plots had been remeasured. An ecoregion section was considered to have diminished biological components if (1) average annual mortality volume was more than 60 percent of gross annual growth volume, (2) the ZB-index, an indicator of crown condition, was increasing at a rate of 0.015 or more per year, or (3) more than half of the forest area was in fire Current Condition Class 3 (fire regimes significantly altered; high risk of losing ecosystem components).

Overall, 20 percent of the forest area of the coterminous 48 States (or about one-third of the forest area analyzed) was found to have diminished biological components. Those areas are concentrated in the Lake States and in the Northwestern United States. In several areas, especially northern Minnesota and the Eastern Cascades of Washington and Oregon, mortality is high and a large proportion of forest is in Condition Class 3. This high proportion of the forest in Condition Class 3 suggests that high mortality may be producing high fuel loads for fire or that fire suppression and/or other past management may have produced a large proportion of overmature, senescent stands.

Indicator 18. Area and Percent of Forest Land with Significant Soil Erosion

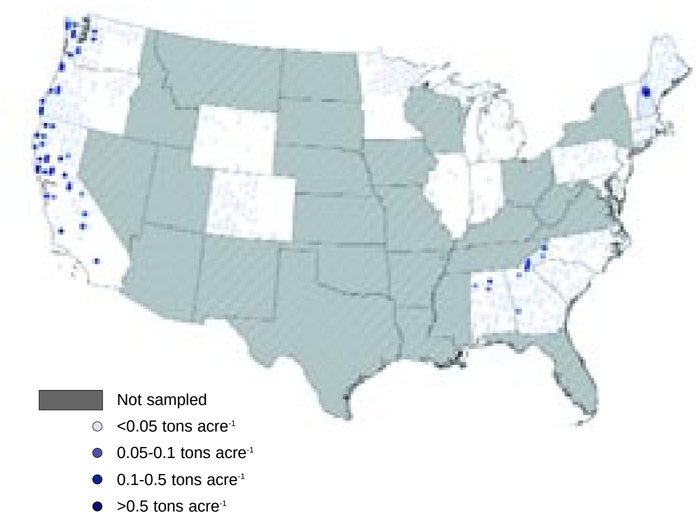


Figure 18-1. Modeled erosion rates on forest health monitoring plots (1999) under average climatic conditions (2-year return interval) using the Water Erosion Prediction Project model.

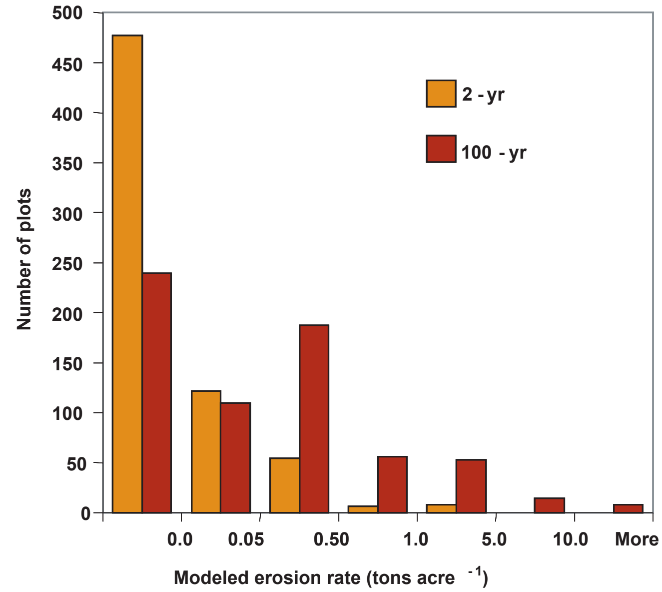


Figure 18-2. Frequency distribution for modeled erosion rates on forest health monitoring plots (1999) following 2-year (average) and 100-year storm events.

What Is the Indicator and Why Is It Important?

Erosion removes stored nutrients and organic matter from the soil surface, diminishes the capacity of the soil to support vegetation, and can represent a threat to soil, water, and related forest resources. This indicator measures the extent of accelerated erosion in forests that is sufficient to lower soil productivity or cause significant sediment delivery to streams. Long-term rates of geologic erosion or mass wasting events are not considered in this analysis.

What Does the Indicator Show?

Potential erosion rates for plots measured in 1999 as part of the Forest Health Monitoring Program (FHM) were modeled using the Water Erosion Prediction Project. Modeled erosion rates on undisturbed forest land were generally small, with nearly 90 percent of the 677 plots modeled having potential erosion rates of less than 0.05 tons acre^{-1} under average precipitation events (2-year return interval). For comparison, these values are an order of magnitude smaller than the 3.1 tons/acre/year estimated for agricultural lands (1997 National Resources Inventory). Following a more severe precipitation event (100-year storm), modeled erosion rates increased, with 19.6 percent of plots having a modeled erosion rate greater than 0.5 tons acre^{-1} (median 0.04 tons acre^{-1}). Sensitivity analyses indicate that disturbances can increase erosion rates by two to three orders of magnitude in the first year after the disturbance. Exposed mineral soil was a common occurrence in all regions of the country sampled, with most plots (65 percent) reporting bare soil on less than 5 percent of the plot.

Erosion estimates are limited by model assumptions, and aggregate estimates of soil erosion often have little meaning in and of themselves because of the natural variability in soil erosion. The term "significant" needs to be defined with respect to variation among different landscapes, soils, and vegetation communities.

Indicator 19. Area and Percent of Forest Land Managed Primarily for Protective Functions (e.g., Watersheds, Flood Protection, Avalanche Protection, Riparian Zones)

What Is the Indicator and Why Is It Important?

This indicator provides a measure of the extent to which soil and water resources are protected.

Why Can't This Indicator Be Reported at This Time?

At this time, data is not available for this indicator. Although there are many examples of protected areas, such as the Portland, OR, and New York City watersheds, no attempt has been made to aggregate data to a national scale. Partly at issue is determination of management intention. For example, management objectives on public and private forest land would have to be ascertained. Partly at issue are reporting protocols. For example, much of the publicly owned and some privately owned forest lands are managed with multiple objectives. It would be difficult to attribute some of the area to any one objective.

Indicator 20. Percent of Stream Kilometers in Forested Catchments in Which Stream Flow and Timing Have Deviated Significantly from the Historic Range of Variation

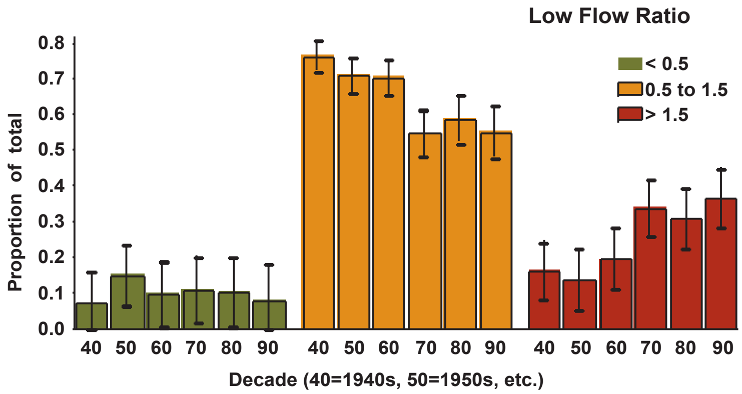


Figure 20-1. Decreased (< 0.5) and increased (>1.5) ratios of 1940–2000 data over 1870–1939 data indicates decreased and increased minimum flow rates for watersheds. Also apparent is an increase in the number of watersheds with increased minimum flows for 1970–2000.

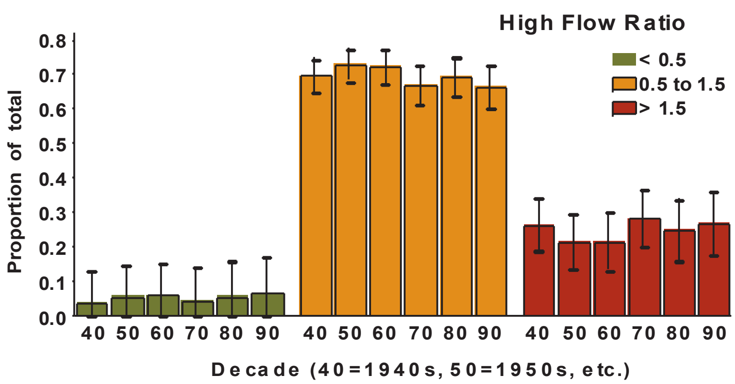


Figure 20-2. Decreased (< 0.5) and increased (>1.5) ratios of 1940–2000 data over 1870–1939 data indicates decreased and increased maximum flow rates for watersheds. There was no apparent increase in the number of watersheds with decreased or increased maximum flow rates for the period 1970–2000.

What Is the Indictor and Why Is It Important?

This indicator measures the effects of forest management and other factors on water flow, including variations in quantity and timing of flow. The timing, magnitude, duration, and spatial distribution of maximum and minimum flow rates must be sufficient to create, and then sustain, aquatic and associated riparian ecosystem habitat to ensure the health and sustainability of those systems, and for the quantity and quality of water for humans. This indicator measures long-term changes in stream or river maximum and minimum flows (most likely resulting from human activities), rather than singular occurrences of flooding or dry periods.

What Does the Indicator Show?

More than 20 million waterflow measurements from 1870–2000 were analyzed for 506 of 1960 hydrologic unit code watersheds (HUC-8) in the coterminous 48 States. Maximum flow ratios (95th percentile of annual flow values) and minimum flow ratios (5th percentile of annual flow values) of pre-1940 flow rates were compared with flow rates in subsequent decades. Data from watersheds in 1870–1939 were often sparse and were combined to compare with post-1939 data. That data represents both forest and nonforest area. Ratios greater than 1.5 indicated significant change in maximum and minimum flow rates in 1940–2000 compared to1870–1939. Ten percent of the watersheds had decreased minimum flow rates and 25 percent had increased minimum flow rates. Similarly, 5 percent of the watersheds had lower maximum flow rates and 25 percent had higher maximum flow rates. Additional analyses of watersheds by decades (1940s, 1950s, etc.) indicated no apparent temporal change in lower or higher maximum flow rates, but did show an increasing change in higher minimum flow rates for the 1970s, 1980s, and 1990s, with about 20 percent of the watersheds showing increased minimum flows in 1940–1969, to about 35 percent of the watersheds with increased minimum flows in 1970–2000. Spatially, most of the increased minimum and maximum flow rates were found in the Eastern United States, and most of the decreased minimum and maximum flow rates were more common in the Central and Western United States.

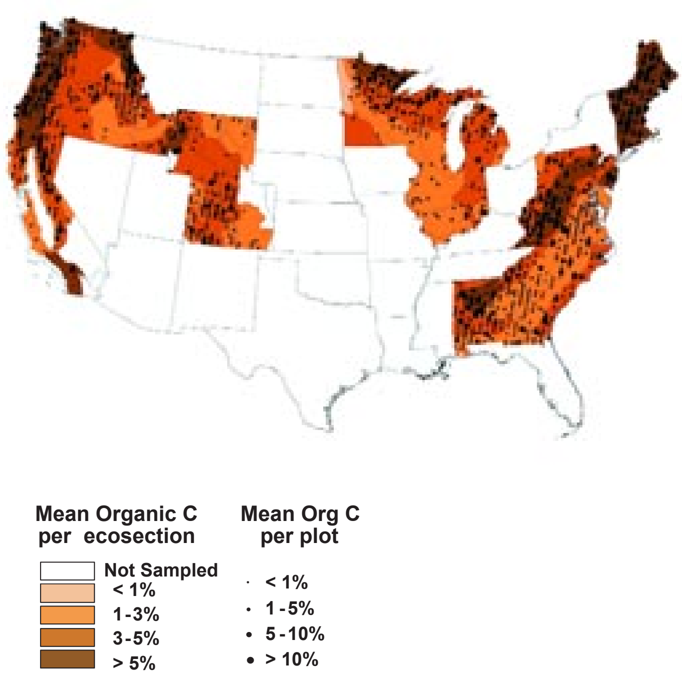


Figure 21-1. Percent of organic carbon in upper mineral soil layers measured on forest health monitoring plots (1998–1999).

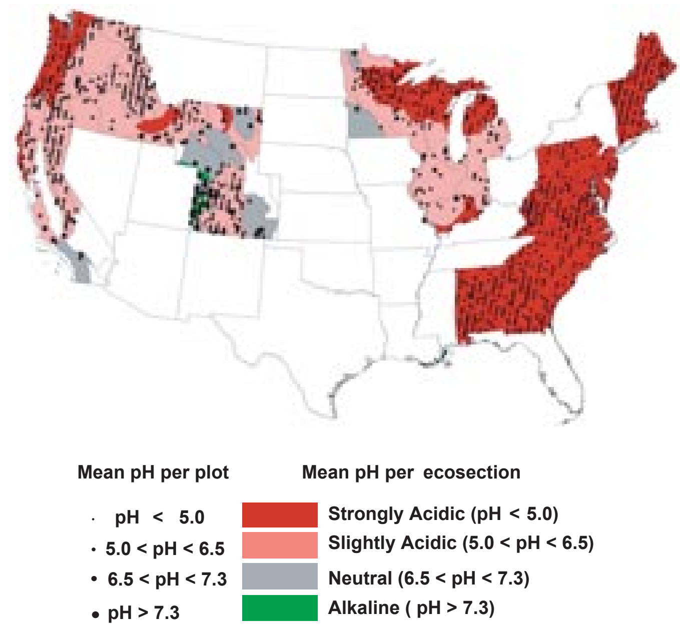


Figure 21-2. Water pH in upper mineral soil layers measured on forest health monitoring plots (1998–1999).

What Is the Indicator and Why Is It Important?

Forest productivity may be adversely affected by changes in soil chemical properties following disturbances or certain management practices. The goal of this indicator is to quantify changes in soil chemical variables relative to long-term average values that may be sufficient to negatively affect soil fertility and site productivity. Soil organic matter (SOM) and pH were selected as indicators because they function as key regulators of soil chemical, biological, and physical processes.

What Does the Indicator Show?

Monitoring of forest soils is relatively new, and little is known about historical values for soil properties in undisturbed forest ecosystems. As a result, this report focuses primarily on documenting the current distribution of SOM and pH. Data from the NRCS STATSGO (Natural Resources Conservation Service State Soil Geographic) database indicates that the lowest concentrations of SOM are expected in regions where high rates of decomposition are promoted by environmental or chemical variables, such as temperature, moisture, or pH. Nationally, 3.8 percent of woodland soils have a mean SOM concentration of less than 1 percent by weight. More than 95 percent of those low SOM soils were located in the Rocky Mountain and Southern Resources Planning Act (RPA) regions. Across all regions, 18 percent of woodland soils were characterized as strongly acidic (pH ≤ 5.0). Although the STATSGO designation of woodland soils differs from definitions used in the Forest Inventory and Analysis (FIA) program, and care must be taken in comparing data from these two sources, these geographic trends are supported by initial data from the Forest Health Monitoring (FHM) program in 1998–1999 (Conkling et al., in press). The effect of a reduction in SOM or an increase in acidity on site productivity, as well as the degree of change that is tolerable, varies for different soil and vegetation types. Once baseline levels have been established, interpretation of trends should be made within the context of specific forest type-soil associations. When fully implemented, the FIA soil data will provide critical information on changes in the chemical status of forest soils for use in future reporting efforts.

Indicator 22. Area and Percent of Forest Land with Significant Compaction or Change in Soil Physical Properties Resulting from Human Activities

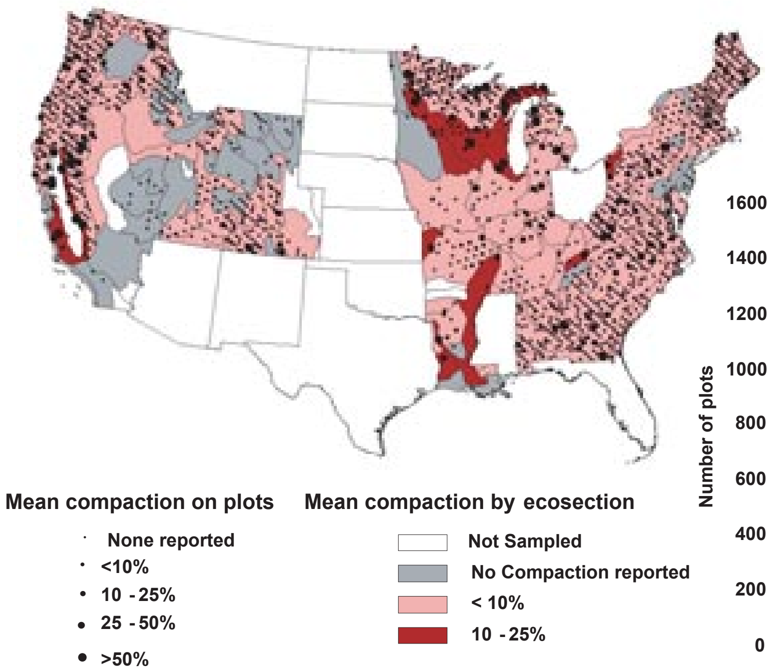


Figure 22-1. Mean surface compaction reported on forest health monitoring plots (1999–2000).

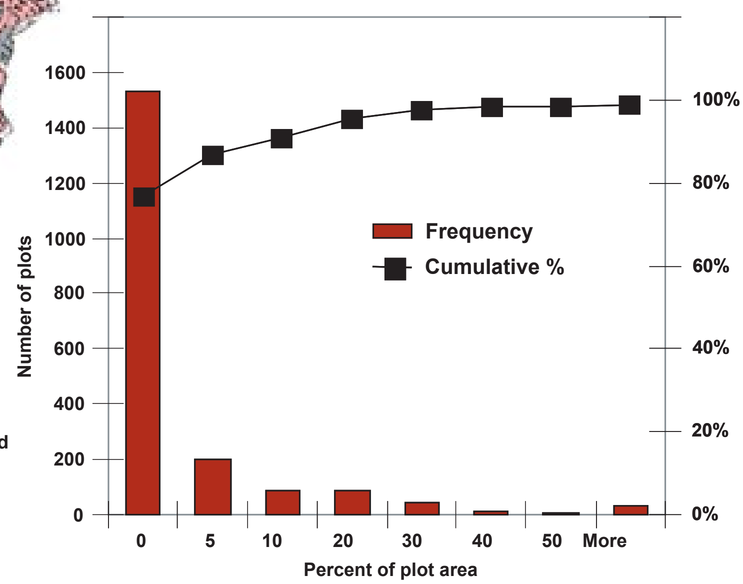


Figure 22-2. Frequency distribution of surface compaction reported on forest health monitoring plots (1999–2000).

What Is the Indicator and Why Is It Important?

Soil is a complex mixture of air, water, mineral material, and organic matter. Compaction changes the ratio between these components and has the potential to negatively affect productivity. The purpose of this indicator is to quantify the extent of human-induced changes to soil physical characteristics that might adversely affect soil fertility, hydrology, or other ecosystem processes.

What Does the Indicator Show?

Visual estimates of surface soil compaction are currently measured on a subset of the national Forest Inventory and Analysis (FIA) plot network. Initial data collected from 1999 to 2000, as part of the Forest Health Monitoring (FHM) Program indicate that soil compaction was primarily a localized phenomena. More than 86 percent of the 2,006 FHM plots measured during this time reported only trace levels of soil compaction (< 5 percent of the plot area). In addition, only a small fraction of plots (1.6 percent) reported surface disturbance on more than 50 percent of the plot area. Soil compaction may be a serious problem on a local scale, however, as indicated by the high proportion of disturbance reported for some individual plots.

The FIA soil indicator program is still in the implementation phase, and plots have not yet been established in all States. As such, any analysis of data from this program is necessarily limited in scope. In addition, no measurements were made regarding the degree or intensity of compaction. Physical disturbances that are not readily visible from the surface may be underreported. Compaction data from FIA/FHM is intended to provide only a "presence/absence" index of the occurrence of disturbed soils across the landscape. Linkages to process-level research are needed to determine the ecological significance of these measurements for different forest systems and soil types.

Indicator 23. Percent of Water Bodies in Forest Areas (e.g., Stream Kilometers, Lake Hectares) with Significant Variance of Biological Diversity from the Historic Range of Variability

What Is the Indicator and Why Is It Important?

This indicator measures how well biological diversity (however measured) compares with what might be expected under natural or "historic" conditions. Water bodies where biological diversity is "close" to natural or historic conditions are more likely to withstand natural and manmade stresses.

Why Can't This Indicator Be Reported at This Time?

Comparisons of current conditions with natural or historic conditions must be tailored to each region of the country to ensure that each stream or lake is compared with the appropriate reference. Only a handful of States regularly conduct quantitative tests of the condition of fish or bottom-dwelling animal communities. Thirty States are developing such tests, and five States already use such tests in regulating water quality.

Indicator 24. Percent of Water Bodies in Forest Areas (e.g., Stream Kilometers, Lake Hectares) with Significant Variation from the Historic Range of Variability in pH, Dissolved Oxygen, Levels of Chemicals (Electrical Conductivity), Sedimentation, or Temperature Change

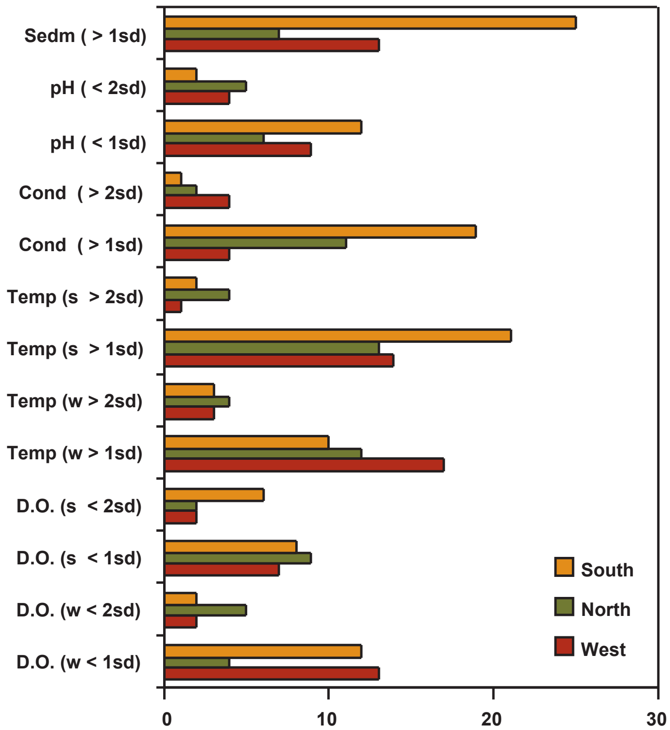


Figure 24-1. Percentage of counties with HUC8 watersheds that were significantly different from other counties within each Resources Planning Act region. (Sed=sediment; pH=water pH; EC=electrical conductivity; T=temperature of water; DO=dissolved oxygen in water; s=summer; w=winter; sd=standard deviation of mean).

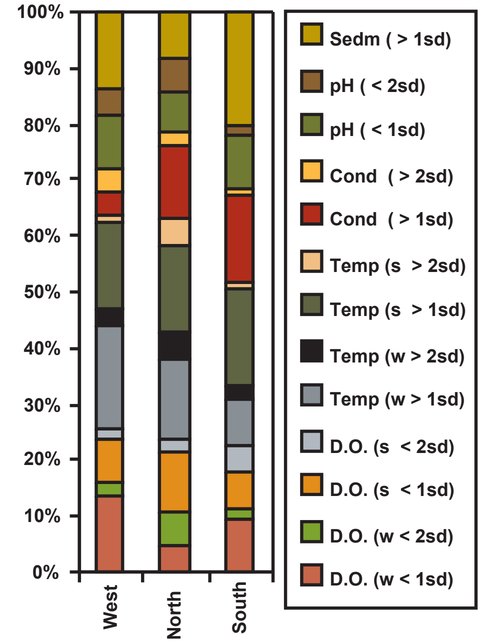


Figure 24-2. The relative contribution of each variable to the effects on aquatic systems within forested watersheds in counties of each Resources Planning Act region.

What Is the Indicator and Why Is It Important?

This indicator measures key chemical and physical attributes of aquatic health and water quality. Water temperature (T) is an important aspect of aquatic habitat and influences metabolism, behavior, and mortality of aquatic species. Dissolved oxygen (DO) is essential for most aquatic life. Electrical conductivity (EC) represents the amount of total dissolved salts (ions) in the water. The pH of a water sample measures the concentration of hydrogen ions, and determines the biological availability of nutrients and heavy metals. Sediment (SED) is composed of finely divided solid particles (larger than 0.062 mm) that are transported by wind, water, or ice and deposited in water. Declines in water quality indicated by the above variables often indicate that forest-related management activities and conversions are having adverse effects on aquatic ecosystem health, and are affecting drinking water quality, fisheries, industry, recreation, agriculture, and other uses.

What Does the Indicator Show?

Generally, high T, low DO, high EC, low pH, and high SED are indicators of the major problems affecting aquatic systems. Since nationally standardized data is available only since 1990, problem areas were identified by looking at differences in forested counties within a Resources Planning Act (RPA) region, using standard deviations (sd) from the mean as a statistical method to identify abnormal conditions. Greater than 1 (poor) or 2 (bad) sd above or below the mean, depending on whether low or high values were of concern, were evaluated for all indicators. DO and T were the only indicators that showed marked seasonal differences, so values for both winter (w) and summer (s) were given. Each RPA region had a significant proportion (greater than 10 percent) of forested counties in the poor or bad condition. For example, the west region's biggest issues were DO (winter), T (winter and summer), and SED. The north region's biggest issues were T (winter and summer), and EC. The south region's issues were DO (winter), T (winter and summer), EC, pH, and SED.

Indicator 25. Area and Percent of Forest Land Experiencing an Accumulation of Persistent Toxic Substances

What Is the Indicator and Why Is It Important?

Forest ecosystems may be adversely affected by toxic substances from industrial and urban sources or from chemicals used in forest management. This indicator aims to assess the degree to which pollutants and environmentally damaging chemicals from activities conducted outside the forest (e.g., air pollution), forest management activities, specific events, or the legacy of past human activities may be affecting ecosystem function and the future health and productivity of the forest ecosystem.

Although the accumulation of persistent toxic substances in the soil is typically viewed as problematic, toxic materials may ultimately be more damaging to aquatic environments than they are to the soil. Soils can play a beneficial role in detoxifying pollutants and limiting releases to aquatic environments through processes such as the microbial decomposition of pesticides and the immobilization of metals. In some cases, toxic materials accumulate in high organic matter forest soils that may prevent large leaching and runoff losses.

What Does the Indicator Show?

Currently, no national-level monitoring programs address this indicator. The accumulation of persistent toxic substance in the soil depends on a large number of site-specific factors, including proximity to the source, the composition and chemistry of the soil (e.g., pH, organic matter content, clay content), drainage, and local climate. For those reasons, accumulation of pollutants in the soil can be measured only at the local level and cannot be inferred from deposition or soil properties alone.

In recognition of the lack of national-level data for this indicator, Forest Inventory and Analysis has initiated analysis of trace elements, including manganese, iron, nickel, copper, zinc, cadmium, lead, and aluminum, from mineral soil samples collected as part of the soil indicator program. When fully implemented, these data will provide critical baseline information on the current status of forest soils and will establish a mechanism for monitoring future changes in soil quality in response to atmospheric deposition and other sources of toxic compounds.

Indicator 26. Total Forest Ecosystem Biomass and Carbon Pool, and if Appropriate, by Forest Type, Age-Class, and Successional Changes

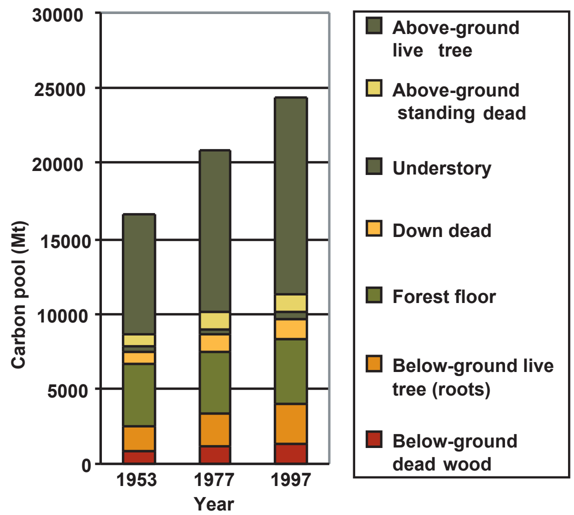


Figure 26-1. Carbon pools (Mt) of coterminous U.S. forest land.

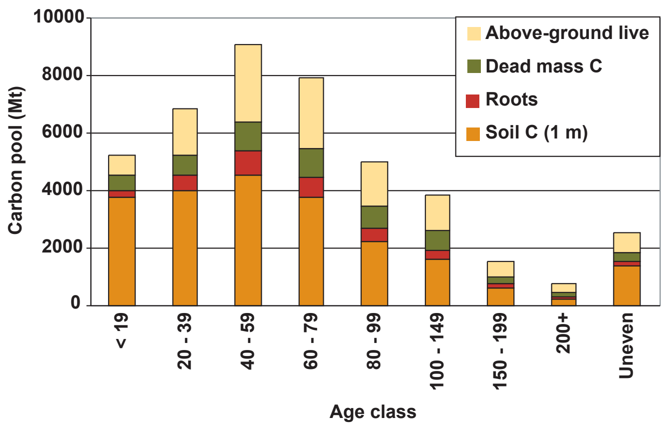


Figure 26-2. Carbon pools (Mt) by age-class, 1997. Uneven refers to uneven-aged stands.

What Is the Indicator and Why Is It Important?

The United States emitted a net 1,665 megatonnes (Mt) C in the year 2000. Because plants utilize carbon dioxide in the photosynthesis process, forests provide a primary vehicle to sequester carbon from the atmosphere. During this process, the carbon becomes part of the plant mass. Thus, managing forests to sequester carbon reduces the net amount of carbon dioxide accumulating in the atmosphere. Less carbon dioxide in the atmosphere may help reduce the possibility of human-induced climate change. Carbon can also be viewed as a measure of productivity. Productive forests feature a greater increase in carbon per year than forests of lower productivity.

What Does the Indicator Show?

All carbon pools, with the exception of soil carbon, are estimated using the USDA Forest Service Forest Inventory and Analysis measured data or imputed data, along with inventory-to-carbon relationships, developed with information from ecological studies. Thus, trends of volume and area in other indicators should be consistent with this information.

From 1953 to 1997, nonsoil forest carbon increased almost 46 percent, from 16,613 to 24,292 Mt. The 1997 inventory is equal to about 15 years of current net emissions for the United States. Most of the increase in forest carbon is caused by vegetation, particularly live trees. In 1997, total aboveground tree biomass was 28,505 Mt dry weight on 250,026 thousand hectares of forest land. Soil carbon (to 1 m depth) was omitted from figure 26-1 because of the complexity of interpreting carbon trends from land-use transfers. In terms of age-class, almost 50 percent of forest carbon is in stands less than 60 years old, and about 80 percent is in stands less than 100 years old. About 6 percent of the carbon on unreserved timberland is in uneven-aged forests. Almost 56 percent of forest carbon on unreserved timber land is in sawtimber stands. The oak-hickory forest type contains more carbon than any other type.

Indicator 27. Contribution of Forest Ecosystems to the Total Global Carbon Budget, Including Absorption and Release of Carbon (Standing Biomass, Coarse Woody Debris, Peat, and Soil Carbon)

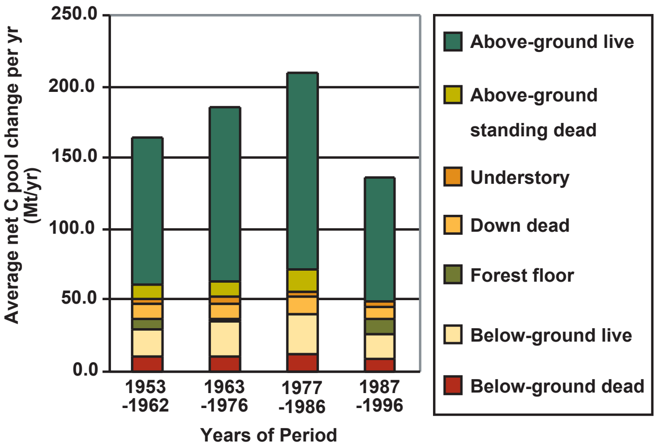


Figure 27-1. Average annual net forest carbon change (Mt/yr), 1953–1996.

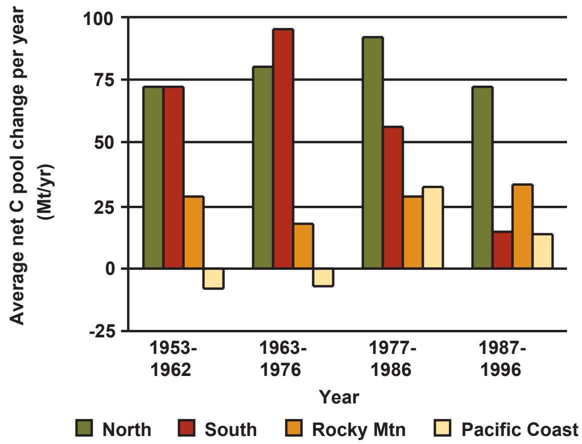


Figure 27-2. Average annual net forest carbon change (Mt/yr) by region.

What Is the Indicator and Why Is It Important?

Because plants utilize carbon dioxide in the photosynthesis process, forests provide a primary vehicle for sequestering carbon from the atmosphere, During this process, the carbon becomes part of the plant mass. Thus, managing forests to sequester carbon reduces the net amount of carbon dioxide accumulating in the atmosphere. Less carbon dioxide in the atmosphere may help reduce the possibility of human-induced climate change. The United States emitted a gross 1,909 megatonnes (Mt) equivalent of C in the year 2000. This indicator provides an estimate of forest carbon sequestration that may be subtracted from the gross emissions to estimate net emissions. Currently, soil carbon changes are not included in this indicator; however, forest soils are expected to be sequestering carbon.

What Does the Indicator Show?

A positive number means carbon is being sequestered from the atmosphere into the forest. The average annual net change in nonsoil forest ecosystem carbon pools for the period 1953–1997 is 175 Mt C/yr being absorbed by forests from the atmosphere. Between 1987 and 1996, about 135 MtC/yr were added to nonsoil forest carbon stocks. Forest ecosystems sequester about 10 percent of the gross U.S. greenhouse gas emissions, with additional carbon sequestration accounted for in products (see indicator 28). U.S. forest ecosystems sequester more than 10 percent of the global total for terrestrial ecosystems. The decrease in sequestration in the last period is thought to be because of more accurate data, increased harvests relative to growth, and accounting issues related to emissions from dead wood. The North Region is sequestering the greatest amount of carbon, followed by the Rocky Mountain Region. The trend of decreasing sequestration in the South Region is because of the increase in harvesting relative to growth. This harvested carbon will be shown as being sequestered in wood products (see indicator 28).

Indicator 28. Contribution of Forest Products to the Global Carbon Budget

Year	Change in products in use (1)	Change in products in dumps & landfills (2)	Total change in stock of carbon in product (3)=(1)+(2)	Emitted by burning with energy production (4)	Emitted by decay or burning without energy production (5)	Total emissions from products (6)=(4)+(5)	Total wood carbon consumed (7)=(3)+(6)
1950	13.6	6.3	19.9	37.4	25.5	62.9	82.8
1960	9.0	7.1	16.1	34.6	30.6	65.2	81.3
1970	12.4	9.2	21.6	32.8	35.9	68.7	90.3
1980	11.8	27.9	39.7	48.1	19.2	67.3	107.0
1990	26.0	33.4	59.4	74.4	11.4	85.8	145.2
2000	25.0	32.5	57.5	88.1	14.3	102.4	159.9

Table 28-1. Changes in harvested wood carbon using the carbon stock approach (Mt/yr carbon). Calculations began in 1900.

What Is the Indicator and Why Is It Important?

Less carbon dioxide in the atmosphere may help reduce the possibility of human-induced climate change. Carbon continues to be sequestered in wood after it is harvested. Also, burning wood for energy as a substitute for using fossil fuels may be a strategy of interest to lower fossil fuel emissions. Indicators 26 and 27 do not include carbon sequestration in harvested wood. For a complete picture of carbon sequestration by U.S. forests, indicators 27 and 28 must be summed.

These estimates feature net imports of harvested wood. In the future, the United Nations Framework on Climate Change may adopt an accounting approach to use for harvested wood, particularly for imports and exports. Future estimates will reflect any changes in the preferred accounting approach.

What Does the Indicator Show?

This data includes only carbon harvested and removed from the forest; that is, logging slash left in the forest is counted with the forest ecosystem. Harvested wood carbon is categorized as products in use and in landfills, as emissions produced by burning wood for energy production, and as emissions without capture of energy.

The carbon in use and in landfills has been increasing in the last 20 to 30 years because of increasing harvests, utilization, and use of anaerobic landfills. Carbon stored in products and landfills over this time period is about 35 percent of that being sequestered in the forest, about 60 Mt/yr compared to about 170 Mt/yr. The amount of carbon emitted when wood is burned for energy is becoming much greater than the total amount stored in products and landfills. By 2000, more than half of the carbon in harvested wood was being burned for energy production.

Indicator 29. Value and Volume of Wood and Wood Products Production, Including Value Added Through Downstream Processing

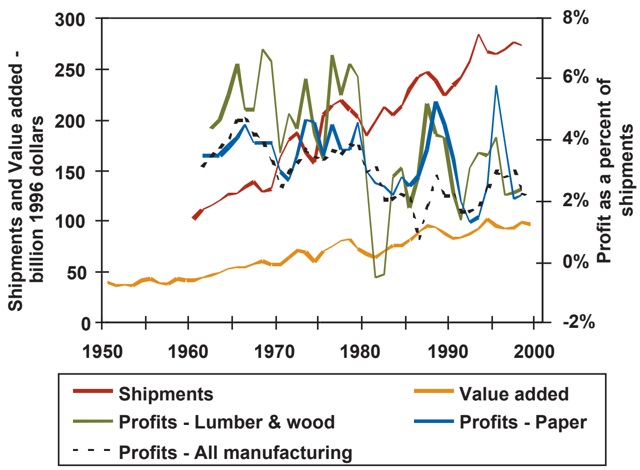


Figure 29-1. Value of shipments and value added for solidwood and paper industries, and after-tax profit as a percent of shipments, 1950–1999.

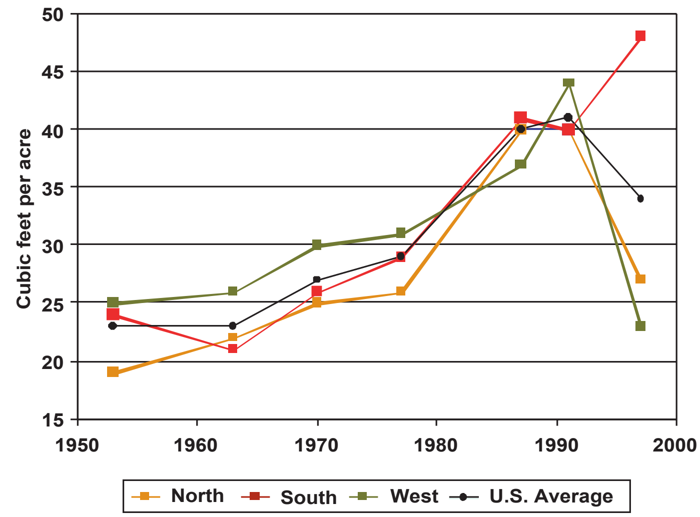


Figure 29-2. Growing stock roundwood production (harvest) per acre of timber land by region, 1952–1997.

What Is the Indicator and Why Is It Important?

The intent of the indicator is to (1) show the size and economic health of the wood products sector by identifying trends in the value and volume of wood products production and (2) allow comparison of those trends against management objectives. The revenue from the sale of products is important because it helps pay for management and provides a reason for keeping the land in forests. In the absence of national production objectives, the acceptability of production and harvest levels may be judged based on objectives for the things production affects: local economies, values for consumers, environmental and economic outcomes of product trade, and environmental outcomes from forest management and industry, including industry for substitute products.

What Does the Indicator Show?

The United States produced 203 million tons of wood and paper products in 1999, up from 83 million tons in 1950; and 2.6 Quad of wood energy (2.7 percent of U.S. consumption), up from 1.7 Quad in 1950. In comparison, the United States produced 119 million tons of steel in 2000, and 95 million tons of cement in 1999. Production in 1999 included 3.4 billion cubic feet (cf) of lumber (27 percent of world production, up from 22 percent in 1961), 1.0 billion cf of plywood/OSB, and 105 million tons of pulp, paper, and paperboard (27 percent of world production, down from 40 percent in 1961). U.S. industrial roundwood production (harvest excluding fuelwood) increased from 9 to 15 billion cf between 1961 and 1999 (24 percent and 27 percent of world production). As a share of all U.S. manufacturing, value of shipments has been increasing while value added has been decreasing. Value of shipments for lumber and wood products industries (1996 dollars) increased from $35 to $118 billion between 1962 and 1999 (2.0 percent and 3.0 percent of all manufacturing) and for paper and allied products industries from $67 to $159 billion (4.0 percent and 4.1 percent of all manufacturing). Value added in lumber and wood products industries (1996 dollars) increased from $19 to $42 billion between 1950 and 2000 (3.9 percent and 2.8 percent of manufacturing) and for paper and allied industries from $18 to $56 billion in 2000 (3.7 percent and 3.8 percent of manufacturing). In 1996, shipments and value added in the wood furniture industries was $25 and $9 billion, respectively. Wood, pulp, paper, and recovered paper exports were valued at $19 billion in 1999, 2.9 percent of all commodity exports, down from 3.4 percent in 1965. In 1997, value added per acre of timber land per year was highest in the North ($328), followed by the South ($241), Pacific Coast ($232), and Rocky Mountains ($76). Industry profitability has been quite variable and declining. After-tax profits per dollar of shipments for lumber and wood products and paper and allied products have both been above the average profits for all manufacturing, and all three have declined since 1960. Roundwood production (harvest of industrial roundwood plus fuelwood) has increased from 11 to 18 billion cf between 1950 and 1999, or 21 to 35 cf per acre of timber land per year. Growing stock harvest per acre of timber land per year in 1997 (may be compared to growing stock growth) was highest in the Pacific Coast (54 cf, without national forest harvest), followed by the South (48 cf), the North (27 cf), and the Rocky Mountains (21 cf, without national forest harvest), and national forests in the West (7 cf); and highest for industrial land (70 cf), followed by nonindustrial private land (34 cf) and public land (9 cf).

What Is the Indicator and Why Is It Important?

This indicator measures values and trends in values and production of nonwood forest products, where available. Nonwood forest products are economically important to local and regional economies in the United States. The value and production of nonwood products fluctuate because of changes in general economic conditions, societal preferences, and local or seasonal availability. Fluctuations in value and production can affect local economies and labor.

What Does the Indicator Show?

Nontimber forest products (NTFPs) include many plants, lichens, and fungi from forests, including understory species used in floral markets, for seasonal greenery, as wild foods, for medicinals, as plant extracts, and for transplants. Posts and poles, firewood, and Christmas trees are all significant secondary tree products in many regions. Game animals in U.S. forests are an important source of food to many people. As the number of people desiring naturalness both in an ecological and a cultural sense grows, the demand for and the value placed on these natural products increase. Annual or regularly collected data on domestic production and prices for NTFPs are generally not available. Information about game animal and fur-bearer populations and harvest is collected by State and Federal agencies, but national information is not generally available for all species. Prices for many NTFPs in the United States are influenced by international supply and demand, by seasonal fluctuation in availability, and by rising domestic demand.

Data on the size of the medicinal market is limited, but global markets are well developed. From July 1997 to June 1998, the three most significant native species in terms of sales were American ginseng (*Panax quinquefolius*) at $138 million, Echinacea species at $33 million, and saw palmetto (*Serenoa repens*) at $27 million. Food and forage species are significant products harvested from both public and all private forest lands. Black walnuts (*Juglans nigra*), maple sugar and maple syrup (primarily from sugar maple, *Acer saccharum*), and wild blueberries and huckleberries (*Vaccinium* spp.) are produced in the United States; they are consumed domestically and are exported. It has been estimated that as many as 36 species of fungi are traded commercially, but Boletus, chanterelles (*Cantharellus* spp.), morels (*Morchella* spp.), and American matsutake (*Tricholoma magnivelare*) make up the bulk of the industry. Forage grass species are particularly important to Federal and private land management in California and the Pacific Northwest, Rocky Mountain, and Southwest regions, where grazing in or near forest environments is a major land-use activity and where native range restoration is a goal. Christmas trees are an example of an NTFP that has been increasingly cultivated in the United States. Some people in the United States go into the forest to harvest their Christmas trees. A tremendous variety of native plant, lichen, and moss species supplies commercial foliage, stems, branches, fruits, and other vegetation for use in the winter holiday season and in the year-round floral industry. The harvest and use of native species have a strongly regional character, particularly for the species that people wildcraft. Species availability and use can change rapidly with changes in taste and with the introduction of new items into the marketplace. The use of NTFPs in arts and crafts is an integral part of innumerable traditions in the United States.

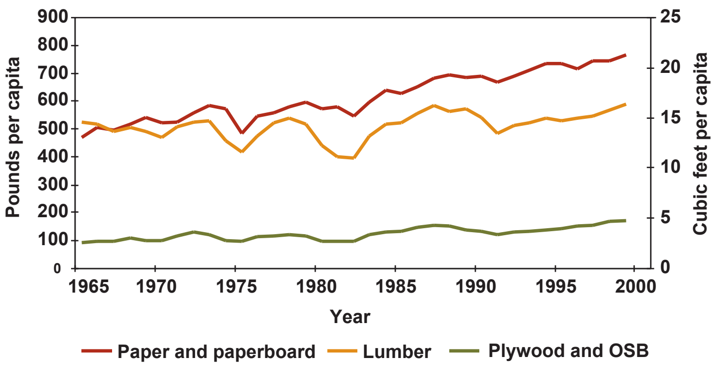


Figure 31-1. Wood and paper product consumption per capita, 1965-1999.

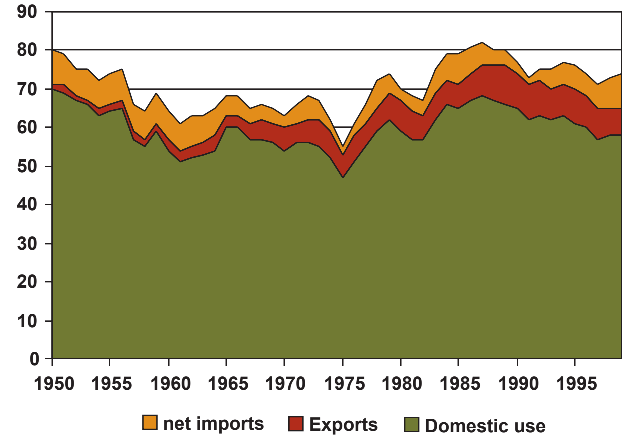


Figure 31-2. Wood use per capita to make wood and paper products consumed in the United States, 1950-1999.

What Is the Indicator and Why Is It Important?

Consumption of wood products per capita is one indication of the value people and businesses place on using wood products, given their relative availability reflected by prices, prices of substitutes; their perceived use qualities; and environmental benefits and costs. The amount of consumption from domestic supply (versus imports) indicates the degree to which resources, investment, management, and regulation for U.S. forests and U.S. industry meet U.S. consumer demand. Domestic fiber supply comes from recycled fiber and U.S. wood harvest. Harvest is influenced by many factors, including investment, management, regulation, and owner objectives, and it changes timber productivity and ecosystem conditions in various regions. Changing productivity and forest conditions in various regions also influences the level of harvest that is possible to meet consumer demand. Harvest of wood for imports to the United States and export of U.S. products influences forestry and the forest industry in other countries.

What Does the Indicator Show?

Per capita consumption of wood and paper products in 1999 was 1,580 pounds (lbs) (up from 1,240 lbs in 1950), with an additional 9 cubic feet (cf) consumed as fuel wood (down from 15 cf in 1950). This consumption required 74 cf of of roundwood equivalent of wood harvest per capita in the United States and other countries, (80 cf in 1950). Wood needed for industrial products (not fuel wood) was roughly constant at 65 cf per capita. Consumption also used 272 lbs of recovered paper per capita in 1999, up from 105 lbs in 1965. Per capita consumption of sawn wood for the United States, all developed countries, and the world in total are, respectively, 19, 9, and 2 cf for 2000. Per capita consumption of paper and paperboard for the United States, all developed countries, and the world in total are, respectively, 729, 388, and 118 lbs for 2000. A key use of solidwood products is home construction: 1.7 million units in 1999. The main paper and paperboard uses in 1999 were containerboard, 33 percent; printing and writing paper, 31 percent; newsprint, 13 percent; and tissue and sanitary paper, 7 percent. The portion of wood required for U.S. wood and paper products consumption that came from imports (versus U.S. harvest) has increased from 13 percent in 1950 to 20 percent in 1999. If wood for exports is deducted from wood for imports, wood for net imports decreases from 11 percent to 9 percent of wood needed for consumption. Between 1952 and 1996, per capita wood supply increased in the South – (31 to 38 cf), decreased in the West – (22 to 16 cf), and remained constant in the North.

Indicator 32. Value of Wood and Nonwood Products Production as a Percentage of Gross Domestic Product

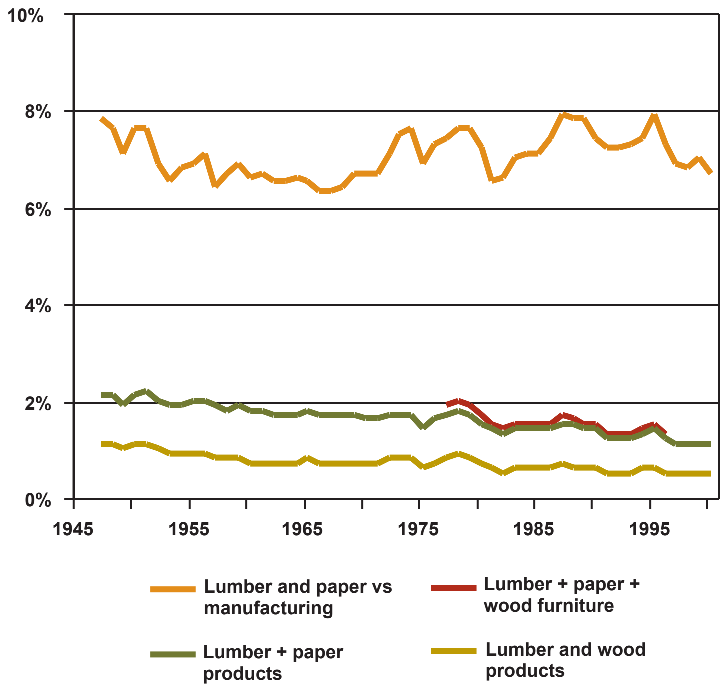


Figure 32-1. Value added for solidwood and paper industries as a percent of manufacturing Gross Domestic Product and total Gross Domestic Product, 1947–1999.

What Is the Indicator and Why Is It Important?

This indicator is one measure of the contribution of the wood and nonwood product sectors to the U.S. economy. Changes in the percentage contributions reflect changes in both the overall economy and the wood and nonwood sectors. The trend in contribution relative to all manufacturing gross domestic product (GDP) may be more informative. The trend indicates the degree to which wood and nonwood product economic contributions based on forest resources are keeping pace with other manufacturing economic contributions based on other resources. Also, an increase in the dollar value of economic contributions of nonwood products would indicate a diversification of the sources of value from forests. The economic contribution by region or per unit of timber resource indicates variation in contribution by regions and by forest resources in regions. The indicator does not account for economic contributions to GDP based on nonproduct forest resources, such as forest-based recreation.

What Does the Indicator Show?

Contributions to U.S. GDP from the wood and paper products sector are estimated here as the value of timber harvested from nonindustrial land plus the value added by forest products industry in growing trees on their own land and value added in processing. The value of timber harvested from nonindustrial land has decreased from 0.15 percent to 0.12 percent of GDP between 1952 and 1997. The value added by lumber and wood products, paper and allied products, and wood furniture industries (value added) as a percent of GDP has decreased for each between 1947 and 1999. In total, their contribution decreased from 2 percent to 1 percent of total GDP. Their total value added as a percent of all manufacturing contributions to GDP has remained relatively constant since 1947, averaging about 7 percent for wood, paper, and wood furniture industries, and 0.5 percent for the value of timber on nonindustrial land. The contribution of nonwood forest products includes the value of the following products less the value of material inputs in producing them. The categories include (1) medicinals, (2) food and forage species, (3) floral and horticultural species, (4) resins and oils, (5) arts and crafts, and (6) game animals and furbearers. The only nationwide estimates of value available are for medicinals—in excess of $4 billion dollars. Partial estimates for food and forage species, floral and horticultural species, and hunting and trapping indicate values of several hundred million dollars. A conservative estimate of nonwood products value is $5 billion. Assuming the value of other material inputs is minor, the contribution of nonwood products to GDP would be about 0.05 percent.

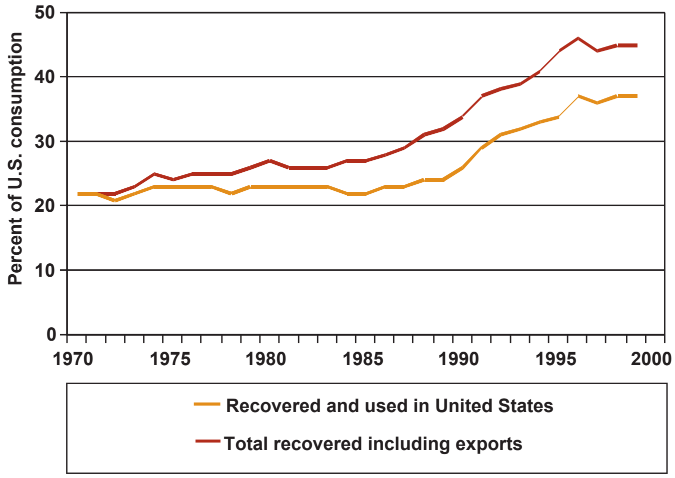


Figure 33.1. Percent of U.S. paper consumption recovered (including exports) and percent used in domestic production, 1970–1999.

What Is the Indicator and Why Is It Important?

Paper and solidwood products may be recovered and recycled into new products or they may be recovered and used for energy. Both forms of recovery have an effect on timber harvest, energy use, and emissions associated with production, product consumption, trade, and waste disposal. High levels of recovery and recycling may hold down timber harvest that may aid in forest conservation. They may also hold down prices for timber that would help support forest management. The desirability of higher levels of recovery and recycling may be judged in part by their effects on providing environmental management outcomes (forests, emissions, waste), support for communities, and providing consumption values.

What Does the Indicator Show?

U.S. recovery of paper and solidwood for use in making products and in making energy has increased in recent decades. The United States consumed 105 million tons of paper and paperboard in 1999, up from 56 million tons in 1970, and recovered 45 percent in 1999 for recycling, up from 22 percent in 1970. In comparison, consumption and recovery for all developed countries in 1999 was 252 million tons and 43 percent. An increasing fraction of recovered paper has been exported, 18 percent in 1999, up from 3 percent in 1970. The amount of recovered paper used per unit of U.S. paper and paperboard production has increased from 24 percent in 1970 to 39 percent in 1999. Some solidwood products are also recovered and recycled from wooden pallets, construction waste, demolition waste, and municipal solid waste. In 1998, 665 million wooden pallets were produced, and 250 million were recycled. Those amounts are up from 355 million pallets produced, and 66 million recycled in 1992. In 1998, an estimated 9, 26, and 12 million tons of wood waste were generated from construction, demolition waste, and municipal solid waste, respectively. Much of that waste is used for products, is burned, or is not useable. The estimated fractions available for use are 76 percent, 34 percent, and 46 percent, respectively.

In addition to paper and wood products recovered after use to make new products, other recovery and use has environmental and economic effects. These include recovery and burning of pulping liquor for energy (1.1 Quad in 1999, up from 0.7 Quad in 1972) and recovery of wood residue at wood and pulp products mills (92 million dry tons generated, 50 million tons used for products, 40 million tons used for energy, and 2 million tons unused in 1996.)

What Is the Indicator and Why Is It Important?

The intent of this indicator is to measure the extent to which the supply of nonwood products meets the needs of consumption. Trends in the indicator may reflect changes in either supply or demand, and may also be influenced by changes in social values placed on the products. National consumption, however, as well as the demand for consumption, of nontimber forest products (NTFPs) is unknown. Demand for many specific species is high locally or regionally, and in some cases supply and/or consumption might be an issue, such as for medicinal plants of concern.

What Does the Indicator Show?

As the number of people desiring naturalness both in an ecological and a cultural sense grows, the demand for and the value placed on natural products increases. In many parts of the United States, producing goods from native plants has become an active expression of cultural survival and conservation of indigenous knowledge. The harvest and use of native species have a strongly regional character, particularly for the species that people wildcraft. Species availability and use can change rapidly with changes in taste and with the introduction of new items into the marketplace. Domestication may mean improved conservation by reducing pressure on stocks, but prices for wild product is often still high enough to keep pressure on the wild resource for species of concern such as ginseng (*Panax quinquefolius*) and goldenseal (*Hydrastis canadensis*). Nonwood forest products are an integral and important part of many rural communities' lifestyle and economy, enabling people to make ends meet during times of economic hardship. The harvest and first levels of production of many goods, such as Christmas wreaths or grave blankets made of boughs, give people a source of supplemental income. One indicator of demand and consumption of nonwood forest products is the range of products for which people seek commercial harvest permits on public lands. In fiscal year 2000, the Department of the Interior Bureau of Land Management sold millions of permits and contracts for fuel wood, boughs, medicinal plants, greenery, fungi, seed cones, forage, transplants, and other products. In the same fiscal year, the USDA Forest Service sold millions of dollars worth of permits for the same kinds of products. The compliance rate of people purchasing mushroom permits, as an example, is quite variable. In well-established markets with oversight, such as in the Winema National Forest in Oregon, compliance is estimated to be as high as 85 percent or higher. In other areas, compliance is far lower. Permit sales can be used as an indicator of general demand and market size from one product type to another, and for shifts in demand. They cannot be used, however, to calculate total consumption. Projected changes in land use indicate an expected increase in game and fur-bearer species that tolerate intensive land use activities, increases in species associated with agricultural habitats, decreases in species associated with grasslands and early successional stages of forest habitats (especially in the North), and general declines in species dependent on wetlands. Water from forest land has value for municipal users, agriculture, recreation, hydropower, and industry. National forest land is the largest single source of water in the United States and contributes water of high quality. Water from all national forest lands is estimated to be worth at least $3.7 billion annually, with the Pacific Northwest forests contributing an estimated $950 million. Water withdrawals to offstream uses, including farms, industry, and homes, increased more than tenfold in the 20th century. Streamflows have dropped, while demands for instream water have increased for water-based recreation and protection of water quality.

Indicator 35. Area and Percent of Forest Land Managed for General Recreation and Tourism in Relation to the Total Area of Forest Land

Ownership	North	South	Rocky Mtns.	Pacific Coast	U.S. Total Available
All Federal land	13,740 9.5%	17,848 11.7%	100,089 73.1%	121,508 58.1%	253,185 39.4%
State and local government	27,578 19.2%	5,902 3.9%	6,029 4.4%	41,382 19.8%	80,891 12.6%
Forest industry	11,847 8.2%	24,482 16.0%	2,362 1.7%	10,259 4.9%	48,950 7.6%
Nonindustrial private	90,712 63.0%	104,832 68.5%	28,489 20.8%	36,069 17.2%	260,102 40.4%
All owners	143,877 84.8%	153,064 71.3%	136,989 94.9%	209,218 95.0%	643,128 85.9%

Source: Smith et al. 2001, and National Survey on Recreation and the Environment, 2000–2001.

Table 35-1. Forest land area in the United States available for recreation by ownership category and region, 2002 (thousands of acres and percent of regional or national total that is available).

What Is the Indicator and Why Is It Important?

This indicator addresses the capacity of forests to provide recreation benefits. Some of both public and private forest land must be open for recreation if the full spectrum of socioeconomic benefits is to be realized. Outdoor recreation is increasingly popular and significant in people's lifestyles. As well, significant sectors of the U.S. economy depend on growing recreation markets, and readily available forest lands are essential for that growth.

What Does the Indicator Show?

Nationally, there are approximately 749 million acres of forest in the United States. Of forest area nationally, 643 million acres, 86 percent, are available for outdoor recreation (table 35-1). This availability across owners varies from region to region, with most in the East in private ownership and most in the West in public ownership. Almost all public and industrial forest is open and provides stable capacity for recreation and tourism, especially in the West. In contrast, nonindustrial forest land, a major potential source of capacity, accounts for most of the increases or decreases in the East. In 1985–86, around 25 percent of nonindustrial owners permitted some public access; now only about 11 percent permit access (Cordell 1999). This decrease in recreation capacity has been compounded by population growth from almost 250 million in 1990 to more than 280 million in 2000. Currently, across the United States, approximately 2.3 acres of forest are available per person for recreation, public, and private. Even if the downward trend in available private nonindustrial forest were to cease, population growth by 2020 to around 325 million would reduce capacity to less than 2 acres per person nationally.

Indicator 36. Number and Type of Facilities Available for General Recreation and Tourism in Relation to Population and Forest Area

Facilities and miles	Region			
	North	South	West[30]	U.S.
Millions of forest acres open	90.7	104.8	64.6	260.1
Percent with overnight facilities[31]	24.1	17.9	30.9	22.5
Percent with day-use facilities[32]	20.4	17.3	13.6	18.2
Millions of trail miles	2.3	3.6	0.4	6.3
Millions of road miles	3.0	4.3	1.2	8.5

Source: National Survey on Recreation and the Environment, 2000–2001.

Table 36-1. Estimated number of overnight and day-use facilities and miles of maintained roads and trails on private nonindustrial lands in relation to forest area by region.

What Is the Indicator and Why Is It Important?

This indicator shows the degree to which forest recreation capacity has been enhanced by developing facilities or otherwise providing more access. While it is essential to have forest land open for outdoor recreation (indicator 35), it is also essential that access and facilities are provided for a wide range of activities and physical abilities. Facilities on private land are especially important in the populated East. On all forest lands they will become more important as the population becomes more urban and older. Activities that depend on roads, trails, and developed sites have been growing in popularity among all segments of the U.S. population. Significant sectors of the U.S. economy depend on that growth, and available outdoor facilities are necessary to sustain it.

What Does the Indicator Show?

Direct measures are largely unavailable for most types of forest recreation facilities. Best available sources were used to approximate camping, hiking, picnicking, winter sports, and private, nonindustrial forest facilities. Those sources indicate that 30 to 50 percent of camping capacity is in forest settings. In addition, of 2,172 Federal areas, 917 are predominantly forested and provide camping, picnicking, hiking, and/or snow sport facilities. Also, nearly 58 percent of State parks in the country (1,533 of 2,665) have significant forest cover and provide camping, trails, picnicking, and winter sports facilities. Facilities on nonindustrial private forest lands are important sources of outdoor recreation, especially in the East, and are a major driver of overall facility capacity trends. Table 36-1 shows generally greater percentages of owners of private forest lands in the eastern two regions provide day-use facilities, while a larger proportion of western forest owners provide overnight facilities. Eastern owners provide greater miles of trails (94 percent of the national total) and of roads (nearly 86 percent of the national total). The trend in facility capacity has generally been down in recent decades because of modest decreases to minimal growth in investment in developed forest sites on public lands and falling nonindustrial forest acres open to the public (where facilities are provided).

Why Can't the Entire Indicator Be Reported at This Time?

Systematic inventory of facilities at Federal, State, local, and private levels has not been funded since the last Nationwide Outdoor Recreation Plan in the 1970s. The USDA Forest Service conducts the Nation's decennial Resources Planning Act Assessment using largely secondary sources, but these sources provide inconsistent coverage, detail and format. None of these secondary sources provide information about whether the facilities are in forest settings.

[30] The Rocky Mountain/Great Plains and Pacific Coast regions are combined because of limited data sample size.
[31] Cabins, campsites, or other overnight sites.
[32] Picnicking, swimming, or other day-use facilities.
Source: National Survey on Recreation and the Environment, 2000–2001.

Indicator 37. Number of Visitor Days Attributed to Recreation and Tourism in Relation to Population and Forest Area

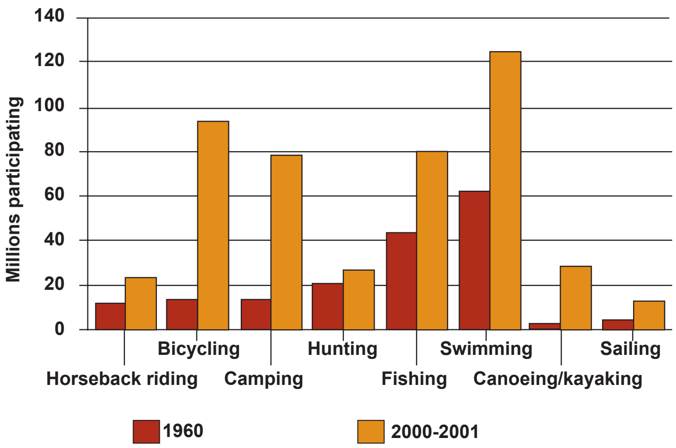


Figure 37-1. Trends in outdoor recreation participation (millions) since 1960.

What Is the Indicator and Why Is It Important?

The indicator shows use of lands and facilities for outdoor recreation as a measure of benefits from forests. The most widely accepted measures of use are a recreation visit (an occasion in which one person enters the land, a site, or a facility for one or more recreational activities of any duration), participation (when a person participates any number of times in an activity during a specified period of time), and activity days (the number of different days on which a person participates in an activity). Increases or decreases in these measures indicate a change in capacity (facilities or access to lands) and/or demand. The measures are important because they indicate the size of the market for activities and demand for the services, facilities, equipment, and land for activities. Societal welfare and the health of the economy are linked to satisfaction of demands for outdoor activities.

What Does the Indicator Show?

Outdoor recreation is a fast-growing use of forests, continuing a steady trend since the 1950s (Figure 37-1). Currently, more than 90 percent of Americans participate in outdoor recreation. Walking has the most participation (84 percent of the population), followed by attending family gatherings (74 percent), visiting nature centers, nature trails, visitor centers, and zoos (57 percent), picnicking (55 percent), and viewing/photographing natural scenery (54 percent). The 10 fastest-growing outdoor activities since the 1980s are bird watching, hiking, backpacking, snowmobiling, walking, off-road vehicle driving, primitive camping, developed camping, downhill skiing, and swimming. Growth of these activities points to the rapid rise in the popularity of trail, motorized, camping, and skiing uses. To measure intensity of use, estimates of recreation days occurring in forest settings show walking for pleasure, viewing natural scenery, viewing birds, viewing flowers, viewing wildlife, day hiking, sightseeing, driving for pleasure, mountain biking, and visiting a wilderness or primitive area as the most actively engaged activities. Estimates of visits to national forests for fiscal year 2001 show that most visits are in general, undeveloped areas (compared with developed site use) and total nearly 137 million visits per year, most of which are in the West. Generally, participation in outdoor activities continues to grow, with greatest growth in nonconsumptive activities that have relatively low impact on forests. Rising demand and declining per capita acres of forest available for recreation will accelerate future conflicts over access by different user interests.

Why Can't the Entire Indicator Be Reported at This Time?

Visitor days as a measure is rarely used any more. Instead, site visits, activity occasions, and participation are the accepted measures. Most sources of use data, however do not distinguish use in forest settings. Additionally, few public and almost no private providers maintain suitable visitation data and none record whether it has occurred in forest settings.

Indicator 38. Value of Investment, Including Investment in Forest Growing Forest Health Management, Planted Forests, Wood Processing, Recreation, and Tourism

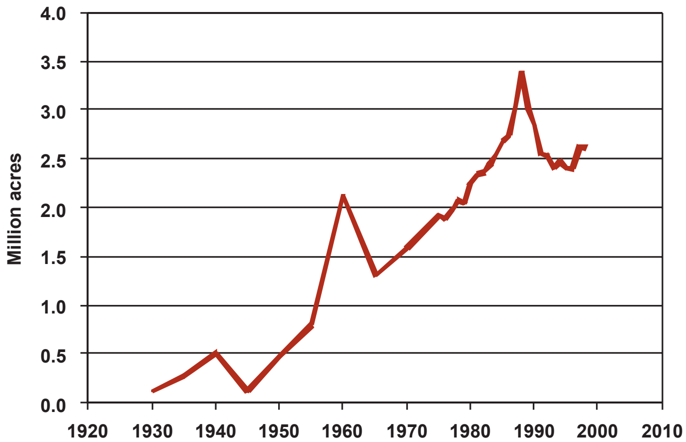


Figure 38.1. Area of tree planting in the United States, 1930–1998 (million acres).

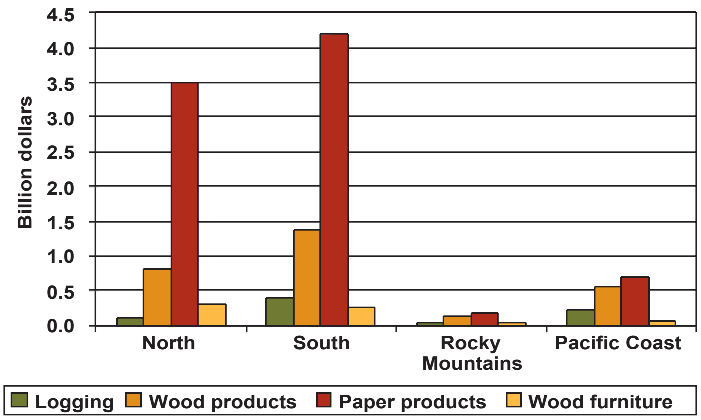


Figure 38.2. Capital investment in logging, wood products, paper products, and wood furniture industries by region, 1997 (billion dollars).

What Is the Indicator and Why Is It Important?

This indicator measures efforts to maintain or increase capacity to provide economic, social, and environmental benefits from forests. Forests are natural capital that provides benefits. Forest management activities, including planting, silviculture, protection, and preservation, are investments in this capital. Investments in wood and nonwood products businesses support capacity to provide wood and nonwood products. Investments in recreation facilities and businesses support capacity to provide recreation benefits. This is only part of all investment in natural, built, human, and social capital needed to sustain benefits.

What Does the Indicator Show?

Investment in forest management includes tree planting, which has increased from 0.5 to 2.6 million acres per year between 1950 and 1998. This and other forest management efforts, along with increases in value of timber, have increased the value of timber capital (standing trees). Between 1952 and 1997, the value changed most in the North (up 99 percent), followed by the South (up 68 percent), the Rocky Mountains (up 27 percent), and the Pacific Coast (down 14 percent). The decline on the Pacific Coast is due primarily to a decline in volume on industry land. Planted forest area in the East in 1997 was 40 million acres or 10 percent of forest land area. About three-fourths is southern pine. Planted area in the West is about 14 million acres or about 6 percent of forest land area. Area planted in fast-growing hardwood plantations through 1996 was about 128,000 acres. New capital expenditures in lumber and wood products, and paper and allied products, have increased in real terms over the last four decades, from $0.9 and $2.0 billion in 1962, to $1.6 and $6.2 billion in 1996. But lumber and wood products investment has declined as a percent of the value of shipments from 2.5 to 1.5 percent over this period, while pulp and allied product investment has remained about 4 percent of shipments.
Investment in recreation and tourism to maintain capacity to provide forest recreation experiences is wide ranging, including investment in facilities on public and private land, and investment in businesses that provide services and products to those recreating on forest land. Investment in recreation facilities includes expenditures by the USDA Forest Service ($40 million in 2001) and the U.S. Department of the Interior National Park Service ($367 million in 2002) (forest and nonforest areas).

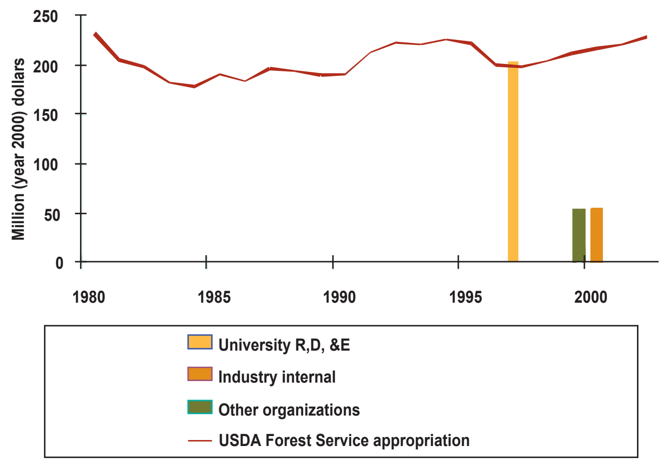


Figure 39-1. Expenditure on university research, development and education; and USDA Forest Service, industry internal, and other organization research, selected years 1980–2001.

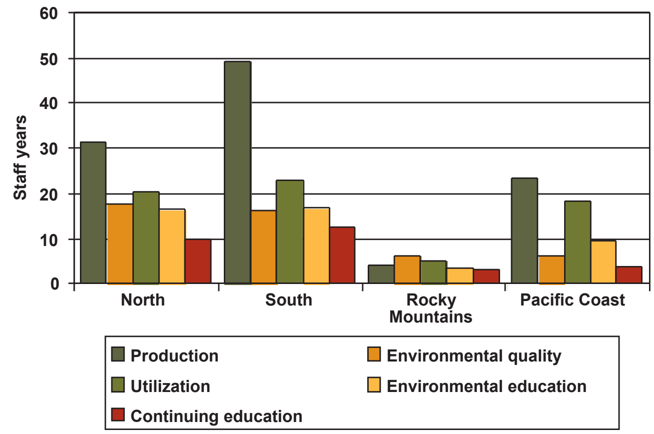


Figure 39-2. University extension staff years devoted to forest land-related activities, 1999.

What Is the Indicator and Why Is It Important?

With increasing population and the strong multiple values people hold for forests, research, development, and education are needed to anticipate and help resolve environmental, social, and economic problems in order to continue to provide multiple resource values for current and future generations. Research, development, and education areas include all disciplines that influence forest resource management decision-making. The adequacy may be judged by the ability of research capacity to vigorously address problems and develop needed knowledge and technology.

What Does the Indicator Show?

Forest resource management-related research and development efforts are centered in the USDA Forest Service, in universities, and in industry, with additional efforts by other agencies and nongovernmental organizations. USDA Forest Service funding for research, including construction, and net of inflation, has been largely unchanged over the past 20 years. Publications increased from 1,886 in 1981 to 2,718 in 1998, with the largest number in 1998 in vegetation management and protection (1,158), followed by wildlife, fish, watershed, and atmospheric sciences (754, up from 334 in 1981), resource valuation and use (683), and inventory and monitoring (123). Employment in universities has been relatively stable (1,503 in 1984–85, 1,459 in 1993–94, and 1,361 in 2001). Baccalaureate, masters, and doctorate degrees in forest science programs totaled 1,976 in 1998 and were up 60 percent, 27 percent, and 30 percent, respectively, between 1989 and 1998. Funding for forestry research at universities that receive Federal funding was $209 million in 1995 and $226 million in 2000 (both in year 2000 dollars). Funding in 2000 was highest in the North ($76 million), followed by the South ($70 million), Pacific Coast, ($51 million), and the Rocky Mountains ($29 million). More than 100 scientists also conduct research in State agencies, Federal environmental agencies, and environmental nongovernmental organizations. In 2000, under the Sustainable Forestry Initiative program, industry provided $73 million for internal and external research. Recent years' research funding has also come from the National Science Foundation ($16 million), U.S. Department of Energy—Agenda 20/20 ($2-3 million), Environmental Protection Agency ($10-20 million), National Aeronautical and Space Administration (about $10 million), and other Federal and nongovernmental organizations (as much as $10 million). Funds for extension efforts by forestry schools and colleges were about $20 million in 1999, with 343 staff years. Forest resource education is also provided by public schools, and by a wide range of nongovernmental organizations.

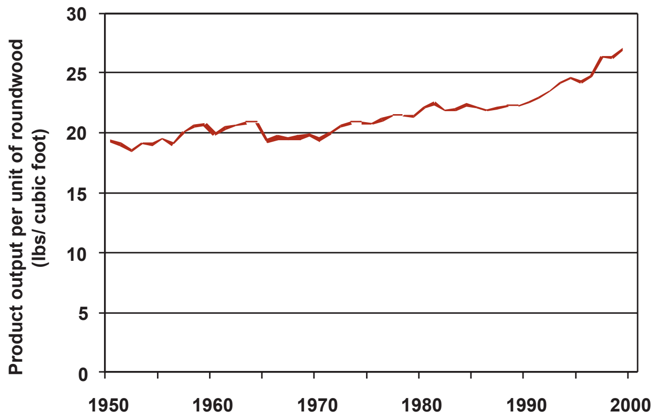


Figure 40-1. Wood and paper product output per unit of roundwood input, 1950–1999 (lbs per cubic foot).

What Is the Indicator and Why Is It Important?

This indicator measures improvements in forest management and forest products industries that affect forest management. These improvements can conserve, help manage, or help produce goods and services and can have environmental and economic effects. The effects of these changes are shown in other indicators. The indicator does not cover improvements affecting forest-based recreation and tourism.

What Does the Indicator Show?

Technology changes have affected each stage of production, processing, and use of wood in recent decades: Forest management for timber production and environmental protection has been changed by improvements in genetic stock of trees, insect and disease treatments, fire treatments and protection, and improvements in silvicultural regimes, including establishment and fertilizers. Harvesting systems and practices have improved to provide greater yield of timber at lower cost and lower environmental impact for each type of forest condition. Processing to make existing solidwood and pulp and paper products has improved, including improvements in (1) sawing to allow changes in size of trees or species needed to make structural-grade or appearance-grade lumber, (2) product output per unit of wood input, (3) lower costs, (4) emissions from processing, (5) new grading regimes to identify wood with special qualities for high-performance use, such as machine stress rating for use in trusses, and (6) techniques to clean recycled paper and improve its stiffness and bonding to allow increased paper recycling. New wood products, such as reconstituted panels, wood/plastic composites, laminated veneer lumber, wooden I joints, glulam beams that allow for use of smaller trees and different species of trees as well as wood residue, recycled wood, and nonwood materials (e.g., plastics), have been developed. Improvements in wood and paper products processing and new products have affected forest management over the last 50 years by increasing products output per unit of roundwood input (harvest needed) by 40 percent, due to increased paper recycling, use of wood residue for products, and increased processing efficiency. Use of wood for energy has increased and includes use of pulping liquor for energy at pulp mills, higher efficiency stoves for residential wood burning, and use of wood for electric power production. Changes in application of solidwood and paper products in uses have allowed for more efficient and diverse uses of wood, including use of wood trusses in structures, substitution of wood composite panels for lumber and softwood plywood in structures, use of wood for housing basements, expanded use of paper for computer printers, and new uses of paperboard in packaging. Development of substitutes for solidwood products and paper products in applications has influenced wood use. This includes use of vinyl and aluminum siding for buildings, light steel framing for residential structures, and electronic communication media for paper. Recycling of paper, mill residues, and solidwood products has influenced the use of wood. This includes use of recycled paper to make new paper and paperboard products, mill residues for composite panels and for paper production, recycling of wooden pallets, and recycling of wood from deconstructed structures.

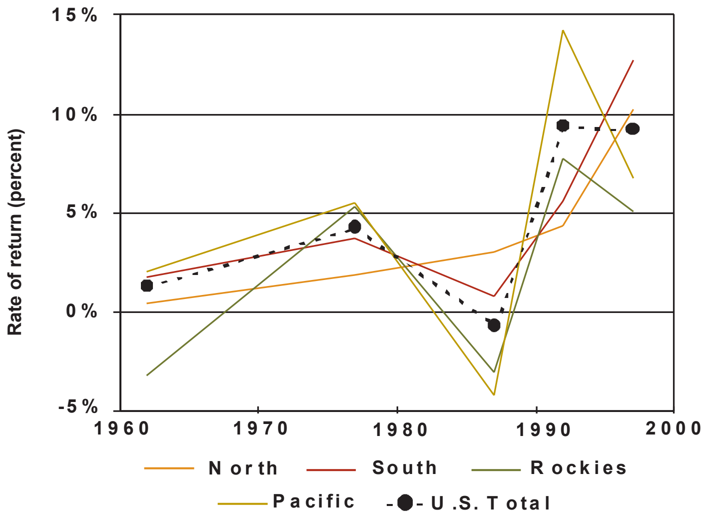


Figure 41.1 Implied long-run rates of return to timber assets by region, 1962–1997.

What Is the Indicator and Why Is It Important?

Rate of return on investment is an indicator of the financial attractiveness of the forest sector to capital. Rates of return must be competitive to attract investment in the forest sector versus other land uses or other businesses. This may include investment in forest land, wood and paper product mills, or ecotourism. A detailed analysis by type of investment and location may be needed to discern local competitiveness. Aggregate returns by region includes active and passive investment and may not represent local competitive conditions.

What Does the Indicator Show?

Ideally, data would be provided for local areas comparing rate of return for holding land in forests (e.g., timber, nonwood products, recreation) to rate of return from other uses (agriculture, housing, business development). And data would be provided on rate of return for wood and nonwood products businesses, recreation, and other businesses compared to rate of return for their local, national, and international competitors to discern how readily they may provide jobs in local areas. Such detailed data is not currently available. We present data that explains, in general terms, rate of return to forest land for timber values by region. This data, along with data on return for other values such as recreation (both monetary and intangible), could be used to evaluate, in general, where returns are highest to support retaining land in forest. Rates of return require measures of revenues from the resources and asset values of the resources. Timber value can be estimated by summing up the asset values of all timber in a region. The preferred method for valuing timber assets (capital) is to use estimates of harvest age, anticipated revenues, and the value of subsequent rotations to calculate rents for forests of different types. Such detail is not available, so we use stumpage prices and inventory volumes to provide a rough estimate of forest asset value. Revenue from timber is the estimated stumpage price for different timber products. Capital gains from forests are measured as the change in asset values. Rate of return to timber assets (capital) is the ratio of total return (revenue plus capital gains) to asset value.

The long-run rate of return to timber assets for the United States as a whole has fluctuated and reflects changes in market conditions between measurement periods. Capital gains strongly influenced this rate of return and were negative between 1977 and 1987 but were strongly positive between 1987 and 1997. The long-run implied rate of return has risen to about 9 percent for the United States as a whole, and ranges from 5.1 percent in the Rockies to 12.7 percent in the South. Rates of return are generally higher in the Eastern United States than in the West. One measure of competitiveness for forest products firms is shown in Indicator 29, profit as a percent of shipments. This percent has been declining for lumber and wood products and paper and allied products industries in recent decades.

Indicator 42. Area and Percent of Forest Land Managed in Relation to the Total Area of Forest Land To Protect the Range of Cultural, Social, and Spiritual Needs and Values

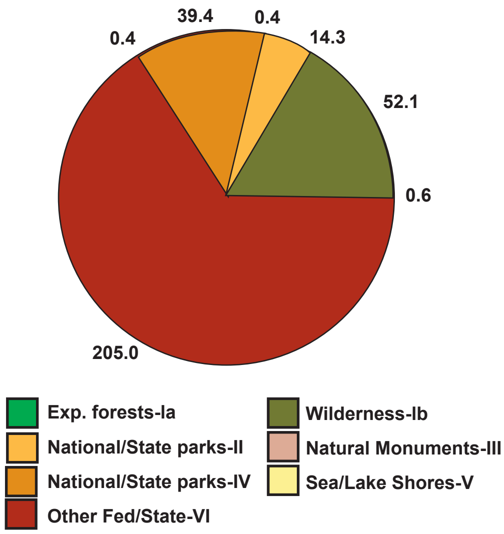


Figure 42-1. Millions of protected forest acres by category.

What Is the Indicator and Why Is It Important?

This indicator measures the amount of forest land placed under the range of tenure classifications and/or management/protection regimes that are designed to protect cultural, social, and/or spiritual values. It recognizes the cultural and spiritual connections of society to forests beyond the commercial or livelihood values of forest resources. It excludes forests owned and/or managed for strictly private or commercial purposes, and includes all known forest lands designated and managed to serve public purposes. Over the last several decades, evidence has shown that American society has been attaching greater value to natural forests, even as most of the population, more than 80 percent, live in urban environments. This indicator helps monitor the degree to which forest management recognizes public needs and values beyond private economic gains.

What Does the Indicator Show?

An estimated 312 million acres of forest in the United States are protected (figure 42-1). This includes 0.6 million acres of experimental forests, 52.1 million acres of forest area in the National Wilderness Preservation System, 14.3 million acres in national and State parks, 0.4 million acres in natural monuments, 39.4 million acres in Federal and State wildlife refuges, 0.4 million acres in lake and seashores, and 205.2 million acres in all other categories of Federal and State forest lands. Since most of the protected land is Federal, most is west of the Mississippi. Most forested national park, monument, and refuge land is in the Pacific Coast States, especially in Alaska. The most protected of forest lands are those in the National Wilderness Preservation System, which has some representation in all but six States. Protected Federal and State lands are very stable in area and percent over time. Most national forests, Bureau of Land Management lands, and State forests are managed for commodity production, in addition to being managed for other cultural, social, and spiritual values. An estimated 29.3 million acres of nonindustrial private forest land are protected by conservation easements with local/State agencies or private organizations. The overall trend in this indicator is modest growth through modest additions of Federal and State forest lands to protection systems and modest additions of private land under conservation easements.

Why Can't the Entire Indicator Be Reported at This Time?

Estimates are based on a coarse overlay of protected areas and forest cover by county. Area of forest land that is protected is not inventoried as such. Thus, indirect approaches are used. Area and percent of forest land can measure only the degree to which resources valuable for cultural, social, or spiritual reasons have been recognized. It does not measure how well the lands are protected to sustain social, cultural, and spiritual values.

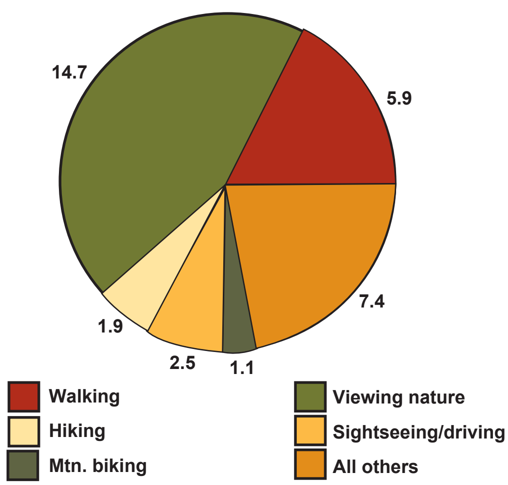


Figure 43-1. Millions of occasions for nonconsumptive outdoor activities in forest settings in the United States, 2001.

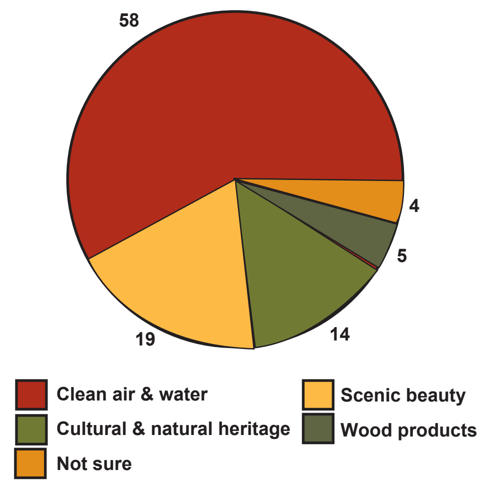


Figure 43-2. Percent of U.S. population indicating the value that is most important for management of public lands.

What Is the Indicator and Why Is It Important?

The indicator measures nonconsumptive uses and values of forests. It includes uses that do not result in physical removal or destruction of forest materials. Included are onsite uses, such as recreation and educational activities, and offsite values, such as ecological services, scenery, or existence values. Direct data sources are limited, but measuring nonconsumptive forest uses and values is highly important since recreation and other nonconsumptive and noncommodity uses seem to be rising in interest among Americans. Knowing the magnitude and trends in nonconsumptive uses and values is necessary to guide balanced forest management on both public and private lands.

What Does the Indicator Show?

At the same time that forest recreation capacity has been decreasing (indicators 35 and 36), demand has been rising. In terms of numbers of added participants, walking increased most between 1994 and 2001, up 46 million participants. Other increases include attending family gatherings outdoors (+36 percent), viewing and photographing wildlife (+34 percent), hiking (+24 percent), picnicking (+20 percent), visiting nature centers, museums, etc., (+17 percent), viewing and photographing birds (+16 percent), camping in developed campgrounds (+16 percent), visiting historic sites (+12 percent), and driving motor vehicles off road (+10 percent). Participation in outdoor activities in both forested and nonforested settings is growing, with greatest growth in nonconsumptive activities that have relatively little effect on forests. With rising demand and declining acres of forest available, recreation use per acre continues to grow, as do conflicts over access by different users. Estimates of per capita economic value are highest for snowmobiling, nonmotorized boating, rock climbing, biking, and hiking.

When interviewed concerning values most important in managing public forests, clean air and water were identified as most important by more than 50 percent of national and regional populations. Scenic beauty was second. For private forests, clean air and water were identified as most important. For national forests, the values selected as most important nationally and across regions include protection of streams and other sources of clean water, management to assure healthy forests for future generations, protection of habitat for abundant wildlife and fish, protection of habitat for rare and endangered plant and animal species, and management to keep national forests natural in appearance.

Indicator 44. Direct and Indirect Employment in the Forest Sector and the Forest Sector Employment as a Proportion of Total Employment

What Is the Indicator and Why Is It Important?

Some people derive value from forests from employment based on forest resources. Much of this employment supports people living in rural areas, and some supports people in urban areas. Forest resource-based direct employment includes wood and nonwood forest products industries, research, management, protection, education, and recreation and tourism. These activities, by their expenditures, also support indirect jobs in other sectors. The importance of trends in employment may be judged in part by their effect on communities, their relationship to government policy goals, and the values they provide for the general public.

What Does the Indicator Show?

Employment in the forest sector is increasing and accounts for roughly 2 percent of all U.S. jobs. In 2000, jobs in logging, lumber, and wood products and paper and allied products were 849,000 and 660,000, respectively (combined they were 1.1 percent of all U.S. jobs, and 8.1 percent of manufacturing jobs). This is up from 824,000 and 485,000 in 1950 (combined they were 2.5 percent of all jobs, and 8.6 percent of manufacturing jobs). Jobs in wood furniture industries were 182,000 in 1997. Although the current number of jobs from forest-based recreation is uncertain, an estimate for the U.S. is 1.1 million or 0.8 percent of all U.S. jobs. An increase may be inferred by the increase in participation in U.S. forest recreation (see Indicator 37). Jobs in producing nonwood forest products including medicinals, food and forage species, floral and horticultural species, resins and oils, arts and crafts, and game animals and furbearers probably number in the tens of thousands. Jobs in forest management include those in the USDA Forest Service: 29,400 in 2001, down from 37,236 in 1980; jobs on tribal lands in the United States Department of the Interior (DOI) Bureau of Indian Affairs and Tribal governments, about 900 in the early 1990s; in State forestry agencies, 12,405 permanent and 5,648 seasonal in 1996; in the DOI Bureau of Land Management, 9,728 in 1997; and an undetermined number in county and municipal governments, private land management organizations, private consultants, and private forest-resource related organizations. Nationwide, firefighting and support jobs during fire season have recently been 12,000 to 15,000.

Management of forests in parks includes many of those in the DOI National Park Service, 18,361 total in 1997, and an undetermined number in State, county, tribal and municipal governments. Jobs in forest management education and research in 2001 include colleges and universities, 1,361; USDA Forest Service research, 701 (included in the USDA Forest Service total), industry research, 124; and an undetermined number in providing forest resource education in grade schools, and in education efforts of private associations and organizations. Total forest-related jobs are estimated to be close to 3 million or about 2 percent of all U.S. employment. This does not include indirect jobs generated by expenditures of government agencies, businesses, or others. Direct jobs in forest-based recreation and tourism employment is estimated to be highest in the North, followed by the South, Rocky Mountains, and Pacific Coast. In 1997, forest products industry employment was highest in the North (about 600,000), followed by the South (550,000) Pacific Coast (200,000), and Rocky Mountains (70,000). In 1996, employment in State forestry agencies was highest in the South (6,064 permanent and 1,508 temporary), followed by the North (3,399 permanent and 1,934 temporary), Pacific Coast (2,017 permanent and 1,714 temporary), and Rocky Mountains (924 permanent and 492 temporary). Indirect jobs supported by expenditures of wood products firms, furniture firms, paper products firms and forest recreation-related businesses and the expenditures of their employees are estimated to be 2.2 million, 1.2 million, 2.7 million, and 0.9 million, respectively.

Indicator 45. Average Wage Rates and Injury Rates in Major Employment Categories Within the Forest Sector

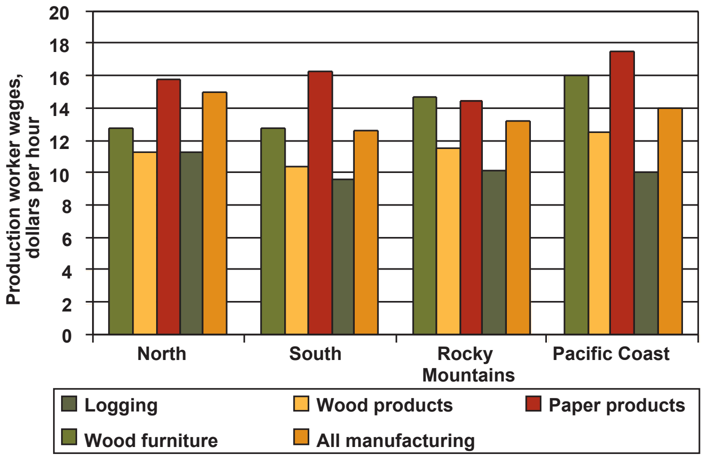


Figure 45-1. Production worker wages: logging, wood products, paper products, wood furniture, and all manufacturing, 1997, dollars per hour, by regions.

What Is the Indicator and Why Is It Important?

This indicator measures forest sector wage rates and injury rates as a measure of workforce health and welfare. The forest sector includes wood and nonwood forest products industries, research, management, protection, education, recreation, and tourism. Comparison of wages in the forest sector with similar occupations by region provides an indication of the economic viability of the sector and potential for income security in dependent communities. Decreasing injury rates may reflect improved occupational health and safety and employment quality, a benefit for communities.

What Does the Indicator Show?

Annual wages and salaries in deflated dollars for paper and allied products industries have increased steadily since 1930 and have remained above the average for all manufacturing and all domestic employment. In 2000, the average annual wage was $46,519. Wages and salaries for lumber and wood products in deflated dollars increased from 1930 to about 1980, decreased in the 1980s, but have increased since about 1990. In 2000, the average annual wage was $30,018. In 1997, the highest production worker wages for logging, wood products, and paper products were on the Pacific Coast, and the highest wages for furniture products was in the North. Average salaries in State forestry agencies include jobs in forest management and protection. In 1996, the average salary for district foresters was highest in on the Pacific Coast ($50,000), followed by the North ($41,211), the South ($39,233), and the Rocky Mountains ($35,970). The average salary for forestry technicians ranged from $25,000 in the North to $18,500 in the Rocky Mountains. USDA Forest Service median salary for full-time employees (in 1996 dollars) increased from a range of $11,000–$22,000 in 1992 to $37,000–$46,000 in 2001. Salaries cover employees in the National Forest System, Research and Development, and State and Private Forestry. The increase came with a decrease in employees in the lowest pay ranges during the 1990s. Wages for collecting nonwood forest products vary widely. For example, mushroom picking may pay as little as $30 a day to as much as $15 per hour. Higher wages are possible for experienced pickers, but most workers earn low wages. Many workers receive fewer benefits or lower wages than if they worked in the formal economy. Since 1976, the illness and injury rates for wood and furniture products industries, while higher than the average for all manufacturing, have fallen in line with the rate for all manufacturing. The illness and injury rate for paper industries has been below the national average since 1984. In 2000, the annual occurrence of illness or injury per 100 workers was 12.1 for wood products, 6.8 for paper products, 9.8 for wood furniture, and 9 for all manufacturing. Information on injury rates for workers in four State forestry agencies (forest management and protection) in the South shows the rate has ranged from 8 to 19 occurrences per 100 workers in recent years. Information on wages and salaries and injury rates for the large number of jobs specifically linked to forest-based recreation and tourism, a substantial contribution to local and national economies, and in research and education has not been determined.

Indicator 46. Viability and Adaptability to Changing Economic Conditions of Forest-Dependent Communities, Including Indigenous Communities

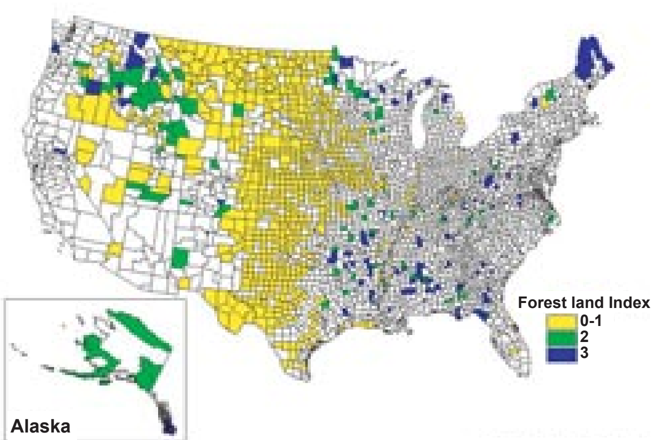


Figure 46-1. Counties with low viability and adaptability to changing economic conditions. Forest land area index 0-1 = low, 2 = medium, and 3 = high.

What Is the Indicator and Why Is It Important?

Indicator 46 takes a broad view of how sustainable forest management influences social well-being, which includes the expected concerns about determinants of economic well-being (often measured by jobs) as well as concerns about community well-being. Attempting to define the propensity of communities to be viable and adaptable in response to changing economic conditions creates an understanding of the set of conditions that might persist over an indefinite future.

What Does the Indicator Show?

Using county-level data, a composite measure was developed that combined population density, lifestyle diversity, and economic resiliency. The ratings for the 3,110 counties, boroughs, and county/city combinations were arrayed in ascending order, and those with the lowest composite scores were assigned a low rating. There were 837 counties assigned a low rating, designating them as areas in which concerns exist about the viability and adaptability of the associated communities. Those counties represent 36 percent of the area of the United States, but they represent less than 3 percent of the U.S. population. The rest of the population is roughly divided among the 2,064 counties assigned medium ratings and the 209 counties assigned high ratings. In terms of forest-dependent communities, 742 counties are heavily forested, but only 14 percent of those counties are classified as having low viability and adaptability. Indicator 46 also addresses areas with indigenous communities. In the United States, 66 counties and boroughs have significant American Indian or Native American Alaskan populations. Regionally, most of the affected population lives in the East, while most of the affected area is in the West (figure 46-1).

Why Can't the Entire Indicator Be Reported at This Time?

The lack of comprehensive community-level databases (except in some unique cases, such as the Pacific Northwest, which has been assembled as part of ecoregion assessments) limits the ability to assess community viability and adaptability and the relations among local, regional, and national scales. Even where the data has been assembled, severe limitations remain for measuring certain elements of community viability and adaptability. Also, little guidance is available for how to scale community information upward to broader spatial scales.

What Is the Indicator and Why Is It Important?

Forest lands provide products for survival outside the formal economic or market-based system. Such products include foodstuffs, medicine, fuel wood, clothing, and shelter. Subsistence hunting, fishing, and gathering are important to the material and cultural survival of people from a variety of ethnic backgrounds. Forest policy and management affect the area of forest land available for subsistence activities, the physical availability of those goods, and the terms of access to them. Identifying available lands and trends in access provides an indication of the continued potential for individuals and cultural groups to engage in subsistence practices.

What Does the Indicator Show?

Three legal cannons establish subsistence rights in the United States: (1) the Alaska National Interest Land Conservation Act (P.L. 96-487) provides for "customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption…for the making and selling of handicraft articles…for barter or sharing…and for customary trade"; (2) Federal treaty law, which has consistently upheld the rights of American Indians to hunt, fish, trap, and gather on reservations and on treaty-specified lands off reservation as "not much less necessary to the existence of the Indians than the atmosphere they breathed" (U.S. v. Winans 1905); and (3) Article XII, Section 7 of the Hawaii State Constitution, which protects "all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians." While subsistence activities have unique legal and cultural standing for indigenous communities, they also have multicultural importance. The Alaska legislation guarantees subsistence rights for rural residents of all ethnicities. Hunting, fishing, and gathering to meet basic needs have been documented for African Americans, Asian Americans, and European Americans and in all regions of the United States. Families that rely on subsistence practices do so within mixed livelihood systems that generally include at least some income earned in the formal market system. There are 749 million acres of forest land in the United States. Access to forest lands for subsistence purposes varies by practice and landownership. Legal foundations for access may be greatest for fishing, followed by hunting, with gathering least protected. Nevertheless, State-established season limits, bag limits, size limits, permit costs, equipment restrictions, and prohibitions on harvesting of individual species—designed to regulate recreational and commercial uses—can pose barriers to subsistence hunting and fishing. Within these limitations, some activity is legally permissible on most of the 316,475,000 acres of public lands in the Nation. Recent events, however, indicate that access to public lands may be abruptly curtailed in response to security concerns. Tribes determine eligibility and set seasons and allowable takes on the 17,902,658 acres of reservation and tribal forest lands. Several trends appear to be reducing access to subsistence resources on the 362,796,000 acres of nonindustrial private forest lands. These include fragmentation, subdivision, conversion to nonforest cover, increased posting, and leasing for hunting and recreation. Rural residents have traditionally used forest industry lands (67,687,000 acres nationally) for hunting, fishing, and gathering. A clear trend toward limiting or closing access to industry lands is evident, however, as corporations respond to concerns over liability and vandalism and increasingly let leases for hunting and recreation. Thus, in general, the area and percent of U.S. forest lands available for subsistence appear to be decreasing.

Indicator 48. Extent to Which the Legal Framework (Laws, Regulations, Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It—Clarifies Property Rights, Provides for Appropriate Land Tenure Arrangements, Recognizes Customary and Traditional Rights of Indigenous People, and Provides a Means of Resolving Property Disputes by Due Process

What Is the Indicator and Why Is It Important?

Stable property rights and the assurance that those rights will be protected, or disputed through due process, are essential for sustainable forest management. It is suggested that those who depend on forests for daily subsistence and livelihood, or who have a connection to forests over long periods of time, will take responsibility for better long-term care of the land if they are able to own the forest or can be assured access to needed forest resources.

What Does the Indicator Show?

Property rights and land tenure arrangements in the United States are extremely diverse, have evolved through time, and are continuously being defined, interpreted, and revised by all levels of government. Fundamentally involving concepts of private property, common property and public (or State) property, tenure, and property arrangements are growing as popular, yet often contentious, political topics, with property-related advocacy groups increasing in number across the full spectrum of beliefs about forest resource ownership. Special property arrangements, such as conservation easements, that support long-term sustainability of natural resources are increasing in number and acceptability. Such rights and arrangements have mostly been defined and interpreted in State and Federal case law. Much of the recent efforts to clarify property rights and land tenure arrangements has been in response to Federal conservation and environmental laws.

Although the Federal Government has contributed extensively to the clarification of property rights and land tenure, State governments have assumed the primary role in this respect. For example, State governments have focused extensively on the protection of private property from takings and have addressed local government establishment of ordinances that may classify forestry as a nuisance.

Property rights and land tenure arrangements of indigenous peoples involve special circumstances in the United States. These rights and arrangements have evolved separately from other views of property, and their interpretation has largely been the responsibility of the Federal Government. In recent years, the Federal Government has focused attention on the forest resources associated with indigenous peoples and the often unique and special contribution these forests make to their culture and way of life. Congress and Federal courts have played an influential role in this evolution of rights and land tenure claims.

The concept of due process, like property rights, has also evolved over time, changing mostly through interpretation by Federal courts. Processes for resolving disputes over property rights and land tenure are evolving as well, although the Constitution (Fifth and Fourteenth Amendments) provides the foundation for citizen protection against State deprivation of life, liberty, and property. Institutional structures for addressing disputes are many (legislatures, courts, executive agencies), as are approaches for settling disputes (negotiation, arbitration, collaboration, citizen initiative).

Indicator 49. Extent to Which the Legal Framework (Laws, Regulations, Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It—Provides for Periodic Forest-Related Planning, Assessment, and Policy Review That Recognizes the Range of Forest Values, Including Coordination with Relevant Sectors

What Is the Indicator and Why Is It Important?

The sustainability of forests is dependent on society's ability to comprehensively evaluate trends and conditions in diverse sectors and to subsequently take responsive actions that will ensure the sustained use, management, and protection of forest resources and the communities that are dependent upon them. These actions are typically predicated on well-focused and technically sound plans, assessments, and policy reviews that are sensitive to a range of forest values and are coordinated with a variety of forest-related sectors.

What Does the Indicator Show?

Forestry and related government agencies at all levels in the United States have a long legal history requiring plans, assessments, and periodic reviews of policies and programs. In general, ample statutory and administrative authority is in place to conduct these activities, although the intensity with which they are carried out varies widely within and among different levels of government. The plans and assessments resulting from such authorities are not always comprehensive; they often focus on a single resource sector within forests. In only a limited number of cases does evidence exist of concerted and effective efforts to coordinate plans. Whether existing legal capacity is actually being translated into meaningful plans and their subsequent implementation is largely unknown.

Federal legal capacity requiring planning for the use, management, and protection of forests has existed for many years, with early legal requirements most often requiring Federal agencies to define broad strategic direction for agency activities. Federal statutes requiring plans focused on Federal public forests are nearly split in character between requirements for the preparation of strategic program plans and land-use and management plans. Federal agency authority for carrying out assessments is set forth by statutes that call for continuous assessments, periodic assessments at specified intervals, or intermittent assessments needed to address important issues regarding resource use and management. Assessments are frequently conducted in concert with the development of strategic program plans or land-use and management plans.

State governments also engage in forest planning and assessment activities, although responsibility for such activities has increasingly become dispersed across more and different types of State agencies (for example, agencies with broad environmental responsibilities). Over the last 20 years, nearly all States have prepared a statewide forest resource plan; many States have actively updated their forest plans. Legal authority to initiate planning processes exists in all States, although such processes and the resulting plans vary considerably in strength and sophistication. State legal authority to engage in forest resource planning often parallels Federal statutory authority for planning. Although never comprehensively defined, local and regional governments are also known to engage in planning, assessment, and policy and program review activities.

Planning activities of the private sector are motivated by self-interest or often are prodded by requirements for participating in some government programs (for example, fiscal incentive programs). In some cases (for example, State forest practice laws), State law may require private concerns to prepare for government review or approval of a timber harvesting plan. Because of proprietary concerns, the planning and related activities of industrial forestry concerns are not commonly known.

Indicator 50. Extent to Which the Legal Framework (Laws, Regulations, Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It—Provides Opportunities for Public Participation in Public Policy and Decisionmaking Related to Forests and Public Access to Information

What Is the Indicator and Why Is It Important?

Forests may be managed more sustainably if citizens have responsibility for their use, management, and protection. If through active influence, citizens are given an opportunity to identify areas of opportunity and concern over forests, they are more likely to support the management of forests and the principles of sustainability as might be incorporated therein. In a broader context, public participation processes can foster practical and political support for sustainable management. Access to timely, complete, and accurate information about forests, forest resources, and socioeconomic trends will enhance those participatory processes.

What Does the Indicator Show?

Public participation in public agency decisions is exercised in a variety of ways, ranging from engagement in the electoral process to testifying at public hearings and meetings and from direct involvement in multistakeholder collaboration activities to engaging in some form of challenge or protest action. Legal capacity for engaging the public in decisions regarding forest sustainability exists for nearly all State and Federal agencies that have responsibility for forests and related resources. The extent to which this capacity is exercised, however, varies considerably within different levels of government and among different agencies. Such processes are generally embodied in various administrative structures and procedures, and agencies are increasingly interpreting their public participation authority to be more interactive and collaborative in nature. Public participation processes are also becoming more sensitive to ethnic and minority interests in forest and related natural resources.

Federal legal capacity for public participation is largely a product of laws and rule-making occurring over the last 50 years. Federal statutory requirements are expressed in a variety of ways, including procedures for rule-making, conditions for agency issuance of permits, requirements for public meetings, public access to information, and processes for developing and implementing plans. Federal authority to initiate public participation activities emanates from forest resource law, environmental law, and general government administrative law. As it relates to forests, substantial variation exists in scope, focus, and intensity of Federal agency capacity stemming from those different legal authorities. Furthermore, Federal legal requirements for public participation are not always comprehensive in that they often focus on a single resource sector within forests.

State government authority to engage in public participation and related activities emanates primarily from open meeting and open record laws (all but one State has an open meeting law). States, however, also authorize public participation in policy development via election of initiatives and referendums, citizen service on governing or advisory entities (248 such entities focused on forest resource and related agencies), citizen participation in forest resource planning activities, and participation in interest groups that focus the forest resource interests of many citizens. Local units of government often follow their State counterparts on matters of public access to government decisionmaking. The extent of local government capacity to carry out public participation activities is largely unknown in general and especially so from a sustainable forestry perspective.

Indicator 51. Extent to Which the Legal Framework (Laws, Regulations, Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It—Encourages Best Practice Codes for Forest Management

What Is the Indicator and Why Is It Important?

Forest management practices that are well designed are fundamental to the sustainability of forest resources. At all levels (stand, landscape, local, regional, national, global), forests depend on the application of forest practices that are capable of ensuring sustained use, management, and protection of important social, economic, and biological values. Well-founded best practice codes, and the forest management practices that comprise them, can ensure sustained forest productivity for market goods; protection of ecological values; and protection of the various social, cultural, and spiritual values offered by forests. They can be among the most important tools for responding to national trends and conditions involving forests.

What Does the Indicator Show?

In the United States, best practice codes represent an integration of technically effective, economically wise, and politically palatable forest practices considered necessary for sustaining forest conditions and values. These codes are commonly identified by terms such as "forest practice guidelines" and "best management practices." When implemented on public forests, best practice codes are applied directly (required) by forest administrators, whereas their application on private forests is encouraged by a variety of programs, including education, technical assistance, tax incentives, fiscal incentives, and regulatory requirements (a mixture of different types of programs has proven to be most effective). Best practice codes are often monitored to determine their rate of application and effectiveness.

Significantly strengthened in recent decades, a variety of Federal laws and associated Federal rules and administrative directives symbolizes significant legal capacity to develop and implement best practice codes for both public and private land. This legal capacity is not always fully integrated, in that best practice codes are often developed for specific forest sectors within the forest sector (e.g., different codes for water quality, fish and wildlife, endangered species, scenic amenities). In some cases, Federal agencies develop and promote best practice codes for direct application to Federal land (e.g., via land management plans), while in other cases they develop codes for application on private forest land (e.g., endangered species recovery plans). Guided by statute, Federal agencies also encourage State governments to develop and promote the use of best forest practice codes.

State governments most commonly encourage the application of best practice codes by encouraging their voluntary application by landowners and timber harvesters. Such application is supported by extensive educational and technical assistance programs. State-initiated regulatory programs specifying the type and manner in which best practice codes are applied have especially increased both in number and intensity during the past three decades, as have related laws and regulations at local government levels. In 2001, all States had some form of best practice code of which 60 percent had been revised one or more times since 1994. In 1993, 522 local ordinances in 24 States required (by regulation) the application of best practice codes. Often in response to Federal incentives, 34 States in 1997 conducted monitoring programs to determine compliance with best practice codes.

Private organizations also actively develop and implement best practice codes. Certification programs, for example, are increasingly more common, involve more sophisticated codes, and are being applied to ever-larger areas of forest land.

Indicator 52. Extent to Which the Legal Framework (Laws, Regulations, Guidelines) Supports the Conservation and Sustainable Management of Forests, Including the Extent to Which It—Provides for the Management of Forests to Conserve Special Environmental, Cultural, Social, and/or Scientific Values

What Is the Indicator and Why Is It Important?

Forests often possess unique or otherwise special social, cultural, scientific, and environmental values. Formal legal mechanisms are often needed to protect those values from certain uses and activities. Since the values to be protected are often large in number and wide in scope, the resulting legal framework is frequently complicated and many times broadly dispersed among Federal, State, and local governments.

What Does the Indicator Show?

Legal capacity for conserving special forest values is driven by societal interest in various sets of values, most often involving amenity values (nature, scenery, lifestyle), environmental quality values (air, water), ecological values (biological diversity, endangered species), public use values (recreation, tourism), commodity values (timber, range, forage, water, minerals), and spiritual values (reverence for forests). In the last three decades, emphasis appears to have given priority to ecological and environmental quality values, with other values being given far less consideration.

Federal legal capacity to conserve special forest values is incredibly broad (more than 250 individual Federal laws focus on the conservation of special values), involving restricted use or set-aside laws (e.g., wilderness designation), procedural and administrative laws (e.g., environmental impact statement review), fish and wildlife conservation laws (e.g., fisheries' restoration), cultural and recreational laws (e.g., archeological site protection), forestry and forest resource laws (e.g., management of Federal forests), and pollution control and prevention laws (e.g., pesticide management). Few of these laws call for integration and coordination of protective measures to conserve special values; protection is instead generally afforded sector by sector (e.g., wildlife, wilderness, scenic easements, historic sites) within the forest resource sector.

State governments also have extensive legal capacity to conserve special forest values, doing so via education programs, technical assistance initiatives, fiscal and tax incentives, regulatory programs, and State government ownership of forests. In 1994, eight States had formal programs devoted to wilderness. State legal capacity to conserve special values is increasingly being dispersed among a variety of agencies, a situation fostering potential for overlap in conservation purposes. Local units of government also have legal capacity to conserve special values associated with forests, although such capacity is not uniform in substance or in application across local units of government.

Assisted by State and Federal laws, private landowners pursue interest in conserving special forest values using conservation easements, land retirement programs, fiscal incentive programs, registry programs, deed restrictions, mutual covenants, leases, and general management. Private sector organizations and conserving special forest values are many in number, ranging from local civic trusts to large national land trusts. In recent years, private land trusts have been especially active in the conservation of special forest values, with more than 1,200 regional and local land trusts existing in 2000. These trusts were responsible for direct ownership, or transfer of ownership to government agencies, of more than 2.6 million acres of land.

Indicator 53. Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity To Provide for Public Involvement Activities and Public Education, Awareness, and Extension Programs, and Make Available Forest-Related Information

What Is the Indicator and Why Is It Important?

Well-informed and knowledgeable citizens and forest owners create a foundation of support for applying principles of sustainable forest management. To accomplish such a purpose requires institutional conditions (agencies, organizations) that are capable of promoting programs considered necessary to inform the public and private forest owners about forest resource sustainability.

What Does the Indicator Show?

Organizations responsible for communicating information about forest sustainability are many in number and diverse in mission and program responsibilities, although the intensity with which they engage in educational activities varies widely within and between public and private sectors. In recent years, the number of organizations so engaged has increased considerably. That increase has created opportunity to serve more and larger audiences, yet has posed challenges to program coordination and the presentation of integrated messages regarding forest sustainability. Extensive partnering occurs between public and private organizations that are responsible for educational initiatives. Implementation of education programs in manners that complement other types of programs (e.g., fiscal incentives) often leads to more efficient accomplishment of overall forest sustainability goals and objectives.

Federal Government agencies represent extensive institutional capacity to implement a wide range of educational programs focused on forest sustainability. This capacity is exercised via programs (very often involving partnerships) focusing on public education generally (e.g., Natural Resources Conservation Education Program, Environmental Education Grants Program), one-on-one technical assistance initiatives (e.g., Forest Stewardship Program, Resource Preservation and Development Program), and extension service programs. Renewable resources extension staffing exceeded 700 extension staff years in 1999, with emphasis on production, environmental education, environmental quality, and utilization.

State government agencies also have substantial institutional capacity to implement educational programs. State education and technical assistance programs offered to private forest landowners for purposes of encouraging forest sustainability exist in virtually all States and focus on major forestry activities (e.g., protecting water quality, promoting reforestation, protecting from wildfires). In many cases, the programs are tightly partnered with Federal programs, an example being the extension service that engages the educational abilities of approximately six full-time equivalent staff years per State. In recent years, State governments have initiated a variety of K-12 environmental education programs, many of which have relevance to a better understanding of forest sustainability principles.

Private sector institutional capacity to undertake public educational efforts is diverse and extensive. More than 80 private national organizations claim responsibility for education initiatives involving forests. Privately sponsored forest certification programs have important implications for education on matters of forest sustainability. Nongovernmental organizations are increasingly making their presence known as leaders in the field of environmental education and are increasingly devoting attention to matters involving forest sustainability.

Indicator 54. Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity To Undertake and Implement Periodic Forest-Related Planning, Assessment, and Policy Review, Including Cross-Sectoral Planning Coordination

What Is the Indicator and Why Is It Important?

The sustainability of forests is dependent on society's institutional ability to comprehensively evaluate trends and conditions in diverse sectors and to subsequently take responsive actions that will ensure the sustained use, management, and protection of forest resources and the communities that depend on them. Such actions are typically predicated on institutional conditions that foster well-focused and technically sound plans, assessments, and policy reviews that are sensitive to a range of forest values and that are coordinated with a variety of forest-related sectors.

What Does the Indicator Show?

Forest and forest-related public and private organizations in the United States have a long history of engaging in forest planning and assessment activities, as well as in undertaking periodic reviews of forest resource policies and programs. Organizational responsibility for planning is diverse, as is the nature of the planning activities carried out. Public agencies are especially active in planning and assessment efforts. These agencies at times create a fragmented planning environment wherein coordination is increasingly viewed as an important yet difficult task to meaningfully accomplish. Assessment activities are very often one-time agency efforts that respond to major issues involving controversy over proposed resource development or management. Some assessment activities, however, have become monitoring initiatives that are conducted on a continuous basis (air quality monitoring) or at periodic intervals (forest inventory and analysis). Whether the public and private institutional capacity for planning and assessment is actually being translated into meaningful plans and their subsequent implementation is largely unknown.

Federal institutional capacity for planning the use, management, and protection of forests has existed for many years, as has significant institutional capacity to undertake comprehensive examinations of present and prospective conditions that are likely to affect forest resources. Federal agencies respond to statutes (or administrative directives) that require direct and exclusive consideration of forests and to statutes that require development of broad multisector plans (air, water, wildlife) of which forests are but one part. Multisector type authority tends to fragment institutional capacity and the administration of forest activities.

State governments' institutional capacity to engage in some form of forest planning activities has existed since the early 1900s, although the character of these activities has changed dramatically over the years, as has the number and type of involved State government organizations. Over the last 20 years, nearly all States have prepared a statewide forest resource plan.

Private sector institutional capacity for land management planning is apparent in the development and implementation of management plans for private forests. In some cases, forest management certification programs require development of a management plan as a prerequisite for certification (e.g., certification of forest management practices by the Sustainable Forestry Initiative of the American Forest and Paper Association). In 1994, approximately 5 percent of nearly 10 million private landowners had a plan for managing their forest property, which combined, directed the use and management of forest on nearly 154 million acres of private forest.

Indicator 55. Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity To Develop and Maintain Human Resource Skills Across Relevant Disciplines

What Is the Indicator and Why Is It Important?

Extensive knowledge and skills applied by persons engaged in the development and implementation of forest resource policies and programs are critical to accomplishing the wide-ranging goals of forest sustainability and conservation. Of special importance to sustainability is access to a broad range of disciplines and resource orientations. These disciplinary and resource skills are developed via formal educational programs, as well as via professional work experiences and access to continuing education opportunities.

What Does the Indicator Show?

Professional educational opportunities in the Untied States occur in some form in virtually all public and private natural resource and related organizations. Those activities range from formal professional education in a university setting to professional continuing education via electronic media, and from forest practice workshops for timber harvesters to national and international conferences on forest sustainability and conservation. Educational endeavors to maintain human resource skills are enormous in breadth and substance. Information about the professional workforce of private organizations focused on forest sustainability is particularly limited in quantity and quality.

Universities, colleges, and some technical schools generally provide formal education to resource professionals. Such educational programs offer students an opportunity to select from an wide array of subjects and disciplines. Information about the type, focus, and investments in these educational programs is widely available, although questionable in quality and consistency. In recent years, formal professional education programs appear to have increased students' exposure to a wider range of disciplines and a broader set of resources. Unclear, however, is the magnitude of this increase and the extent to which integration of knowledge actually occurs across disciplines and resources. Formal programs are often required to conform to standards specified by accreditation programs. In 2001, nearly 2,200 academic degrees were awarded in some field of forest resources. Seventy-one percent of those degrees were at the baccalaureate level.

The wide array of organizations offering continuing education programs for forest resource professionals are often implemented in a partnership fashion. The approaches to continuing education range from correspondence courses to formal doctoral programs and from short-term workshops to extensive international forest study tours. Universities and colleges are major sources of continuing education, although employers and some private organizations provide such opportunities as well. At least three Federal statutes provide for the continuing education of forest resource professionals and those in related professions.

Occupational registration and certification programs focused on forest resource professionals and timber harvesters commonly require the maintenance of professional skills applied to forest and related natural resources. State governments have been most active in developing and implementing such programs. At least 16 States, in 1996, registered, certified, or licensed forestry professionals, while 25 States applied similar occupational programs to timber harvesters.

Indicator 56. Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity To Develop and Maintain Efficient Physical Infrastructure To Facilitate the Supply of Forest Products and Services and To Support Forest Management

What Is the Indicator and Why Is It Important?

Capital resources that take the form of a physical infrastructure (e.g., roads, utilities, processing facilities) are essential to the management of forests and ultimately to economic development and quality of life in rural forested areas. Investments in public infrastructure, such as roads, bridges, sewerage and sanitation systems, schools, parks, and other physical facilities, are important government initiatives that complement the capital investments of private firms. Together, these investments constitute the capital basis for protecting forests and related resources and for producing the goods and services that sustain economies of forested areas. Some people have suggested that forest ecosystems per se can be considered a form of infrastructure ("green" infrastructure).

What Does the Indicator Show?

Information regarding Federal, State, and local authority and institutional capacity to develop and maintain an infrastructure is scattered among various sources and seldom has a central focus on the importance of infrastructure to sustaining certain forest conditions. Sources of information describing private infrastructure investments of relevance to sustaining forests are few and the amount of information they make available is not very extensive.

The institutional capacity to affect infrastructure important to forest and community sustainability is distributed among and within many levels of government. In reality, nearly all forest resource agencies exercise some capacity to influence infrastructure, although very few government agencies have explicit responsibility for infrastructure conditions. The closest to concentrated responsibility for promoting infrastructure investments occurs in economic development agencies, pollution control agencies, and in some resource management agencies.

Public investments in infrastructure are significant. Examples are the more than $430 million of infrastructure investment by the United State Department of the Interior National Park Service in 1997, and the more than $270 million by the USDA Forest Service in 1998 (facility construction, facility maintenance, road and trail construction, and road and trail maintenance). In 1986, an estimated $5.2 billion was invested by Michigan, Minnesota, and Wisconsin in infrastructure considered important to forests and their use (e.g., transportation, utilities, parks, schools).

Infrastructure investments by the private sector are primarily the result of access to privately raised capital. In 1999, capital expenditure in paper manufacturing was approximately $7 billion, while investment in wood product manufacturing was about $3 billion. In 2000, the pulp and paper industry invested more than $1 billion in environmental resource protection infrastructure. The government often provides finances and technical advice that complements private sector investments in infrastructure.

Indicator 57. Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity To Enforce Laws, Regulations, and Guidelines

What Is the Indicator and Why Is It Important?

The achievement of conditions conducive to forest conservation and sustainability implies that various biophysical standards and assorted political processes have been applied. In many cases, such will occur in response to market systems or to various participatory processes involving different segments of the public. Circumstances exist, however, in which the application of sustainability standards occurs only in response to the fear of penalty or punishment. Some unwilling persons or entities respond only to the imposition of a sanction in the form of an order, fine, or incarceration. Without some form of adequately and appropriately applied enforcement effort to which landowners or timber harvesters must respond, the effectiveness of laws, regulations, and guidelines focused on forest resources may be substantially diminished in some circumstances.

What Does the Indicator Show?

Institutional capacity needed to accomplish standards of forest sustainability exists for nearly all public agencies and is very often designed and organized to be implemented in a targeted fashion. For example, enforcement actions are focused on specific sectors (private forests), geographic areas (riparian areas), forestry practices (clear cutting), pollutants (pesticides), and products or benefits (timber, wildlife). The intensity with which enforcement capacity is applied across these target areas is not uniform. Furthermore, enforcement varies considerably within and between different levels of government. The severity of penalties associated with enforcement authority is wide ranging. Largely unknown, however, is how effective these penalties are as a deterrent to landowners or timber harvesters who fail to cooperate in the application of sustainability standards.

Federal institutional capacity supporting enforcement of standards of forest sustainability has been strengthened in recent decades. At a minimum, 10 new Federal laws provide additional authorities to address matters involving, for example, endangered species, pesticide application, archeological resources, and conditions of employment. In addition, the issuance of agency-promulgated rules (nearly 80 in 2001) has promoted additional institutional capacity to enforce laws, rules, and guidelines. In most cases, each agency's enforcement authority is grounded in its responsibility for a single forest value, a situation that poses significant challenges to coordination within and between governments and to the understanding of landowners and timber harvesters of the often many different enforcement provisions.

State governments also have extensive enforcement capacity. Such capacity often has its origin in enforcement activities focused on nonpoint sources of water pollutants. Some States use sophisticated regulatory programs to enforce standards of forest sustainability (more than 400 full-time enforcement staff in 1991). This authority is exercised in a variety of ways, ranging from pre-harvest reviews and post-harvest inspections to fines and imprisonment, and from court-ordered injunctions to recovering the cost of repairing damaged resources through liens on private property. Some States have adopted "bad actor" laws or "contingent regulation," wherein enforcement is focused on the exceptionally uncooperative landowner or timber harvester.

Local governments often engage in enforcement actions, although some States prohibit local regulation. The forest sustainability consequences of local regulatory actions are uncertain.

Indicator 58. Extent to Which Economic Framework (Economic Policies and Measures) Supports the Conservation and Sustainable Management of Forests Through Investment and Taxation Policies and a Regulatory Environment That Recognizes the Long-Term Nature of Investments and Permits the Flow of Capital in and out of the Forest Sector in Response to Market Signals, Nonmarket Economic Valuations, and Public Policy Decisions in Order To Meet Long-Term Demands for Forest Products and Services

What Is the Indicator and Why Is It Important?

The sustainability of forests and the many benefits they are capable of providing requires high levels of sustained investment in their management and protection. It is only through such investment conditions that a full range of products, values, and services provided by forests can be assured. If investment capital is lacking in the forest sector, sustainable management and expected economic, ecological, and social benefits may not transpire. Similarly, if investment capital is prevented from leaving the forest sector, inefficiencies can occur and over-exploitation of forests is a possibility. These conditions of investment are driven by a number of economy-wide factors, most notably product or service prices, forest land productivity, and discount rates as affected by risk.

What Does the Indicator Show?

Forest landowners in the United States have a long history of making long-term investments in forest land through reforestation and various silvicultural practices. Tax policies and fiscal incentive programs can influence the extent to which the Nation's private landowners invest in the management of their forests and maintain the land in a forested condition. These include income taxes, estate taxes, and property taxes implemented at the local, State, and Federal levels.

The Federal tax code contains a number of provisions that affect private landowners in the course of managing their forest land, including the reforestation amortization and investment credit, the capital gains treatment of timber, treatment of management expenses, and estate tax provisions. The Federal Government also levies an estate tax, which can impose significant burdens on the heirs of highly valued forest lands. In conjunction with tax policy, the Federal Government maintains a number of agencies and programs involved in reducing or offsetting large, initial investments in management and related activities considered necessary to protect, improve, and sustain forest resources.

State governments have also established significant legal and institutional capacity involving tax and fiscal incentives important to forest sustainability. State tax programs targeting private forest landowners for purposes of encouraging forest sustainability are generally of three major types of tax programs: income, estate, and property. All but 7 States were found to impose income taxes, whereas 29 States imposed an estate or inheritance tax. Property taxes, though generally a local source of revenue, are most often governed at the State level. Every State was found to have at least one property tax program or classification that gives preferential treatment to forest land. Many States have also developed cost share programs and other fiscal incentives to aid private landowners in sustainable management. These programs are often complementary to Federal fiscal incentive programs.

Indicator 59. Extent to Which Economic Framework (Economic Policies and Measures) Supports the Conservation and Sustainable Management of Forests Through Investment and Taxation Policies and a Regulatory Environment That Recognizes the Long-Term Nature of Investments and Permits Nondiscriminatory Trade Policies for Forest Products

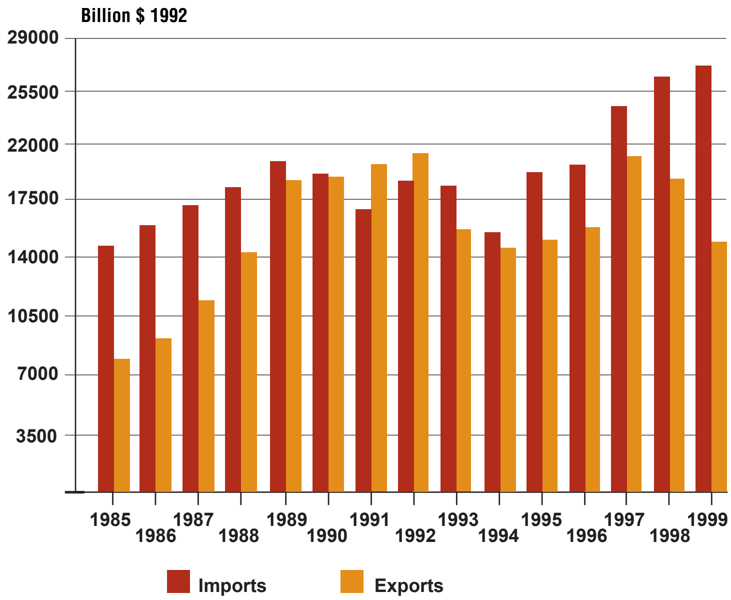


Figure 59-1. Value of imports and exports (billion $, 1992).

What Is the Indicator and Why Is It Important?

This indicator provides information about the Nation's trade policies and how they may affect markets in ways that can affect sustainable forest management. If trade policies, such as import or export quotas, mask market signals that affect domestic timber harvest, there may be unwanted effects on sustainable forest management.

What Does the Indicator Show?

Since 1965, imports as a percent on consumption of industrial roundwood have grown from about 13 percent to about 25 percent. Exports as a percent of production of industrial roundwood increased to a peak of 16.1 percent in 1991 and then generally declined to about 12 percent in 1999, in part because of a strong U.S. dollar. Thus, trade is important in determining domestic timber harvest. The United States participates globally to develop policies that support nondiscriminatory practices in forest products trade. Available data is inadequate, however, to support measurement of nondiscriminatory trade policy linkages to sustainable forest management. Areas needing further analysis include the agreement on Technical Barriers to Trade, domestic legislation affecting trade, counter-vailing, antidumping and safeguard actions, invasive and alien species import restrictions, external influences on trade policies, environmental measures to affect forest management, tariff liberalization, internalized costs and benefits, actions under the North American Free Trade Agreement environmental free trade agreement, nontariff measures, national and subnational procurement requirements, domestic processing requirements, and bilateral trade agreements.

Indicator 60. Capacity To Measure and Monitor Changes in the Conservation and Sustainable Management of Forests, Including Availability and Extent of Up-To-Date Data, Statistics, and Other Information Important to Measuring or Describing Indicators Associated with Criteria 1-7

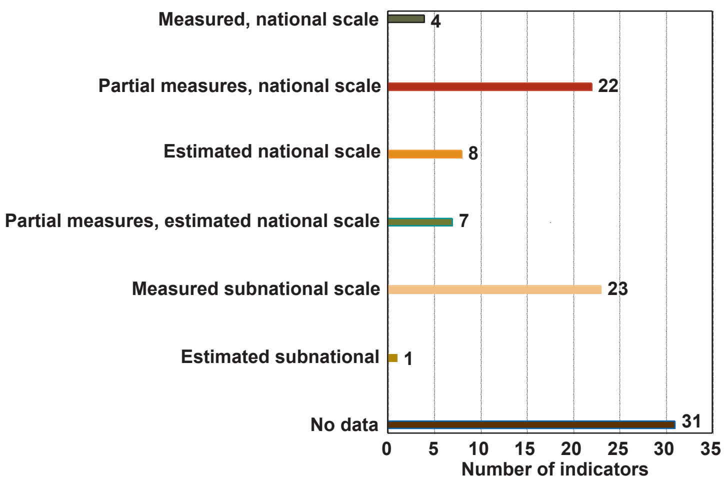


Figure 60-1. Number of indicators by data availability, criteria 1-6.

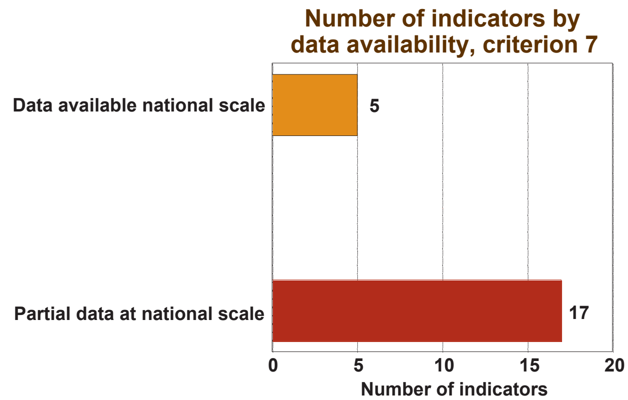


Figure 60-2. Number of indicators by data availability, criterion 7.

What Is the Indicator and Why Is It Important?

This indicator assesses the availability of information needed to measure or describe the indicators associated with criteria 1 through 7. Successful implementation of the criteria and indicator concept requires the availability of information to report on the indicators.

What Does the Indicator Show?

For criteria 1 through 6, three indicators have measured data reported at a national scale. This data is for area of forest, by forest type, wood and wood products production, and supply and consumption of wood and wood products. As the USDA Forest Service implements the Forest Inventory and Analysis Program across all forest land, measured data will be available at a national scale for several more indicators. An indicator can be classed in more than one category. For example, the indicator—value and quantities of production of nonwood forest products—has partial measures at a national scale, partial measures at a subnational scale, and no data for some parts.

For criterion 7, 5 indicators have enough data to make a statement at a national scale, while 17 indicators have data to make a partial statement at a national scale.

The state of the data indicates that much work needs to be done in the area of data collection.

Indicator 61. Capacity To Measure and Monitor Changes in the Conservation and Sustainable Management of Forests, Including Scope, Frequency, and Statistical Reliability of Forest Inventories, Assessments, Monitoring, and Other Relevant Information

What Is the Indicator and Why Is It Important?

Public discussion and decisions related to natural resource sustainability issues should be based on comprehensive, current, and sound data. Information regarding the frequency, coverage, and reliability of data provides analysts with critical information for evaluating and prioritizing sustainability needs.

What Does the Indicator Show?

Data for the 67 indicators range from full, current coverage to one-time studies, to very anecdotal information. By looking at a cross-section of the information in three broad categories, a brief overview of the situation for each criterion can be seen. Few indicators have a full suite of data that is current, national in scope, and collected frequently. The most persistent gap is the lack of systematic national data collection for many indicators. Given the numerous gaps, all data presented are considered reliable as the best data currently available. The following table summarizes the status of each indicator.

Criterion		Indicator	Data status: Coverage	Currency	Frequency
1 Conservation of Biological Diversity	1	Extent of area by forest type relative to total area	🟢	🟢	🟢
	2	Extent of area of forest by type and by age-class or successional stage	🟠	🟠	🟠
	3	Extent of area by forest type in protected area categories as defined by IUCN or other classification systems	🟢	🟠	🔴
	4	Extent of area by forest type in protected areas as defined by age-class or successional stage	🟠	🟠	🔴
	5	Fragmentation of forest types	🟡	🟠	🔴
	6	Number of forest-dependent species	🟠	🟠	🔴
	7	Status (threatened, rare, vulnerable, endangered, or extint) of forest-dependent species at risk of not maintaining viable breeding populations as determined by legislation or scientific assessment	🟠	🟠	🔴
	8	Number of forest-dependent species that occupy a small portion of their former range	🟠	🟠	🔴
	9	Population levels of representative species from diverse habitats monitored across their range	🟠	🟠	🔴
2 Maintenance of Productive Capacity of Forest Ecosystems	10	Area of forest land and net area of forest land available for timber production	🟢	🟢	🟢
	11	Total growing stock of merchantable and nonmerchantable tree species on forest land available for timber production	🟢	🟢	🟢
	12	Area and growing stock of plantations of native and exotic species	🟢	🟢	🟢
	13	Annual removal of wood products compared to the volume determined to be sustainable	🟢	🟢	🟢
	14	Annual removal of nontimber forest products (e.g., fur bearers, berries, mushrooms, game) compared to the levels determined to be sustainable	🔴	🔴	🔴
3 Maintenance of Forest Ecosystem Health and Vitality	15	Area and percentage of forest affected by processes or agents beyond the range of historic variation (e.g., by insects, disease, competition from exoctic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals).	🟠	🟠	🟠
	16	Area and percentage of forest subject to specific levels of air pollutants or ultraviolet B that may cause negative effects on the forest	🟡	🟠	🟠
	17	Area and percentage of forest land with diminished biological components indicative of changes in fundamental ecological processes and/or ecological continuity	🟠	🟠	🟠
4 Conservation and Maintenance of Soil and Water Resources	18	Area and percentage of forest land with significant soil erosion	🟡	🟠	🟠
	19	Area and percentage of forest land managed primarily for protective functions (e.g., watersheds, flood protection, avalanche protection, riparian zones)	🔴	🔴	🔴
	20	Percentage of stream kilometers in forested catchments in which stream flow and timing have deviated significantly from the historic range of variability	🟠	🟠	🟠
	21	Area and percentage of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties	🟠	🟠	🟠
	22	Area and percentage of forest land with significant compaction or change in soil physical properties resulting from human activities	🟡	🟠	🟠
	23	Percentage of water bodies in forest areas (e.g., stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability	🔴	🔴	🔴
	24	Percentage of water bodies in forest areas with significant variance from the historic range for dissolved oxygen, temperature, electrical conductivity, acidity (pH), and sedi mentation	🔴	🔴	🔴
	25	Area and percentage of forest land experiencing an accumulation of persistent toxic substances	🟡	🟠	🔴

Criterion		Indicator	Data status		
			Coverage	Currency	Frequency
5 Maintenance of Forest Contribution to Global Carbon Cycles	26	Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age-class, and successional changes	yellow	orange	orange
	27	Contribution of forest ecosystems to the total global carbon budget	yellow	orange	orange
	28	Contribution of forest products to the global carbon budget	yellow	orange	orange
6 Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits To Meet the Needs of Societies	29	Value and volume of wood and wood products production, including value added through downstream processing	green	orange	green
	30	Value and quantities of production of nonwood forest products	red	red	red
	31	Supply and consumption of wood and wood products, including consumption per capita	green	orange	green
	32	Value of wood and nonwood products production as a percentage of GDP	orange	red	orange
	33	Degree of recycling of forest products	orange	red	red
	34	Supply and consumption/use of nonwood products	red	red	orange
	35	Area and percentage of forest land available for general recreation and tourism, in relation to the total area of forest land	yellow	red	orange
	36	Number and type of facilities available for general recreation and tourism in relation to population and forest area	orange	red	orange
	37	Number of visitors days attributed to recreation and tourism in relation to population and forest area	orange	red	orange
	38	Value of investment, including investment in fast-growing forest health management, planted forests, wood processing, recreation, and tourism	orange	red	orange
	39	Level of expenditure on research and development and on education	orange	red	orange
	40	Extension and use of new and improved technologies	red	red	orange
	41	Rates of return on investment	orange	red	orange
	42	Area and percentage of forest land managed in relation to the total area of forest land to protect the range of cultural, social, and spiritual needs and values	red	red	red
	43	Nonconsumptive forest use and values	red	red	red
	44	Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment	orange	red	orange
	45	Average wage rates and injury rates in major employment categories within the forest sector	orange	red	orange
	46	Viability and adaptability to changing economic conditions of forest-dependent communities, including indigenous communities	red	red	red
	47	Area and percentage of forest land used for subsistence	red	red	red
7 Legal, Institutional, and Economic Framework; Capacity To Measure and Monitor Changes; and Capacity To Construct and Apply Research and Development for Forest Conservation and Sustainable Management	48	Clarifies property rights, provides for appropriate land	orange	red	red
		tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides a means for resolving property disputes by due process	orange	red	red
	49	Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors	orange	red	red
	50	Provides opportunities for public participation in public policy and decisionmaking related to forests and public access to information	orange	red	red
	51	Encourages best practice codes for forest management	orange	red	red
	52	Provides for the management of forests to conserve special environmental, cultural, social, and/or scientific values			
	53	Provide for public involvement activities and public education, awareness, and extension programs, and make available forest-related information	orange	red	red
	54	Undertake and implement periodic forest-related planning, assessment, and policy review, including cross-sectoral planning and coordination	orange	red	red

Criterion		Indicator	Data status		
			Coverage	Currency	Frequency
	55	Develop and maintain human resource skills across relevant disciplines	🟠	🔴	🔴
	56	Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and to support forest management	🟠	🔴	🔴
	57	Enforces laws, regulations, and guidelines	🟠	🔴	🔴
	58	Investment and taxation policies and a regulatory environment that recognizes the long-term nature of investments and permits the flow of capital in and out of the forest sector in response to market signals, nonmarket economic valuations, and public policy decisions in order to meet long-term demands for forest products and services	🟠	🔴	🔴
	59	Nondiscriminatory trade policies for forest products	🟠	🔴	🔴
	60	Availability and extent of up-to-date data, statistics, and other information	🟠	🔴	🔴
	61	Scope, frequency, and statistical reliability of forest inventories, assessments, monitoring, and other relevant information	🟠	🔴	🔴
	62	Compatibility with other countries in measuring, monitoring, and reporting on indicators	🟠	🔴	🔴
	63	Development of scientific understanding of forest ecosystem characteristics and functions	🟠	🔴	🔴
	64	Methods to integrate environmental and social costs and benefits into markets, public policies, and national accounting systems	🟠	🔴	🔴
	65	New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies	🟠	🔴	🔴
	66	Enhancement of the ability to predict effects of human intervention on forests	🟠	🔴	🔴
	67	Capacity to predict effects on forests of possible climate change	🟠	🔴	🔴

KEY				
Notes on the rating system: This rating provides a general overview of the data supporting the indicators. Green means few gaps, orange means several gaps, red means no data or numerous gaps, and yellow indicates data that has been modeled.		**Data coverage**	**Data currency**	**Data frequency**
Data generally complete nationally, current, and reliable.	🟢	National	1997+	Annual to < 5-year periodic
Data may not be consistent nationally, slightly dated, and not measured frequently enough.	🟠	Regional or some national	1980-1996	5+ year periodic
Data is from inconsistent sources or is nonexistent, is more than 15 years old, or is partial, and has no consistent plan for remeasurement.	🔴	Varies or incomplete	Incomplete	One time or incomplete
Data is modeled	🟡			

Indicator 62. Capacity To Measure and Monitor Changes in the Conservation and Sustainable Management of Forests, Including Compatibility with Other Countries in Measuring, Monitoring, and Reporting on Indicators

Member countries: Argentina, Australia, Canada, Chile, China, Japan, Republic of Korea, Mexico, New Zealand, Russia, United States of America, and Uruguay

What Is the Indicator and Why Is It Important?

This indicator conveys information about the compatibility of measurement and reporting protocols among countries. Compatible protocols facilitate global and regional assessments, and they facilitate global dialog.

What Does the Indicator Show?

During the Montreal Process leading up to the Santiago Declaration, criteria and indicators were negotiated with enough ambiguity to enable countries to use their existing data. This flexibility works against the use of common protocols in data reporting. The lack of common protocols became apparent at a capacity-building workshop in Portland, OR (http://www.mpci.org/meetings/meetings_e.html). At this workshop, representatives of the Montreal Process countries worked to understand each other's protocols for reporting data for the following seven indicators: (1) extent of area by forest type relative to total forest area; (10) area of forest land and net area of forest land available for timber production; (19) area and percent of forest land, managed primarily for protective functions; (26) total forest ecosystem biomass and carbon pool; (44) direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment; and (61) scope, frequency, and statistical reliability of forest inventories, assessment, monitoring, and other relevant information. Findings of the workshop indicate that protocols among the 12 countries are generally not compatible for the 7 indicators. Findings from this case study suggest that much work would be involved in developing common protocols for all 67 indicators.

Indicator 63. Capacity To Conduct and Apply Research and Development Aimed at Improving Forest Management and Delivery of Forest Goods and Services Including Development of Scientific Understanding of Forest Ecosystem Characteristics and Functions

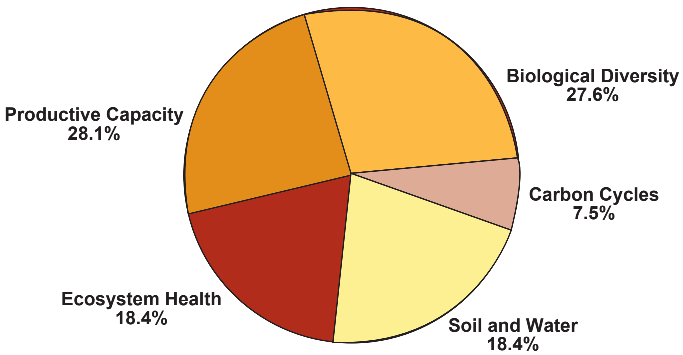


Figure 63-1. Total research and development capacity by criterion

What Is the Indicator and Why Is It Important?

This indicator is a measure of the capacity to understand the workings of forest ecosystems. This understanding is essential to the conservation and sustainable management of forest ecosystems.

What Does the Indicator Show?

Data in the review of capacity to conduct and apply research and development contained in the Data Report was used to estimate the capacity for development of scientific understanding of ecosystems. Of the 1,628 full-time equivalents reported to be working in teaching, research, and extension for criteria 1 through 5, more than one-half of capacity was in the area of biological diversity and productive capacity. Work on carbon cycles accounted for 7.5 percent of the total. The data includes estimates for the USDA Forest Service, forestry schools, and forest industry, and thus are not inclusive of all teaching, research, and extension efforts.

Until goals or other direction on desired distribution of capacity are in place, little basis will exist for judging the adequacy of the current distribution of effort. Until consistent trend-line information is available over time, little basis will exist for judging what has been happening to the allocation of teaching, research, and extension effort over time.

Indicator 64. Capacity To Conduct and Apply Research and Development Aimed at Improving Forest Management and Development of Methodologies To Measure and Integrate Environmental and Social Costs and Benefits into Markets and Public Policies, and To Reflect Forest-Related Resource Depletion or Replenishment in National Accounting Systems

What Is the Indicator and Why Is It Important?

This indicator assesses the ability to fully account for the costs and benefits of public and private decisions on forest resources. While information on traditional economic measures of forest market values is usually available, information on social and environmental values is often incomplete. Incomplete information may result in suboptimal decisions about forest management. Lack of such information in national accounting frameworks can result in a misleading portrayal of forest resources.

What Does the Indicator Show?

Numerous market and nonmarket valuation methods can be applied to forest resources to improve information on the broad array of costs and benefits. In addition to economic valuation techniques, other methods have been developed to measure resource values. In some cases, resource values cannot be easily characterized, and often a combination of measures must be employed to display consequences of management alternatives and policies on forest resources.

Efforts to expand the U.S. national income and product accounts to incorporate resource stocks and flows, environmental costs, and externalities were largely halted in 1994, when the work of the Bureau of Economic Analysis (BEA) was put on hold, pending an outside review by the National Research Council. The review was published in 1999. The panel concluded that most of the data and methods exist to construct forest accounts. The BEA, however, has not been authorized by Congress to resume work on this topic. The capability to reflect forest-related resource depletion or replenishment in national accounting systems is not available. Work in this area continues internationally, through individual country efforts and work by international organizations such as the World Bank and the United Nations.

Application of available methods is often limited by lack of reliable data on the physical quantities of the resource. Even if physical measures are clearly defined, data collection is often expensive. Also few standards exist for collecting data on quantities of nonmarket goods and services.

Indicator 65. Capacity To Conduct and Apply Research and Development Aimed at Improving Forest Management and New Technologies and the Capacity To Assess the Socioeconomic Consequences Associated with the Introduction of New Technologies

What Is the Indicator and Why Is It Important?

This indicator is a measure of the capacity to assess the effects of new technologies in a broadly defined forest sector on the socioeconomic structure in which the technologies are applied (e.g., employment in the forest sector or congestion caused by visitors). These effects may be important in the decisionmaking process concerning whether to adopt a new technology.

What Does the Indicator Show?

Technologies have evolved over time in all aspects of timber products production and use. New technologies enable the development and use of new equipment for recreation. Research is developing new technologies that affect the growth and management of the forest for timber and nontimber forest products. Case studies demonstrate the effects of technologies on employment and other socioeconomic measures of management in the forest sector.

Research aimed at assessing the socioeconomic consequences of new technologies in forestry has been carried out on a small scale for years, both in forestry departments in several universities and in United States USDA Forest Service Research and Development (R&D). Currently, the only USDA Forest Service R&D program conducting research related to this area is the Timber Demand and Technology Assessment Research Work Unit in Madison, WI. This research work unit conducts both case studies of individual technologies and assessments of the effects of technologies at an aggregate level.

Limitations of past research on the effects of new technologies in forestry are that wood products technologies have been the main focus, with very little attention given to forest management technologies, outdoor recreation technologies, and technologies affecting nontimber forest products. The main focus has been on economic efficiency effects rather than effects on social and ecosystem sustainability. In the U.S. economic system, strong market incentives are in place to keep the focus on economic efficiency.

Indicator 66. Capacity To Conduct and Apply Research and Development Aimed at Improving Forest Management and Enhancement of the Ability To Predict Impacts of Human Intervention on Forests

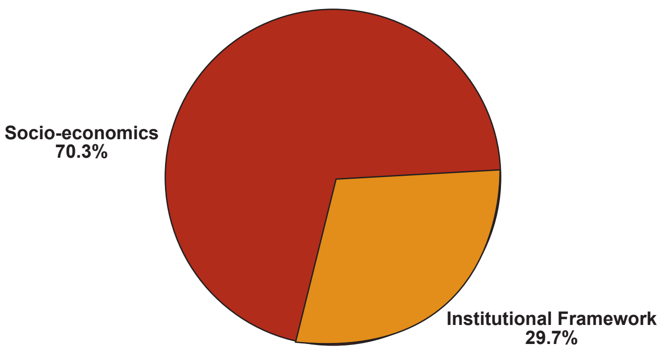


Figure 66-1. Total research and development capacity by criterion

What Is the Indicator and Why Is It Important?

This indicator is a measure of the capacity to predict effects of human intervention on forests. This understanding is essential to the conservation and sustainable management of forest ecosystems.

What Does the Indicator Show?

Data in the review of capacity to conduct and apply research and development contained in the Data Report was used to estimate the capacity for development of scientific understanding of ecosystems. Of the 559 full-time equivalents reported to be working in teaching, research, and extension for criteria 6 and 7, about 70 percent were in the socioeconomics area and 30 percent were in the institutional framework area. The data includes estimates for the USDA Forest Service, forestry schools, and forest industry, and thus are not inclusive of all teaching, research, and extension efforts.

Until goals or other direction on desired distribution of capacity are in place, little basis will exist for judging the adequacy of the current distribution of effort. Until consistent trend-line information is available over time, little basis will exist for judging what has been happening to the allocation of teaching, research, and extension effort over time.

What Is the Indicator and Why Is It Important?

Capacity to conduct and apply research and development to the problem of predicting climate change impacts involves the development of a good understanding of the impacts of climate change on forests and their disturbances such as pests and fire, the ability to quantify those effects on forest productivity, plant and animal species range shifts, carbon sequestration, water yield, forest health and changes in stand structure, and the ability to integrate impacts across the atmospheric, ecological, and economic systems. Improved understanding of climate change impacts will increase the capability to make better informed and earlier climate change mitigating actions, thus improving the likelihood that forests will be managed on a sustainable basis.

What Does the Indicator Show?

The United States Global Change Research Program, initiated in 1989, has prepared annual reports on the improvements in our knowledge of Earth's global-scale environmental processes and helped to identify and explain the causes and consequences of a series of global environmental changes, including ozone depletion and climate change. This program recently completed the first National Assessment of the Potential Consequences of Climate Variability and Change, which described the projected impacts of climate change and variability in the United States on a regional scale. Accomplishments of this assessment included compilation of 100 years of historical climate data made available for the wider community of scientists and the public through the Web, as well as projected climate for 100 years under two different climate scenarios. The results of ecological models describing the potential impacts of climate on species shifts and productivity were made available to the wider scientific community and public through the Web, and were used to explore the impact of climate change on the U.S. forest sector.

Improved modeling capability, and hardware and software technology, have increased the use of plot level forest inventory, soils, and land use data as realistic inputs to climate change impact models. This capacity enables a closer examination of the forest's current capacity to store carbon, as well as to produce wood products. Forest production studies have been enhanced by ecological research examining the nature of forest ecosystem processes as affected by climate, increasing atmospheric carbon dioxide, and nutrient cycling. Better data and knowledge on how climate affects disturbances and how forests respond to them would improve our modeling capability. There is a need to better analyze forest practices and community need to adapt to climate change. For example, integrated models of land use and climate are needed to project the interactions of these two influences on biodiversity at local and regional scales. Continued evaluation of climate change impacts is needed on a wide range of forest goods and services including water supply, carbon storage, non-wood forest products, timber, and recreation.

Concepts To Guide Interpretation

The introduction to this report describes the achievement of sustainability as a journey—an ongoing dynamic process rather than a static condition. Sustainability entails concurrent attention to three spheres of activity: environment, society, and economy. It requires environmental foundations to support economies and societies, economic performance for the sake of social well being and environmental conservation, and social institutions that help foster both the economy and the environment.

Achieving sustainability is a social and public endeavor. The relative emphasis placed on the three spheres of sustainability is based on shared understanding of conditions and trends among the three spheres, and also on shared societal values and goals. Data pertaining to indicators of sustainability must be understood and interpreted by citizens to enable discussions and decisions in the quest for sustainable outcomes.

Forests are complex systems in which many components (represented in this report by the various indicators) influence society's judgement about sustainability of forests. Figure 7 is one visual representation of sustainable forest management, framed in terms of the criteria and indicators. (Note that this formulation relies completely on the seven criteria and 67 indicators that are featured in this report. Using other component building blocks would create numerous opportunities for differently formulated models.) Outputs in the form of physical products, energy, and information flow among all the segments of this conceptual model as direct and indirect inputs and feedback.

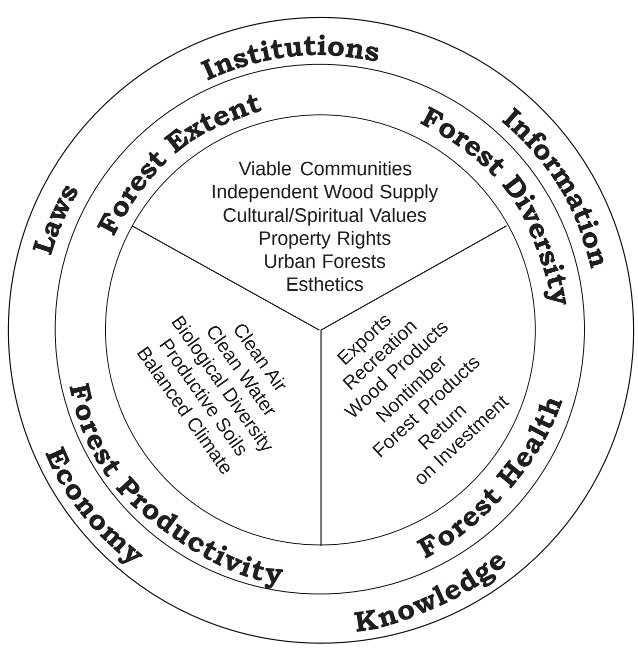


Figure 7. Conceptual model of sustainable forest management.

The outer ring of the model, which comprises the societal matrix of sustainable forest management (criterion 7 and its 20 indicators), includes the societal frameworks that inform, guide, and govern transactions related to the forest resource and its emergent goods and services. As described by criterion 7, this framework includes America's laws, institutions, economy, knowledge, and information. This framework also describes the patterns and bounds of our behavior regarding forests, including how we value them, use them, protect them, and manage them. The framework, therefore, directly influences the condition of the forest resource.

The middle ring in the model represents the forest resource itself—the natural capital that is the object of the societal framework, as well as the source of the outputs flowing to the inner circle. The criteria and indicators in the middle ring of the model are defined by the predominantly biophysical criteria 1 through 4 and parts of the socioeconomic criterion 6. (Note that some of the indicators of criteria 1 through 4 are not descriptors of this middle ring, but rather are representations of outputs—goods and services—that comprise the inner circle of this model.) The nature and condition of the forest resource reflect many natural evolutionary and biogeographic factors that exist almost independently of modern human intervention. For example, forests in the United States are predominantly temperate and boreal, rather than tropical; southern and northwestern forests are high biomass producers; and forests in the southern Appalachians and the Southwest are centers of great biodiversity.[33] These facts are not the result of society's decisions or influence. However, societal frameworks that we have instituted to govern and inform our behavior toward forests greatly influence and determine the nature and condition of many aspects of the forest resource. In other words, information and influences flow from the outer ring to affect the condition of the middle ring of the model.

The condition of the forest resource is reflected in information about the several indicators that describe the extent (criteria 1 and 2), diversity (criterion 1), productivity (criteria 2 and 6), and health (criteria 3 and 4) of the forest resource. The middle ring feeds back information that influences the specific content of the outer ring because our perceptions about the condition of the forest resource shape the societal framework that we institute to guide our behavior with respect to forests. In turn, the nature, extent, and condition of the forest resource directly affect the

[33] This report includes available data for all States, including Hawaii. Although Hawaiian forests are largely tropical ecosystems and not normally included in the Montreal Process, which focuses on temperate and boreal forests, data for Hawaii is included to provide as comprehensive a national report as possible.

degree to which our society can satisfy its needs and wants (reflected in the inner circle).

The inner circle represents society's needs and wants. In this visual representation of sustainable forest management, we divided the inner circle into three components that represent the environmental, social, and economic spheres of sustainability. We chose this representation to show explicitly that all three spheres must be sufficiently satisfied, simultaneously, to create a condition of sustainability. In terms of the criteria and indicators, the elements of the inner circle are defined by most of the indicators of criterion 6, all of criterion 5, and some of the indicators of criteria 1 through 4. These elements include the specifically valued economic goods that we extract from forests, the variety of goods and services that are obtained with or without explicit monetary transactions, conditions that satisfy diverse cultural and spiritual values, and ecosystem services that we deem as valuable, regardless of the lack of specific monetary valuations.

The manner in which we satisfy our needs and wants affects the condition of the middle ring of the model. Information is fed back to the middle ring through energy expended by society to manage and use forests. This feedback is most evident in extractive (or harvestable) goods. When these goods are removed, they directly change the condition of the resource. The effects can be short term or long term, with the possibility of indirect effects on aspects of the forest resource that are not harvested. Feedback also occurs to the middle ring from nonextractive uses of the forest resource (such as hiking and sightseeing), even though these influences are less obvious. The condition of the indicators of the inner circle also influences the outer ring because the degree to which we are able to satisfy our needs and wants for forest-related goods and services is ultimately reflected in the framework that we create to help ensure societal well being.

Although figure 7 shows a static picture of three concentric circles, it represents a dynamic system in which flows of products, energy, and information continually influence conditions and decisions.

The multiple, interacting spheres of activity and the multiple personal and societal values result in myriad interpretation possibilities. The interactions can lead to tradeoffs among components of the system that would be interpreted differently through varied value systems. An example of a tradeoff among the spheres of sustainability is with the biodiversity indicators of criterion 1 (such as the number of forest-dependent species) and several of the production and consumption indicators of criterion 6 (such as the volume of wood production). This tradeoff stems from the ecological principle of competitive exclusion, which states that no species proliferates except at the expense of other species (Ricklefs and Miller 2000). Czech and Krausman (2001) analyzed data linking economic activity to species endangerment and noted the tradeoff between economic growth and biodiversity conservation, as did The Wildlife Society in a recent technical review (The Wildlife Society 2002).

Another aspect of interpretation is reference values or reference conditions. Without reference values against which to gauge the condition of indicators or interactions among indicators, it is difficult to draw inferences about their significance. For example, if insects and pathogens are endemic to forest ecosystems, when does an infestation or outbreak cause a forest health problem to the point at which it adversely affects biodiversity, productive capacity, soil and water, carbon sequestration, or socioeconomic benefits? The selecting of reference values is a normative process that influences how we evaluate tradeoffs and other interactions among the threes spheres of sustainability, among criteria, and among indicators.

At the current time, there is little consensus about how to assess forest sustainability in light of these complexities. Therefore, this section is intended to stimulate dialog about interpretation and assessment rather than offer a particular interpretation of the data leading to a singular conclusion about forest sustainability. We rely on the general concepts of sustainability because they are widely accepted, whereas more specific approaches for judging sustainability depend on individual values and context. These general concepts suggest that sustainability entails (1) meeting the current needs of society, (2) preserving opportunities for future generations to meet their needs, and (3) working within the limits imposed by the natural systems on which we depend.

These three basic concepts are the backdrop for interpreting information about the indicators of sustainability. A concept that guided the production of this report is: "better data lead to better dialog, which leads to better decisions." This reflects the belief that most decisions in our society are not based directly and solely on data. Instead, they are based on shared understandings of the workings of the world with respect to shared values and goals. Data must be understood and that understanding must be widely distributed to affect the many decisions made throughout our diverse society.

The first step in this process is obtaining better data.

Summary of the Data

The following pages present brief findings derived from the indicator data within each criterion. The intent is to provide in one place a condensed summary of the data to enable the process of interpretation and dialog.

Criterion 1: Conservation of Biological Diversity

What Is This Criterion and Why Is It Important?

Criterion 1 addresses the capacity of forests to support their inherent complement of biological diversity. Biological diversity has been defined as "...the variety of life and its processes..." which encompasses "...the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur..." (Keystone Center 1991). We rely on the diversity of life to satisfy many needs and wants of our modern civilization. Many of the goods that are harvested and traded in the human economy are a direct product of the biological diversity within ecosystems (Dailey 1997). Biological diversity also benefits humans by maintaining important ecosystem functions (Risser 1995; Naeem et al. 1999) and providing recreational opportunities, spiritual enlightenment, and intellectual stimulation (Postel and Carpenter 1997).

Because intensive use of natural resources can stress ecosystems to a point at which their ability to function fully is compromised (Rapport et al. 1985; Loreau et al. 2001), it has been argued that the human enterprise may be jeopardizing the continued existence of some ecosystems (Vitousek et al. 1997; Wackernagel et al. 2002). Because we are conscious of these effects, we realize a responsibility to take actions to sustain the Earth's biodiversity for both pragmatic and altruistic reasons.

Land use intensification to meet human needs has led to dramatically elevated extinction rates (Pimm et al. 1995) and to lower biodiversity within managed ecosystems (Rapport et al. 1985). Because the pattern of decreasing biological diversity with increasing land use intensity appears consistently across a variety of habitats (including forests), changes in biological diversity represent indicators of ecosystem health (Costanza 1992), ecological integrity (Karr 2000), and sustainability (Goodland 1995).

What Are the Indicators and How Do They Relate to One Another?

Of the nine indicators for monitoring the status and trends of biological diversity, five track the status of ecosystem diversity, two track species diversity, and two relate to genetic diversity. The nine indicators comprising this criterion interact in an ecologically logical fashion. The first five indicators describe the kind, amount, and arrangement of forest habitats, which when taken together, provide a measure of the capacity of forest habitats to provide for organisms and essential ecological processes. An element of habitat capacity affecting both the amount and arrangement of forest habitats is the degree of protection that society has afforded to the various forest types (indicators 3 and 4).

The other four indicators document the distribution and abundance of species within those habitats—all four of which are influenced by the five indicators of habitat capacity. The geographic range occupied by a species (i.e., its distribution—indicator 8) and its population trend within that range (i.e., its abundance—indicator 9) are directly affected by the amount, arrangement, and protection status of forest habitats. Severe reductions in the distribution and abundance of species lead to increases in species rarity (indicator 7). If such declines continue, species eventually become extinct, resulting in the loss of species from the system (indicator 6).

Because the first five "leading" indicators of habitat capacity partly determine the "trailing" indicators of species distribution and abundance, early signs of nonsustainable resource use might be observed first among the indicators of habitat capacity, followed by those indicators that document shifts in species range and population size. A failure to recognize and respond to these early warning signs is ultimately documented by the loss of forest-associated species.

Major Findings for This Criterion

Even though significant data gaps prevent a comprehensive treatment of the nine indicators of biological diversity, the available data does permit a preliminary assessment of the biodiversity status in the United States that can serve as a basis for future comparisons. The data for the indicators of criterion 1 documents some evident changes in biodiversity. These changes include shifts in the amount and spatial arrangement of forests, and changes to the distribution, abundance, and extinction risk among forest-associated species.

The total forest area in the United States is about 749 million acres. Before European settlement in North America in the 17th century, the area of forest is estimated to have been slightly more than 1 billion (1,000 million) acres. The difference of about 250 million acres represents a permanent reduction in forest area that is no longer available to support forest species. Most of the reduction in the area of forest is in the eastern half of the country.

Nationally, the overall area of forest in the United States has remained approximately the same since the early 20th century, although there have been continuous shifts among land uses in different regions of the country that have marginally altered the location of forests. Although the total area of U.S. forest land (749 million acres) has not changed much in the past century, there have been changes in some major forest types in the past 25 years as a result of management regimes (such as grazing, fire suppression, and timber management) that favor certain forest types. None of the major forest types is at risk of being lost from the mix of forest types that comprise the U.S. forest ecosystems.

Over the past 50 years, the area of nonstocked forest land (timber land less than 10 percent stocked with live trees) has decreased, while the area with large trees has steadily increased. The occurrence of late successional forests of all forest types is well below the pre-colonial proportion. Today, about 7 percent of eastern "timber land" forests are in the 100-year-or-older age-class. Only scattered remnants of very old eastern forests remain in a few parks and other reserves, such as Great Smoky Mountains National Park. In the West, approximately 15 percent to 20 percent of timber land forests are in the 100-year-or-older age-class. For all forests in the West (timber land plus other less-productive forests), the proportion of older forests is probably somewhat higher than 20 percent because of forests that have been reserved in wilderness areas.

Overall, about 14 percent of forest land (106 million acres) is in a protected category. A large proportion of western forest land is protected, typically by Federal ownership, but a much smaller proportion of eastern forest land is protected, making private protection more important in the East. While most forest types have 5 to 20 percent of their total area protected, lodgepole pine and hemlock-Sitka spruce have large proportions (50 percent) protected, and loblolly-shortleaf pine and elm-ash-cottonwood types have small proportions (2 percent) protected.

Fragmentation, which refers to the spatial arrangement of existing forest, is determined mainly by local economics, urban growth, roadbuilding, land ownership, and land uses. One way to look at fragmentation of forests is to consider how much forest area is remote from other kinds of land cover. According to the 1992 data based on satellite imagery, about half of the current fragmentation is associated with perforations in forest land cover that are so pervasive that about half of the continental U.S. forest land is within 100 meters of forest land "edge." At the same time, most forest lands exist in or near the boundaries of large (>12,500 acres) forest land patches, and are well connected and close to other forest land patches. In terms of largely uninterrupted forest areas, about half of all points in the forest are surrounded by at least 5 acres of unfragmented forest, and about 1 percent of all points in the forest are surrounded by at least 1,500 acres of unfragmented forest.

The forest habitats of the United States support a diverse set of animal and plant species. We obtained data on the distribution and conservation status of 689 tree species and 1,486 terrestrial animal species associated with forest habitats. Much of this diversity is concentrated in the Southeastern and Southwestern United States because of a variety of ecological and biogeographical factors predating modern intensive human influence. Declines in forest bird richness since 1975 are found primarily in the Eastern United States, while increases are found primarily in the West. Among trees and terrestrial animals associated with forests, 15 percent are considered to be imperiled or vulnerable to extinction, with most of these species concentrated in the Southeast, on the west coast, and in Hawaii.

Most forest-associated species currently occupy a large proportion of their former range (as measured by presence or absence within the 50 States). Of the species that occur in less than 80 percent of their former range, most are mammals (5.7 percent of the taxon), followed by amphibians (2.3 percent) and birds (1.4 percent). This pattern of range contraction among forest-associated birds is mirrored in recent abundance trends. Over the last three decades, populations of about a quarter of the forest-breeding birds have declined, a quarter have increased, and nearly half showed no evidence of a trend. Species with declining trends occurred more frequently in the Southeast, while species with increasing trends tended to occur in the north and Rocky Mountain regions. The majority of tree species or tree species groups showed increases of more than 50 percent in number of stems more than 12 inches in diameter between 1970 and 2002.

Unequivocal interpretation of what the trends among these nine indicators mean to sustainable forestry in the United States is difficult. On the one hand, forest habitats in general appear to be stable over recent decades. On the other hand, substantial proportions of some forest-associated taxa are at risk of becoming extinct. The former suggests that forest habitats are being used in a manner that is sustainable in the long term. The latter suggests that forest habitats are being lost or used in ways that are incongruous with maintaining the species composition of forest ecosystems. Resolving these conflicting interpretations will only be possible when we better understand the relationship between the indicators and notions of sustainability.

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

What Is This Criterion and Why Is It Important?

Criterion 2 specifically addresses the capacity of the forest to produce extractive goods and services. The nature of the goods and services provided will change over time as a consequence of changes in social and economic demands, technology, and management actions taken in the forest to affect production of these goods and services (criteria 6 and 7). The nature and degree of changes in criterion 2's five key indicators and the factors that account for variations in their representation of productive capacity are examined here.

Forests provide human society with many commodities that either are essential for survival or contribute to enhancing quality of life. Forests are made up of trees, other plants, animals, and other organisms that can be harvested repeatedly if the productive capacity of the forests is maintained sufficiently. If the productive capacity of the forest is exceeded, there is the risk of ecosystem decline.

What Are the Indicators and How Do They Relate to One Another?

Of the five indicators used for monitoring the productive capacity of forest ecosystems to produce extractable commodities, the first four track measures related to status and trends in forests available to supply wood (Smith et al. 2001). The fifth indicator addresses trends in nontimber goods and services of the forest, such as medicinals, food and forage species, floral and horticultural species, resins and oils, materials used in arts and crafts, and game animals and fur bearers (Alexander et al. 2002). Measures for all five indicators are restricted in this report to the forest deemed available to supply them.

The five indicators comprising this criterion interact in a logical fashion within and across the criteria. The structural and functional elements of productive forest ecosystems are dependent on a contiguous ecosystem or ecosystems of a certain minimum size. To have harvestable goods and other services from forests, first and foremost there must be forests. To sustain harvests continuously, forests must be sufficiently productive to grow the raw materials in excess of the demand for removing them. Criterion 2 concerns the fundamental biological capacity of forests to renew, grow, and produce the range of things that humans need and want to remove from the forest for their own use. Because some of the goods that people remove from forests are also the fundamental elements that define a forest (specifically trees, but also other associated flora and fauna), this criterion is also an overall indicator of the basic health of the forest system. Changes in productive capacity could be a signal of unsound forest management or unforeseen agents affecting ecosystems that might reduce the ability of the forest to maintain biodiversity, ecosystem health, or soil and watershed protective functions. In general, the productive capacity of a forest ecosystem is related to its resilience to disturbance and stress, whether caused by humans or nature.

Two fundamental factors determine the productive capacity of forests for harvestable goods: (1) the amount of forest land and (2) the quantity of the producing organisms that exist on the forest land. As a generalization, more forest overall means more productive capacity for forest goods. The greater the per-unit-area productivity (health, vigor) is, the greater the productive capacity for harvestable goods will be.

The notion of availability of forest (for extractive use) as put forth in this criterion is somewhat problematic. Knowledge of the availability of forest land to provide desired goods and services is a critical measure of the balance of forest ecosystems relative to potential end uses. Within the context of this report, forest available for timber production or other extractive use is assumed to be the area of "timber land." The diverse nature of the management objectives and planning guidelines for the Nation's forest owners, however, makes it difficult to summarize the actual area of forest available for extractive use in a single value at a single point in time, much less consistently over time. In the United States, about 10 million private forest landowners own a total of 291 million acres of timber land (Birch 1996), five Federal agencies manage a combined 109 million acres, State governments manage 29 million acres, counties or municipalities manage 8 million acres, and forest industries own 66 million acres. The amount of the area adjustment required to determine the actual availability of timber land related to extractable resources will depend on the ownership mix and the management constraints in place at the time of analysis. While this definition of available forest land provides a generous estimate of extractable resources available at a given point in time, it also enables analysts to apply information about ownership or other caveats to adjust a value that can be easily measured in a reliable and consistent manner over time.

In general, the meaning of productive capacity for nontimber forest products is unclear, and ecosystem sensitivity to management and harvest is largely unknown. Except locally or anecdotally, annual or periodic harvest of these products is largely undocumented, particularly on private forest lands, although it is understood that such activity occurs and influences forest ecosystems. There is an immediate need to (1) compile existing life history information on key products; (2) develop life histories where information is missing; (3) choose several key products based on ecological sensitivity or economic and social importance to test inventory and monitoring protocols; and (4) develop pilot studies to measure both biologically and socially sustainable levels of harvest using the concepts of population biology, social science, economics, and ecology. Future efforts should focus on identifying and measuring extraction of nontimber products to understand sustainability at regional levels and develop ways to summarize data at the national level.

Major Findings for This Criterion

Criterion 2 has perhaps the most complete suite of available data for analysis, but many large gaps remain. For example, indicator 14 suffers from the lack of a consistent national approach to identify and monitor nontimber forest products. Subnational data is reported by five major reporting regions.

The total forest land area of the United States has been stable over the past 100 years and currently stands at 749 million acres. Forest area currently defined as available for timber production (or timber land) stands at 504 million acres (67 percent of all forest land). In the East, about 94 percent of the forest is potentially available for timber production, and in the

West, about 40 percent is potentially available. The forest area excluded from timber land (i.e., unavailable for timber production) is in parks and other protected areas or forests deemed insufficiently productive to provide commercial timber products consistently.

While the overall area of timber land has been stable, the area by forest types (Eyre 1980) has been changing. As a result of active management or natural events, species composition of all forests changes over time. Generally, as forests mature, pioneer species (e.g., aspen, lodgepole pine) are naturally replaced by successor species (e.g., oaks, hickories, maples, firs), as critical light needed for regeneration on the forest floor is reduced and other flows of nutrients and energy change. Other factors such as fire suppression or fire use and other active human management, such as planting and harvesting, can produce concomitant changes. While the data presented in this criterion does not show the complexity of the plant communities within each type, they allow a coarse estimate for connecting to other indicators such as measures of biodiversity. Throughout the Eastern United States, there was a clear decline between 1977 and 2002 in early successional forest types, such as aspen (down by 12 percent) and fir (down by 19 percent), and an increase in mid- to late-successional types, such as oak-hickory (up 18 percent) and maple-beech-birch (up 40 percent). In the North, there has also been a sharp loss in elm-ash-cottonwood forests, declining nearly 38 percent. This decline is generally associated with increased flood control, construction of reservoirs, and agricultural clearing of bottomland forests. In the West, a similar scenario has played out as lodgepole pine declined 12 percent, while fir-spruce forests increased 22 percent since 1977. Western white pine and larch recorded large proportional losses of 20 and 52 percent respectively since 1977, although actual acreages are small.

One method of increasing timber productivity on the available forest land base is through plantations and intensive timber management. In 2002, there were 42 million acres of plantations in the United States, consisting predominantly of pine species in the South, which has 37 million acres or 88 percent of the total plantation area. While constituting only 7 percent of the total forest area, plantation acreage has increased steadily in the United States for more than 50 years and is expected to continue to increase. Currently, more than 2.5 million acres are planted annually (USDA Forest Service 2000), and virtually all plantings are of native species (TBFRA 2001).

While the forest land base has remained constant in recent times, the per-unit-area part of the productive capacity equation has increased. In broad terms, this means that U.S forests are keeping up with and exceeding the demands that are being made on them to harvest wood products—i.e., growing more wood than is being harvested. Growing stock volume on timberland shows an increasing trend, and at 856 billion cubic feet, it is 39 percent higher than the 616 billion cubic feet reported in 1953. Net growth on timberland continues to exceed harvest removals, although the gap is narrowing in the South where a volume equivalent to 88 percent of the net growth is removed annually. The South supplied 63 percent of all U.S. domestic harvests in 2002, an increase from 49 percent in 1953. In the South, timber land represents 94 percent of the total forest area. On public lands in the West, where timber harvesting has been sharply curtailed in recent years, harvesting has declined 70 percent from 2.4 billion cubic feet (14.5 percent of the domestic total) in 1987 to 729 million cubic feet (4.6 percent of the domestic total) in 2001. Overall in the West, harvest removals are currently 45 percent of net growth.

Major gaps in monitoring nontimber forest products have made analyses largely anecdotal. Current approaches include analyses and summaries of the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) permit data, industry surveys, USDA Forest Service Sales Tracking and Reporting System (STARS), Harmonized Tariff Code data, State and Federal game harvest information and biological population function estimates, and other data sources and analyses at regional or local levels. Although for some industries, locations, and species these analyses may be reasonably comprehensive, the majority are incomplete and do not represent the full range of products.

Available data for nontimber products indicates that over the past 20 years, big game hunting is increasing, and the use of medicinal plants has experienced an expansion exceeding that of any other nontimber native flora. Indeed, demand for medicinals has prompted protective measures in some locales. Over the past two decades, small game and migratory bird hunting has declined. Fur harvests declined 85 percent between 1980 and 1991, representing a decline in demand rather than in available supply.

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

What Is This Criterion and Why Is It Important?

Criterion 3 concerns our ability to maintain healthy forest ecosystems. Humankind depends on healthy ecosystems to provide all the essentials of life—oxygen, water, and food. We depend on forests to provide us with materials to satisfy our fundamental need for shelter and numerous other goods that enable our standard of living in the United States. The healthier the ecosystems, the more goods and services they can make available for harvesting and use by an increasing human population. This criterion is fundamentally important because healthy ecosystems support healthy humanity.

This criterion is also important because it influences other aspects of forests to contribute to sustainability. Healthy forests are essential to maintaining biodiversity (criterion 1), productivity (criterion 2), soil and water (criterion 4), carbon cycles (criterion 5), and socioeconomic benefits (criterion 6). In turn, the capacity for healthy forest ecosystems is affected by the overall area and nature of forests and associated flora and fauna (criterion 1), the productivity of forests (criterion 2), the condition of the soil resource (criterion 4), the uses we demand from forests (criterion 6), and the institutional framework that guides how we manage and use forest resources (criterion 7).

The indicators of criterion 3 are measures of problems, damage, or potential damage. Forests have always been affected by insects, disease, fire, and other distrubances. Indicator 15 suggests that these processes or agents may become problems when they affect forests beyond the range of historic variation. The wording of indicators 16 (air pollution) and 17 (diminished biological components) offers no guidance in interpreting the findings in terms of forest ecosystem health and vitality.

This criterion includes stressors that are known to affect forest ecosystems and key ecological processes in forest ecosystems that have been affected. Long-term standardized monitoring of the metrics within each indicator is critical to providing necessary information on the stressors that impinge on forest ecosystems and to determining whether the stressors are of a sufficient magnitude or duration to alter key ecological resources.

What Are the Indicators and How Do They Relate to One Another?

Criterion 3 contains three broad indicators. Indicator 15 addresses many of the known biotic and abiotic stressors (with the exception of air pollution) that have caused negative effects on forest ecosystems. Notable stressors include land clearance, insects and pathogens, exotic species (insects, pathogens, plants, animals, etc.), storms, and fires. Indicator 16 addresses specific air pollutants (oxidants, acidifying ions, fertilizers, and climate-altering chemicals). Indicator 17 addresses whether the stressors in indicators 15 and 16 are of a sufficient magnitude to alter key ecosystem processes.

Generally, the interactions among these and other indicators are relatively direct, because both indicator 15 and indicator 16 include stressors, acting separately, additively, or even synergistically with each other to affect key ecological processes (indicator 17). The biotic and abiotic stressors are direct threats to forest health and sustainability. Air pollution can also directly affect forest health, and air pollutants can increase the susceptibility of forest systems to biotic and other abiotic stressors.

The approach to analyzing indicators was to provide an interpretation of pivotal phrases for each indicator; for example, 'affected,' 'historic variation,' 'subjected to specific air pollutants,' 'diminished biological components,' and 'fundamental ecological processes'. Historic variation regarding exotic species, for instance, is very direct because we know those species were not present in earlier times. Native insects and pathogens by definition have existed since pre-colonial times, so we must make some inferences about what their historic variation was. If we have no idea of historic variation, then we have to employ some alternative method for identifying reference times or areas to determine where native insects and pathogens are causing abnormal amounts of damage and mortality.

Major Findings for This Criterion

A variety of influences has affected forest conditions throughout the evolutionary history of trees and forests. Forests are adapted to endemic levels of insects and pathogens that periodically become epidemic and then have a greater effect on the condition of the forest. Even these greater effects recede with time. Periodic extremes of weather or long-term shifts in climate are also natural occurrences to which forests are adapted in a variety of ways. Insects, pathogens, and weather are all part of normal ecosystem function that include the weakening, death, recycling, and replacement of trees and forests. When these normal processes interfere with human use of forests, the condition is considered damaged or unhealthy.

Since the 19th century, humans have had considerable influence on the health of forests in the United States—they introduced nonnative insects, disease agents, and invasive plants; used forests and suppressed fires; and, as a result of industrialization, contributed to land clearing and air pollution.

Native insects and pathogens are normal components of forest ecosystems, providing important activities such as thinning stands that are exceeding the carrying capacity of the site and removing trees damaged by storms and other natural causes. When native insects and pathogens reach epidemic proportions more frequently, or enter areas previously out of their range, however, they can become a negative influence on forest ecosystems. Similarly, fire is an essential component of all forest ecosystems, and provides many beneficial effects when it occurs within normal cycles of frequency and severity. Alteration of historic fire regimes (indicator 17) often causes serious changes in forest ecosystem processes, resulting in unusually intense, large fires that then again alter many key processes. Exotic species, unusually severe weather events, forest conversion activities, and climatic changes (addressed in indicator 16) also negatively affect forest ecosystems and can cause long-term to permanent changes in forest ecosystems.

Several introduced, nonnative pests have had wide-ranging negative effects on forest health. Chestnut blight and Dutch elm disease have eliminated two major tree species (American chestnut and American elm) from eastern forests, causing a general degradation (although by no means a collapse) of those ecosystems. White pine blister rust has steadily spread throughout the East and West to affect all the five needle pines in the United States. It has changed the way eastern and western white pines are managed, and it is disrupting ecosystem function wherever the susceptible tree species are components of the forest. Gypsy moth has caused periodic defoliation and death of trees over huge areas of eastern forests, and it continues to spread into new areas of broadleaved, deciduous forests, altering the composition of the affected forests. Kudzu, tree of heaven, and empress tree are three examples of introduced plants that kill or replace native trees in eastern forests, again causing a general degradation of the forest ecosystems. Although these damaging agents have been affecting forest health for the better part of a century, new agents that reduce forest health continue to be introduced as a result of ever-increasing global commerce. Some recent introduced pathogens and insects that are damaging trees or forests include dogwood anthracnose, Sudden Oak Death disease, European pine shoot beetle, and Asian longhorned beetle.

About a dozen native insects or diseases have an ongoing effect on the health of varying areas of forests, with many of them (including southern pine beetle, spruce beetle, fusiform rust, western spruce budworm, and mountain pine beetle) causing forest health problems during the latter part of the 20th century that have exceeded normal levels. The occurrence, severity, and spread of these damaging agents can be affected (either positively or negatively) by management activities. Active timber management can sometimes promote forest health and reduce damage by enhancing the overall vigor of trees in a forest or by changing the forest composition. On the other hand, management can sometimes alter the species composition of a forest in a way that makes the forest more susceptible to an insect or disease outbreak. Management that precludes natural processes or avoids timber management and favors preservation of forest for other purposes can alter species composition and create more dense or less vigorous forests that are conducive to some damaging agents

Air pollutants that affect forest health and that are currently of greatest concern fall into three broad categories: (1) acidifying agents (nitrates, sulfates, and other anions), (2) fertilizing agents (N-based compounds and cations), and (3) oxidizing agents (primarily ozone). Ultraviolet-B (a form of radiation from the sun) is also a related agent of concern because of decreases in the protective stratospheric ozone by chlorides, methane, and other gases; little data is currently available to evaluate the intensity with which it is affecting forested ecosystems.

Undoubtedly, forest ecosystems are exposed to elevated levels of air pollutants, although the level of exposure and the specific pollutants vary by region. Sulfur and nitrogen deposition (in the form of "acid rain") occurs in the North and South, while exposure to ozone is greatest in the South and on parts of the west coast. Great uncertainty still exists about widespread effects of air pollution on forest ecosystem health. Observable damage is rare, except for ozone damage in some localized areas. The most likely possibility of broad area effects is from changes in soil chemistry from acid rain. The effects of air pollutants on water resources are not covered in this indicator.

Globally, the period 1996 to 2000 was part of the warmest decade (1991–2000) in the historical record, and 1998 was the warmest year since 1861. Although this observation suggests that temperatures in U.S. forests have exceeded both the ranges of historic and recent variation, no current data specifically addresses whether climate change has measurably altered forest ecosystems.

Indicator 17 evaluates the response of forest ecosystem processes to stressors discussed above. Because it is difficult or impossible to directly evaluate ecosystem processes on large spatial scales, biological components serve as surrogate measures of the processes. Thus defoliation gives a measure of the key process of photosynthesis and carbon fixation since the amount of foliage is related to the amount of carbon that can be fixed. Similarly, mortality volumes are related to key processes such as reproduction and seral development. Changes in ecological condition from altered fire regimes affect many ecological processes.

The evaluation of this indicator suggests that defoliation is a problem in the North and South, with annual increases in the defoliation index between 0 and 1.5 units. Changes in historic fire cycles affected all regions, with moderate (condition 2) to substantial (condition 3) changes in historic fire regimes affecting large areas.

Fire is sometimes a damaging agent that adversely affects forest productivity with respect to human values. During much of the 20th century, fire prevention and fire suppression greatly reduced such damage that had formerly occurred on vast areas of southern and western forests. Such management preserved forests for many desirable uses and contributed to the increasing timber productive capacity of forests throughout the United States, as reflected in the timber area and volume statistics reported in criterion 2. Precluding fires from forests that are naturally adapted to relatively frequent fires (especially many southern and western pine forests), however, has resulted in forests with altered species composition and increased density of trees per acre. These changes have created increased fuel loads and other conditions that are conducive to large, high-intensity fires, as reflected in increasing annual burned acreage in many years since the 1980s.

The absence of fire from many forests for nearly 100 years has exacerbated forest health problems from dwarf mistletoe in many western forests, oak decline in the Ozark and Ouachita Mountains, mountain pine beetle in western pine forests, and western spruce budworm in Douglas-fir and true fir forests in the West. Thus, a highly successful management action that enhanced some aspects of forest health for many decades has led to the unintended consequence of reducing overall health on vast areas of forest lands.

Two side-effects of industrialization and population growth—urban sprawl and air pollution—have had varying effects on the capacity to maintain healthy forest ecosystems. Urban sprawl is moving high-impact development and other human influences directly into forests on millions of acres in the East and West. This incursion of humans fundamentally changes the nature of forest ecosystems, diminishing the ability to maintain capacities for biodiversity (criterion 1), commodity productivity (criterion 2), ecosystem health, and some aspects of socioeconomic benefits (criterion 6). At the same time, this movement of people into the forest provides directly for some other socioeconomic benefits that humans seek from the total landscape.

Criterion 4. Maintenance of Soil and Water Resources

What Is This Criterion and Why Is It Important?

Criterion 4 addresses the conservation of soil and related aquatic ecosystems. Productive, stable soil and clean, abundant water are fundamental elements of healthy humanity. Cyclic relationships exist between soil and water resources and forests. Soil is the foundation for trees and most other plant life of the forest, providing the medium in which the plants grow and supplying essential nutrients for plant metabolism. Water is an essential plant nutrient and a regulator of many plant physiological processes. Sound, healthy forests, in turn, protect, stabilize, and build soils. Forests also capture water as precipitation, store the water in forest soils, and release water to streams, rivers, and lakes in controlled regimens that reduce floods, erosion, and sedimentation. Forests are the source of well-distributed, clean water to countless other biota and to human society. Thus, soil and water resources are both an input to forest systems and an output of those systems.

The basic properties of soil systems are derived from a combination of the underlying rock, topography, and climatic factors. Thus, forest types and their associated soils differ greatly in their inherent fertility and sensitivity to erosion, compaction, acidification, and accumulation of toxic substances.

Precipitation falling on forests enters streams and rivers through surface and ground water flows, and consequently, the condition of the forest, particularly the soil system, is a primary determinant of the condition of the waters. The primary concerns are with water quality and the amount and timing of flows, the physical and chemical condition of the water, and aquatic biological diversity. Water condition, therefore, is a major factor in the overall biodiversity of forest ecosystems.

Our ability to report on these indicators on a regional or national scale is quite limited, especially regarding trend information. Much information is site specific or anecdotal in nature.

What Are the Indicators and How Do They Relate to One Another?

Of the eight indicators of the capacity to maintain soil and water resources, indicator 19, is plainly defined as an "input." That indicator tracks the area of forest that is managed specifically to protect or enhance soil, water, and related outputs or desired conditions. The other seven indicators of this capacity represent outputs of the forest system and are framed in terms of damage or degradation in the soil and water resources. We needed to identify and interpret these indicators by defining terms such as "significant," "historic," "primarily," and "relevant chemical properties." We compared current erosion, compaction, soil organic matter and chemistry, and accumulation of toxic compounds from 1997–1999 Forest Health Monitoring and Forest Inventory and Analysis programs to the Natural Resources Conservation Service (NRCS) estimates of the same indicators compiled in 1994.

The soil indicators interact with the water indicators. Relatively few forest lands are managed primarily to protect soil and water systems; soil erosion, compaction, fertility, and toxin accumulation levels may exceed historic conditions, with subsequent effects on associated aquatic systems. Soil erosion, compaction, and low soil organic matter (SOM) affect the timing and flow of aquatic systems; the chemistry, SOM, and any accumulated toxins in soils can affect the water's physical (sedimentation) and chemical (dissolved oxygen, electrical conductivity, and pH) properties. Ultimately, these combined attributes of the soil and water systems determine the biological diversity of the aquatic systems.

Water temperature (T) is an important aspect of aquatic habitat and influences metabolism, behavior, and mortality of aquatic species. Dissolved oxygen (DO) is essential for most aquatic life, and fish kills are often linked to reduced DO or pH. Electrical conductivity (EC) represents the amount of total dissolved salts (ions) in the water. The pH of a water sample measures the concentration of hydrogen ions and determines the biological availability of nutrients and heavy metals. Sediment (SED) is composed of finely divided solid particles that are transported by wind, water, or ice and deposited in water.

Soil organic matter and chemical properties are important regulators of the nutrient cycling, biological, and physical properties of soils. Soil organic matter is critical for retaining nutrients and moving air and water through the soil; and SOM is a major reservoir of carbon.

The modeling approach used in this analysis was developed for use in agricultural systems and does not account fully for forest management practices. In regions with a well-developed forest floor and no recent disturbance, actual rates of erosion may be significantly lower than portrayed in this analysis. In contrast, sites that have been harvested and mechanically prepared may have higher soil erosion rates. To compensate for those and other potential limitations with the model (detailed in the Data Report), modeled data is presented as relative values.

Major Findings for This Criterion

In general, undisturbed forests are associated with low levels of soil erosion and soil compaction and with high levels of water yield and quality. Nationally, models indicate that erosion rates are low on undisturbed forest lands, with the majority of measured forests predicted to have erosion rates of less than 0.1 ton per acre under normal climatic conditions. Even with the uncertainty associated with erosion models, these estimates are one to two orders of magnitude smaller than rates from cultivated cropland, which is by definition disturbed and exposed for part of the year. More than 65 percent of sampled forests had their soil surface protected (covered) by vegetation or forest floor litter that covered more than 95 percent of the soil surface. Likewise, initial estimates suggest that evidence of surface compaction resulting from disturbance is localized with fewer than 1.6 percent of sampled forests showing evidence of compaction on 50 percent or more of the soil surface. Where human activities directly disturb forest cover and the soil, erosion and compaction can be much greater on a local scale. Statistics do not exist, however, to quantify these effects regionally or locally.

Although we do not have nationally summarized statistics, we do know that many forest areas are managed specifically to serve in a protective capacity that at least partially meets the intent of maintaining the soil and water resources. These areas include national parks, national monuments, national wildlife refuges, and formally designated wilderness areas. In all of these forest areas, the goal is to protect most of the forest from disturbance that would expose the soil surface, promote erosion, or increase direct runoff of water (rather than percolation into the soil). Some metropolitan areas (including New York City, NY, Denver, CO, and Portland, OR) also have large designated municipal forested watersheds that are managed to enhance water flow and quality and to minimize soil compaction and erosion. The oldest specially designated forest area in the United States, the Adirondack Preserve, was created (and still exists) to preserve watershed function for the sake of providing continuous supplies of high-quality water to human settlements.

Ten percent of the watersheds measured before 1940 had decreased minimum flow rates and 25 percent had increased minimum flows compared with post-1940 measurements. Similarly, 5 percent of the watersheds had lower maximum flow rates and 25 percent had higher maximum flow rates. Most watersheds have not experienced changes in their maximum or minimum flow rates since the first half of the 20th century. Where changes in flow rates have been detected (about 30 to 35 percent of watersheds), most increases in flow rates were found in the East and most decreased flow rates were found in the West. In terms of chemical water quality, at least 10 percent of forested counties had watersheds that deviated enough from average chemical concentrations to indicate possible local degradation of some aspect of water quality.

Generally, high T, low DO, high EC, low pH, and high SED are indicators of major problems affecting aquatic systems. Each region had more than 10 percent of forested counties in poor or bad condition. The biggest issues in the West were DO (winter), T (winter and summer), and SED. The biggest issues in the North were T (winter and summer) and EC. The biggest issues in the South were DO (winter), T (winter and summer), EC, pH, and SED.

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

What Is This Criterion and Why Is It Important?

Many scientists believe that increasing concentrations of certain types of gases in the atmosphere are leading to long-term climate change (IPCC 2001). Carbon dioxide and other carbon gases are key regulators of the Earth's climate. In general, more carbon dioxide in the atmosphere means a warmer global climate.

Carbon (C) is one of the fundamental elements of the forest, just as it is of all forms of life. Carbon dioxide and water are the two chemical compounds that plants convert, with the help of the sun's light energy, into sugar molecules and ultimately into the entire chemical structure of all plants , by combining the sugar molecules with other nutrients from the air, soil, and water. Vegetation takes carbon dioxide from the atmosphere through the process of photosynthesis, and carbon dioxide is returned to the atmosphere by plant respiration, by the decay of organic matter in soils and litter, and through disturbances related to fire and harvesting.

The Earth's carbon is stored in organic compounds in biomass (living and dead), in the atmosphere, and dissolved in the oceans. Forests and long-lasting wood products are major reservoirs of stored carbon in a form that is not available to the atmosphere and, therefore, not contributing to increased carbon dioxide concentrations.

Management activities that aim to maintain and enhance the carbon stored in forests and forest products over the medium to long term can make a positive contribution to stabilizing atmospheric carbon dioxide levels. About one-quarter of anthropogenic emissions of carbon dioxide worldwide is the result of land-use change, especially deforestation. The more carbon that is stored in forests and wood products, the less carbon dioxide will be in the atmosphere to exacerbate global warming trends.

Criterion 5 monitors the amount of carbon in forests. Sustaining or increasing the amount of carbon in forests will help stabilize carbon dioxide levels in the atmosphere, which in turn may stabilize the climate. A significant shift in climate could seriously affect all indicators of sustainability.

The indicators of criterion 5 are directed at the interest of human society in mitigating global climate change. Forest productivity (criterion 2) and carbon cycling are directly related, and are, in fact, two representations of the same thing. Forest biomass is stored carbon. Our interest in balanced carbon cycles merely reflects our interest in a specific output of forest productivity.

What Are the Indicators and How Do They Relate to One Another?

Three indicators monitor the contribution of forests to the global carbon cycle. The first indicator (26) is a measure of total forest carbon pools and the last two indicators (27 and 28) are estimates of change related to those forest carbon pools. The total forest ecosystem biomass and the carbon pool provide a context for forest contribution to the global carbon cycle. Forest type, age-class, and successional stages (indicator 26) are important characteristics suggesting future trends. Trends in absorption and release of carbon in standing biomass, coarse woody debris, peat, and soil carbon (indicator 27) are important for determining national strategies to help stabilize global climate. Contribution of forest products to the global carbon cycle (indicator 28) measures the role that forest products play in sequestration, cycling, or emission of carbon.

Subtracting the successive inventories of forest carbon pools in indicator 26 produces the carbon change estimates for indicator 27. Thus, indicator 27 can be directly calculated from a time series of indicator 26. The products indicator, indicator 28, is a measure of the amount of carbon grown as forest biomass that was harvested and is, therefore, no longer reported in indicator 26. Indicator 28 tracks carbon in harvested wood as it is processed into products, decays, or is discarded into landfills. Indicator 26 alone cannot show trends in harvested carbon. Indicators 27 and 28 alone cannot show the total carbon pools in forests.

Major Findings for This Criterion

The United States emitted a total of 1,909 megatonnes (Mt) equivalent of C in the year 2000 (U.S. EPA 2002). From 1953 to 1997, nonsoil forest carbon increased almost 46 percent, from 16,613 to 24,292 Mt C. The 1997 inventory amount is equal to about 15 years of current net emissions for the United States. Most of the increase in forest carbon is the result of vegetation changes, particularly in live trees. In 1997, the total aboveground tree biomass was 28,505 Mt dry weight on 250,026 thousand hectares of forest land. In terms of age-class, almost 50 percent of forest carbon is in stands less than 60 years old, and about 80 percent is in stands less than 100 years old. This increased mass of carbon stored in forests is the result of the increased average tree volume per acre discussed in criterion 2, and it reflects the predominantly young nature of American forests. U.S. forests store about 10 percent of the total carbon stored on land, globally.

In the past decade, an increased harvesting rate on private lands has combined with other factors to result in reduced annual rates of carbon storage, although a positive net storage of carbon still exists in forests. As forests are regenerated following harvest, they continue to store carbon in the new trees. The average annual net change for the period 1953 to 1997 is 175 Mt C/yr being absorbed by nonsoil forest ecosystem pools from the atmosphere. Between 1987 and 1996, about 135 Mt C/yr were added to nonsoil forest carbon stocks. The decrease in the sequestration rate in the last period is thought to be the result of more accurate data, increased harvests relative to growth, and accounting issues related to emissions from dead wood. The northern region is sequestering the greatest amount of carbon, followed by the Rocky Mountain region. The trend of decreasing sequestration in the South is the result of the increase in harvesting relative to growth.

Some of the carbon that is harvested from forests continues to be stored as wood products and, therefore, is not available to contribute to climate change. About one-third of the carbon harvested annually is stored in long-lived wood products or in landfills, where it remains sequestered from the atmosphere. About one-quarter of the total carbon stored in the United States in standing forests or products is in the form of products (including that in landfills). A larger amount of carbon harvested from forests annually is returned to the atmosphere as carbon dioxide when the wood is burned for energy production. To the extent that this wood is replaced by new growth in regenerated forests and displaces the burning of fossil fuels, it contributes in a positive way to global carbon cycles by mitigating the magnitude of climate change. The amount of carbon in use and in landfills has been rising in the last 20 to 30 years because of increasing harvests, utilization, and use of anaerobic landfills. Carbon stored in products and landfills over this time period is about 35 percent of that being sequestered in the forest, about 60 Mt C/yr compared to about 175 Mt C/yr. The total amount of carbon sequestration is the sum of forest and products sequestration, about 235 Mt C/yr. Thus, forests and forest products sequester about 12 percent of the gross U.S. greenhouse gas emissions. Currently, soil carbon changes are not included in this indicator; however, forest soils are expected to be sequestering carbon. Other data gaps and issues with the estimates are included within each indicator report.

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits To Meet the Needs of Societies

What Is the Criterion and Why Is It Important?

Meeting society's needs may be viewed as providing for the values people have for forests, products, recreational and cultural experiences, maintaining ecosystem conditions, and maintaining communities. The level of values provided is influenced by many factors beyond the forestry sector. These factors include population; income growth and distribution; economic development and benefits from other sectors and in other countries; and changes in political, cultural, and spiritual values. Our growing population and high standard of living demand increasing quantities of products and services from forests.

The indicators for this criterion represent various aspects of supply, demand, investment, and utility related to America's needs to derive benefits from our forests. To maintain and enhance forest-related values or socioeconomic benefits over time require that we sustain capacities needed to provide them—natural capital (forests and their functions), built capital (factories, buildings, machines), human capital (knowledgeable, skilled, healthy people), and social capital (knowledge, trust, efficiency, laws, institutions) (Meadows 1998). To maintain these capacities requires investments of funds and human efforts. The level of investment provided, in turn, partially depends on the level of benefits people perceive they are receiving from forests and on the quality of social capital that has developed.

The importance of particular indicators in judging sustainability may vary by geographic scale. Certain indicators may be important in judging sustainability of providing benefits at a national level, but not at a regional or local level; for example, information on the extent to which consumption is met by national capacity for production versus imports may be more important at the national level than at a regional or local level. Some indicators may be more important in judging sustainability of providing benefits at a regional and local level than a national level; for example, information on the capacity to provide employment and community development associated with forests may be more important at a regional and local level than at a national level. To judge sustainability adequately across all scales is likely to take more information than can be provided in a national summary.

What Are the Indicators and How Do They Relate to One Another?

Nineteen indicators provide information on the flow of benefits, investment in capacity, and level of capacity to meet socioeconomic needs. The indicators are grouped into five categories: (1) production and consumption; (2) recreation and tourism; (3) investment; (4) cultural, social, and spiritual values; and (5) employment and community needs.

Production and consumption indicators provide information on trends in quantity and value of wood and nonwood product benefits from U.S. forests and from imported products. These include the product amounts imported and exported, and the contribution of production to the gross domestic product (GDP).

Recreation and tourism indicators provide information on trends in benefits from forest recreation activity and trends in the level of recreation capacity, from the area and percent of forest area available for recreation to the number and kind of facilities available for recreation.

Investment indicators provide information on the trends in investment in forest management, wood processing, recreation and tourism, research and development, education, extension and use of new technology, and information on the return on investment in timber management.

Cultural, social, and spiritual values indicators provide information on the level of capacity to provide values in terms of the area and percent of forest land protected, and the trend in benefits obtained from nonconsumptive use of forests.

Employment and community indicators provide information on (1) employment, wages and injury rates (safety) in forest management, forest industries, production of nonwood forest products, and recreation; (2) benefits and capacities associated with subsistence use of forests; and (3) the degree to which communities associated with forests have a higher or lower capacity to remain viable under changing economic conditions.

To the extent possible, information is provided on national and regional trends, but in some cases information is available only on current national or regional conditions. For each category, indicators provide some information on the flow of benefits, the amount and kind of capacity to provide the benefits, and the flow of investments to maintain or enhance the capacity.

Major Findings for This Criterion

Ownership of capacity to provide benefits is dispersed, as are governments, private industries, and groups investing in capacity to provide benefits. The distribution of forest lands across different owners varies widely from region to region, with the majority in the East being in private ownership and the majority in the West in public ownership. It is not possible to provide the same level of detailed information about each kind of benefit noted in these indicators. The level of information available varies at the national and regional levels on status and trends for flows of benefits, investments, and the levels of capacity.

Since 1950, U.S. forests have been harvested for a consistently increasing demand in quantity (and value) of wood and paper products. The U.S. consumption of major wood and paper products per capita is almost double the average for all developed countries, with consumption per capita increasing about 27 percent over the last 50 years. Consumers use wood and paper for construction, containers, and printing and writing paper. Improved processing technologies and increased use of recycling in paper production has helped meet the increasing demand with a less than proportional increase in the harvest of trees. U.S. wood harvest per capita has remained relatively stable at less than 70 cubic feet per capita per year. This stability is aided by an increase in recovery of paper for recycling to 45 percent and by improvements in production efficiency.

Increases in imports also have contributed to this stable domestic per capita harvest rate. Net imports now account for about 9 percent of our wood needs for consumption. Production has shifted from the West to the South, and toward a greater share of production in paper and composite products (versus lumber) that use smaller diameter trees. The contribution of wood and paper products to the GDP has declined from 2 percent to 1 percent over the last 50 years, but has remained a constant fraction of GDP from all manufacturing activity. Although profitability for the wood product industries has generally been above the average for all manufacturing, it has been decreasing in recent decades.

Supply and demand of nontimber forest products are not well documented regionally or nationally. Local or anecdotal information shows an increase in nontimber demand and harvesting. Production and consumption of nonwood forest products varies widely in type, amount, and value by region. Products include medicinals; food, and forage species; floral and horticultural species; resins and oils; arts and crafts; and game animals and furbearers. With a possible total value of $5 billion or more, these products may contribute 0.05 percent to the GDP.

Almost all public and industrial forests are open for recreational use and provide a relatively stable capacity for recreation and tourism, especially in the West where public land is abundant. Access to industrial forest lands may be limited to lease and other access restrictions. In the East, nonindustrial forest land is the major contributor to increases or decreases in area available for recreation. In 1985–86, nearly 25 percent of nonindustrial private forest owners permitted some free public access. This percentage dropped nationally by 1995 to about 14.5 percent. In 2000–01, only 10.9 percent of owners permitted free public access. The increasing population, which grew from almost 250 million in 1990 to its current level of more than 280 million, further complicates this decline in accessible nonindustrial land area. This trend indicates there is less per capita capacity on private nonindustrial lands now than there was in 1990.

Currently, across the United States, approximately 2.3 acres of forest are available per person for recreation from both public and private sources. Even if available private nonindustrial forest remains stable, with population projected to grow to 325 million, the per capita capacity for forest recreation will decline to under 2 acres per person nationally by 2020.

Another important indicator of recreation capacity is the availability of facilities on forest lands to accommodate use. The trend in facility capacity has generally declined because of modest decreases in investment in the developed forest sites on public lands and the falling nonindustrial forest acres open to the public (where facilities are provided). At the same time that the facility capacity has decreased, the demand has increased. In terms of increased popularity, walking is at the top, adding 46 million participants between 1994 and 2001. Following walking are attending outdoor family gatherings (+36), viewing and photographing wildlife (+34), hiking (+24), picnicking (+20), visiting nature centers and museums (+17), viewing and photographing birds (+16), camping in developed campgrounds (+16), visiting historic sites (+12), and driving motor vehicles off road (+10). Generally, participation in outdoor activities in both forested and nonforested settings continues to grow, with the greatest growth in nonconsumptive activities. With rising demand and slowly declining acres of private forest available, recreation use per acre available in the country continues to grow, as do conflicts over access rights by different user interests.

Increased demands for all goods and services from forests have been supplied from a forest area that has not changed (in total area) for about 100 years. The growth in demand has been met through investments in the basic forest resource (growing trees); in harvesting and processing technologies; in capital facilities (including recreation sites); in recycling; and in research, development, and technology transfer. Public and private landowners make a wide range of investments in forest management. One overall investment is tree planting, which has increased from 1.5 to 2.6 million acres per year over the last 50 years.

Since 1952, the average rate of return for timber management has increased in the South, decreased in the West, and remained fairly constant in the North. Since 1996, investments in lumber and wood products firms have declined from 2.5 to 1.5 percent of the value of shipments. Investments in pulp and allied products firms averaged 4 percent of shipments but declined in recent years. Investments in recreation and tourism include those by Federal agencies, including the USDA Forest Service, National Park Service (NPS), and Bureau of Land Management; the State forestry and park agencies; local governments; and private landowners.

The long-run rate of return to timber assets for the United States as a whole has fluctuated and reflects changes in market conditions between measurement periods. Capital gains strongly influenced this rate of return and were negative between 1977 and 1987 but were strongly positive between 1987 and 1997. The long-run implied rate of return has risen to about 9 percent for the United States as a whole, and ranges from 5.1 percent in the Rockies to 12.7 percent in the South. Rates of return are generally higher in the Eastern United States than in the West. One measure of competitiveness for forest products firms is shown in indicator 29—profit as a percent of shipments. This percent has been declining for lumber and wood products and paper and allied products industries in recent decades.

Investment in forest resource management research and development has declined in the USDA Forest Service in recent years, while the number of forestry faculty at universities has remained relatively stable. There is also substantial research and development funding and effort by State agencies, industry, nongovernmental organizations (NGOs), and by other Federal agencies, including the Department of Energy (DOE), National Aeronautics and Space Administration (NASA), and the EPA. Education includes forest resource education in public schools, university training, university and State extension efforts, training by industry, and training by NGOs. Innovations developed by research have changed forest management, with a shift toward managed softwood plantations, greater use of small trees for products, greater recycling of paper and wood, and development of more wood-efficient and effective products for end users.

Total area of protected forest indicates the relative importance placed on noncommodity social, cultural, and spiritual forest values. The six world Conservation Union (IUCN) categories of managed lands provide a framework for monitoring the U.S. commitment to sustain noncommodity forest values.

- IUCN category 1a, lands managed for science values, shows the recent trend for designated experimental forest and range areas as stable. This follows persistent growth in the decades preceding 1980. Up to 1939, 32 areas were designated; from 1940 to 1959, 22 new areas were designated; 29 areas were designated from 1960 to 1979; and none have been designated since 1979. This trend indicates stable interest in the science value of forests.
- IUCN category 1b, wilderness, shows a trend in which the U.S. Congress recognizes multiple values by designating large areas of Federal lands to be added to the National Wilderness Preservation System. New designations must be added by Congress, which has added 96 million to the 9 million acres in the original system created in 1964. The future trend is likely to show continuing additions as various sponsored State bills are acted upon, but the added acreages will likely be substantially smaller than in previous years.
- IUCN category 2, forested parks, shows a trend in which modest additions of new parklands are made at either national or State levels. Areas in national parks falling into IUCN category 2 have been decreasing slightly during the past 20 years because of redesignations of park area to category 1b, wilderness.
- IUCN categories 3 and 4, protected natural monuments and wildlife refuges, show a trend of increasing slightly in recent years at State and national government levels.
- IUCN category 5, national seashores or lakeshores, show a trend nationally in protecting these forest lands that has remained flat.
- IUCN category 6, forest managed for both commodity and noncommodity benefits, shows a trend that is slightly down. Currently, about 27.5 percent of the Nation's total forest area is managed as public forests, an area exceeding 205 million acres. The trend in category 6 is slightly down because of redesignation of some of this area into other categories that give more emphasis to noncommodity values.

Beyond the IUCN categories, an estimated 29.3 million acres of nonindustrial private forest land are protected through easements with local and State agencies or private organizations. The trend in conservation easements is up, with more States and other organizations sponsoring easement programs. Overall, there is a modest growth in the area of forest protected in this country. Few data, however, directly addresses the multiple values society receives from increased management of forests for protection. Lacking such data, trends in participation in nonconsumptive outdoor activities were examined. This examination revealed that participation in nonconsumptive activities, in both forested and nonforested settings, continues to grow in the United States. In all likelihood, this increase in participation reflects the increase in the recreational value of forests. Looking at other measures of forest values, the public places clean air and water as a highest priority for public forest management. Next in importance is scenic beauty, followed closely by management for cultural and natural heritage values. Nationally, and in all regions, management for wood products has the lowest public support as a priority for management of either public or private forests. The trend in ranking the ecosystem service and environmental values above the wood production values has been persistent over the last few decades.

Employment in wood and paper products industries is currently about 1.5 million, with an increase in recent decades mostly in paper industry jobs. This category of employment has declined as a percent of all U.S. jobs, but has maintained its share of manufacturing jobs. Employment is highest in the North followed by the South, Pacific Coast, and Rocky Mountains. Employment in public and private forest management is in the high 10s of thousands. Employment in producing nonwood forest products may also number in the 10s of thousands. Forest recreation employment is in excess of 1 million people. Wages have been higher than the manufacturing average for paper industry jobs and lower than the average for lumber and solid wood industry jobs. Wages for nonwood products vary widely by product and region. Injury rates for wood and paper industries have been below the national average and continue declining.

A number of counties are identified as having a high density of forests and limited economic adaptability. Of 742 heavily forested counties, 104 or 14 percent were estimated to have low adaptability to economic change, which represents 104 of 3,110 U.S. counties. Most of the affected area is in the West and most of the affected population is in the East.

Sixty-six counties or boroughs have significant Native American populations. Subsistence use rights, established by laws and treaties in Alaska and Hawaii, and with Native Americans, monitor hunting, trapping, and gathering from identified lands. Use rights are provided for most of the 316 million acres of public forest land and for 17 million acres of tribal lands. Access to 363 million acres of nonindustrial land and 68 million acres of industry land appears to be decreasing. In addition to Native American use, subsistence use has been documented for African Americans, Asian Americans, and European Americans in all regions of the United States

Criterion 7: Legal, Institutional, and Economic Framework; Capacity To Measure and Monitor Changes; and Capacity To Conduct and Apply Research and Development for Forest Conservation and Sustainable Management

What Is This Criterion and Why Is It Important?

The human interest in forest sustainability is evident in the legal, institutional, and economic frameworks that a nation adopts and implements. It is through these frameworks that nations (and the individuals comprising them) express their interest in and expectations for the use, management, and protection of forests. While ecological conditions may receive much attention, it is the legal, institutional, and economic conditions embraced by a nation that enable concerns about forest sustainability to be identified, and subsequently addressed, by appropriately designed and properly implemented policy and management responses.

The legal framework for forest sustainability includes the body of laws and customary rules that direct the actions of citizens, while the institutional framework is composed of public and private organizations that are responsible for implementing policies and programs that promote sustainable forest management. The economic framework for forest sustainability embodies the expression of private self-interest in forest sustainability through responses to market systems tempered by society-imposed rules and limitations. Critical to forest sustainability is a nation's capacity (or capability) to adopt and implement a well-designed set of legal, institutional, and economic frameworks.

The capacity to measure and monitor change is also fundamental to implementing and maintaining sustainable forest management. If we do not have indicators of sustainable forest management and the capacity to monitor them, there is little basis for developing policies and programs that assure continuation of sustainable forest management. Increasingly, issues of sustainable development and sustainable forest management transcend national boundaries. To assess multinational and global effects of forest policies, it is essential that data-reporting capabilities are compatible among countries.

The capacity to conduct and apply research and development is fundamental to moving forward in applying sustainable forest management. Outcomes of research and development potentially cross-cut the other six criteria, as well as the other indicators in criterion 7. Research and development can help better define biological diversity, productive capacity, and ecosystem health and vitality, as well as enhance the measurement of soil and water resources; carbon associated with forests; socioeconomic benefits; and the legal, institutional, and economic frameworks.

What Are the Indicators and How Do They Relate to One Another?

Twelve indicators monitor legal, institutional, and economic capacity for forest sustainability. Legal capacity (indicators 48-52) includes property rights and land tenure; forest planning, assessment, and policy review; public participation and access to information; best practice codes for forest management; and conservation of special forest values. Institutional capacity (indicators 53-57) includes public education and extension; forest planning, assessment, and policy review; human resource skills; physical infrastructures; and enforcement of laws, regulations, and guidelines. Economic capacity (indicators 58-59) includes investment, taxation, and regulatory environment, and forest products trade. The eight remaining indicators of criterion 7 (indicators 60-67) assess the quality and availability of data, as well as the level of knowledge that aids in understanding indicators of sustainability.

The indicators of criterion 7 interact with nearly all six other criteria. They establish the legal, institutional, economic, and information foundation for a nation's effective response to conserving the biological diversity and maintenance of forest ecosystem productive capacity, health and vitality, and associated soil and water resources. In addition, these indicators express how a nation intends to have forests contribute to global carbon cycles and to long-term socioeconomic benefits sought by societies.

Major Findings for This Criterion

A national review of information regarding the legal, institutional, and economic capacity of the United States to respond to desired conditions of forest sustainability involved an extensive search for and synthesis of information. The review was at times hindered by the extensive scope of each indicator's subject matter and the frequent, huge gaps in information describing an indicator's capacity. The review suggests the need for further conceptual development of the indicators and the need to focus and, subsequently, intensify information-gathering activities.

A definitive interpretation of the legal, institutional, and economic capacity for forest sustainability and conservation is difficult, but some general statements are possible.

The legal capacity for accomplishing forest sustainability is substantial, although often highly dispersed, frequently in conflict (within and between governments), and often subject to the widely differing interpretations of an appreciable number of Federal, State and local units of government. Even though legal authorities are extensive, the degree to which this potential capacity is actually exercised by implementing agencies is highly variable in intensity and consistency. The private sector represents significant legal capacity in terms of best practice codes and conservation of special values.

The institutional capacity for forest sustainability is also substantial, although it is also highly dispersed, frequently in conflict (within and between governments), and often subject to widely differing interpretations of public and private organizations. The expression of this potential institutional capacity is often limited by constraints on access to financial and human resources. The private sector represents significant institutional capacity, especially in terms of public education and human resource skills.

The economic capacity for forest sustainability is substantial, as are the fiscal and tax incentives that promote positive outcomes in market behavior. In recent years, the economic incentive capacity has broadened considerably and now also focuses on the many noncommodity goods and services forests will provide. Legal capacity constraining private sector responses to markets is substantial, especially as focused on the application of forest practices.

The data from the USDA Forest Service Forest Inventory and Analysis Program provides information on the status and trends in forest area and various measures of the forest cover on this area. As the USDA Forest Service Forest Health Monitoring Program is implemented in all 50 States, more complete data on forest ecosystem health and vitality and forest soils will become available. The U.S. Bureau of the Census provides the basis for monitoring most production and consumption of timber products. Few monitoring programs are in place for measures of species diversity, genetic diversity, water resources, and most indicators of criteria 6 and 7. Because monitoring programs were not in place for all indicators, efforts to quantify the indicators resulted in varied success. Until monitoring programs are in place, the United States has limited capacity to assess sustainable forest management using the Montreal Process criteria and indicators.

The 12 countries involved in the Montreal Process vary in their reporting protocols. For example, the United States is the only country that does not routinely report data in metric units. The experience of one capacity-building workshop on data comparability suggests serious compatibility problems in terms of data for the indicators of the Montreal Process.

Including public and private efforts, the U.S. expenditures for research and development in the forest sector is at least in the hundreds of millions of dollars per year. Some expenditures, such as the USDA Forest Service budget, are readily available, but other expenditures are not so straight forward. For example, informal training in the private sector may be important for some activities such as logging. Even when dollar amounts are known, it is difficult to judge the effectiveness of R&D.

Capability To Report on the Indicators

Information presented for indicator 61 gives a synopsis of our ability to report on all the indicators. It is clear from that synopsis that we are far from perfect in our ability to report on all indicators at this time. We have good, repeatable national statistics for only a few indicators, and these are maintained through established monitoring programs (such as Forest Inventory and Analysis and Forest Health Monitoring). For many indicators (or parts of indicators), we have only anecdotal, local, or occasional information. While such information can be useful, and indeed was used in this report, this type of information does not support periodic reporting or detection of trends that can be compared among the indicators.

One of the main perceived values of the criteria and indicators is the knowledge that can be gained from examining consistent information over time. Many opportunities exist for improving our monitoring and data systems to enhance the usefulness of the current suite of criteria and indicators in the future. Appendix 3 contains an extensive list of data needs and potential enhancements.

For some indicators that are currently monitored periodically, consistent protocols must be established for definitions, data collection methods, and geographic aggregation. Examples include definition of forest (regarding range land and other potentially overlapping categories), forest type, minimum tree size, and fragmentation. For some indicator metrics, this is a matter of continuing adaptation and refinement of long-established procedures. For others, new protocols must be established and inaugurated. These new protocols would include direct measures of genetic diversity, productivity for nontimber products, consumption of nontimber products, and capacity for services (such as recreation facilities).

Some indicators lack the spatial coverage needed for national reporting, including measurement of soil and water condition, carbon cycle metrics, most nontimber products, and many air pollution measures. Some indicators lack sufficient temporal coverage for routine monitoring (or periodic measurement) and reporting. These include carbon cycle metrics and most nontimber products,

Still other indicators are currently measured in widely dispersed systems of data collection. For most of these indicators, there is a need to develop protocols and systems for aggregating data periodically for national reporting. This category includes most indicators related to legal, institutional, and knowledge infrastructure; supply and harvest of nontimber products; animal and plant population information; implementation and compliance for best management practices; water quality; soil condition; recreation availability and use; and area of protected forest.

The lack of sufficient data for all the indicators is one factor that challenges our current ability to interpret the information and assess sustainability. In the final section of this report, we will discuss other factors that challenge interpretation and assessment, as well as future needs for improving our understanding of sustainability.

Beginning a Dialog about Interpretation

In the following pages, we illustrate how information about the indicators informs our understanding of sustainable forest management. We do not suggest any conclusions about the current state of sustainability in the United States. We reiterate the idea that there is no single combination of conditions that equates with achieving sustainability. Identifying sustainability is, indeed, more likely a matter of judgment than a result of clear, measurable facts. The importance of the facts (data about the indicators) is that they can improve our mutual understanding and inform our collective judgments about sustainability.

An Incomplete Understanding

Clearly, we have substantial information in the United States about the state of our forests and forest management, as well as about the economic and societal contexts of those forests. There is also more we would like to know, however, but do not. For most indicators, many factors and pieces of data have been assembled to provide meaning. As this report indicates, we know a lot about some indicators, a modest amount about many more indicators, and not much about others. Of course, lack of perfect and complete information is a perpetual condition, and is, therefore, not a reason to entirely avoid an assessment or dialog about the present situation.

Scale of observation is another potentially confounding issue. When evaluating the state of the environment, society, and economy scale matters. By design, this report on the criteria and indicators addresses the national scale, and where possible, some broad regional data. In the United States, viewing things at the national scale blends some rather large-scale regional features of the environment, society, and economy, and overlooks some unique local situations. When interpreting the information, this view can obscure important regional or local distinctions or trends. In some instances, regional data about indicators simply does not exist. In other instances, only regional data is available and is not readily accessible in an aggregated form. For those few indicators in which we have regional information, the data document provides that important detail. A longer-term objective is to improve the quality of information at multiple spatial and temporal scales.

Another difficulty in assessing sustainability is the absence of agreed-upon reference conditions or standards against which to compare the status of indicators. For most indicators, we simply do not know (or do not agree) how much is enough, how much is too much, or when the observed change is significant or not. Indeed, these are questions in which the answers depend on individually held values and other variable contexts. To make matters even more interesting, there is no universally accepted analytical or synthetic model of sustainability that would lead to a singular assessment of sustainability, regardless of data quality or accepted reference values.

What then should we do with the wealth of information we have? As we suggested earlier, some broad and well-accepted concepts guide us. First, to achieve sustainability, we must attend to the three interacting spheres of environment, society, and economy. While meeting the present needs of humanity, we must bequeath to future generations functioning systems and options that will enable them to meet their needs. The intergenerational satisfaction of needs is the universally recognized notion at the heart of sustainable development. This concept suggests that, as we interpret the information, we should examine in aggregate the status and trends that inform our understanding of the current and future capacity to meet our needs in all three spheres. Are we moving in the right or wrong direction for any of the indicators? How do such trends relate to the other indicators? Are we living within the capacities of the systems to continue to provide what we want, or are we taxing the limits, as monitored by some of the indicators?

The second guiding concept is that human societies assess, evaluate, and decide through dialog—the process of collectively considering information to reach a shared understanding. The shorthand concept we presented earlier for this idea is: "better data leads to better dialog, which leads to better decisions." A good place to begin, therefore, is by articulating interpretations from various points of views. Through sharing and comparing these different meanings, we progress in mutual understanding.

A Beginning Dialog

It is axiomatic that without forests there can be no sustainable forest management. This obvious statement leads to a reasonable question that has no obvious answer—to wit: "Do we have enough forests?" What we can say to begin the dialog on this question is the following:

- There is less forest in the United States now than there was 400 years ago, largely in the East;
- The total area of forest has remained stable for the past 100 years, varying less than 5 percent;
- The location of forests is always changing, especially at the local scale; and
- The nature of the forest and how it is used has changed and is constantly changing.

There have been two notable phases affecting the total area of American forests during the past 400 years. The beginning of European settlement, early in the 17th century, through the subsequent economic growth in the 18th and 19th centuries, led to (indeed was supported by) harvesting vast areas of forest for fuel and lumber, as well as converting forest to other land uses (mostly for agriculture). In total, these actions permanently reduced the total forest area by about 25 percent, or 250 million acres. Most of the change in total forest area occurred in the East, but substantial changes also occurred regionally in the West. Harvesting forests for wood during this period occurred in all regions of the United States, yet in most areas forests still exist to this day. Some consequences of these actions include effects on indicators of biodiversity,[34] productive capacity,[35] forest health,[36] soil and water resources,[37] and cultural and spiritual values.[38]

During this period there were also consequences on indicators of socioeconomic values.[39] There were clearly tradeoffs among the environmental, social, and economic consequences. The use of the natural capital of America's forests was a major element in the economic and social success of the growing United States. This use enabled the construction of cities and rural homesteads, heating of homes, fueling of industry, transport of goods and people (by wooden ship and rail), export of commodities, and growth of agriculture. Forests provided the energy (in the form of energy captured from the sun over centuries and stored by trees in the chemistry of their wood) that supported our growing economy. Cleared forest lands provided previously untapped natural capital to support large-scale agriculture. It is hard to imagine how the United States would have developed without this period of extensive use of our forests.

Beginning in the late 19th and early 20th centuries, this phase gave way to a second phase. During the past 100 years, the total area of forest has been essentially stable at about 750 million acres.[40] During this time, the population and scale of American economic activity continued to grow with associated increasing demands for goods and services from forests. There were, however, significant shifts in use patterns for forests. For example, fuel preferences shifted, with wood yielding to coal and then oil and natural gas. Because of these shifts and their interactions within this overall pattern of stable forest area, there is information in the indicators that can help us better understand sustainable forest management.

A significant contributor to this stability of forest area is the regeneration of forests on most of the area that was harvested or cleared for agricultural use during earlier centuries.[41] Although many forests regenerate naturally, widespread regeneration of cutover lands did not occur solely by chance. Concern about the environmental and economic benefits of forests around the beginning of the 20th century led to concerted efforts to protect, restore, and manage forests and other abandoned lands in the United States. This movement also marked the beginning of forestry as a science and as an academic endeavor in America. These events marked the dawn of a formal institutional framework related to forest management in the United States.[42]

During the past 100 years, active and effective fire prevention and suppression also contributed to protecting forests and communities. In addition to protection and management of natural forests, the planting of new forests became a significant activity.[43] The Civilian Conservation Corps, the Soil Bank Program, and the Conservation Reserve Program were Federal programs that led to big increases in the area of planted forests. Tree planting by industries and individuals added to the total forest area during the 20th century.

The regeneration of harvested forests occurred concomitantly with a great reduction in the rate of conversion of forest to agricultural land and the reversion of abandoned cropland to forests. This process occurred in three major waves—late 1800s, 1920s to 1930s, and 1950s to 1970s. The first two waves were driven by technological advances and the most recent wave by the increasing globalization of trade in agricultural products.

Technological advances in the forestry sector have also been instrumental in enabling the maintenance of a constant area of forest land.[44] These advances include improvement in the management of forests that makes possible the production of more wood output per acre on lands that are more intensively managed. They also include improvements in the processing of wood products and recycling of processed materials. These advances have greatly increased the amount of usable product that we get from a fixed amount of raw material (harvested trees). Although demand increased as a result of the growth of population and economic activity, we are still meeting most demands from a constant overall forest land base.[45]

The United States is both an exporter and an importer of wood, but during the 20th century, the United States became a net importer. These net imports alleviate some of the demand on private and public forests for wood production, as they send some economic value to other forest-producing countries. Increasing demand for fiber-based products has created increasing economic activity in the forestry sector.[46] The total value of wood and paper products, employment, and contribution to gross domestic product has increased for the forestry sector. The share of GDP has decreased, however, since the latter part of the 20th century, reflecting both a trend of a greater share of forest product capacity moving to other countries and more rapid increases in other economic sectors.

Efforts to increase production capacity may be influenced by potentially declining profitability for providing products compared to alternative uses for land driven by increasing noncommodity values and to product production overseas. Investment in capacity has slowed as indicated by a decrease in investment as a portion of value of shipments. General information is lacking on trends in capacity to produce nonwood forest products despite increases in capacity in some regions. Although the value of water

[34] Criterion 1; indicators 1, 2, 5, 7, 8, 9
[35] Criterion 2; indicators 10, 11, 13, 14
[36] Criterion 3; indicators 15, 16, 17
[37] Criterion 4; indicators 18, 20
[38] Criterion 6; indicators 43, 47
[39] Criterion 6; indicators 29, 30, 32, 34, 38, 40, 41, 44
[40] Criterion 2, indicator 10
[41] Criterion 2; indicator 11
[42] Criterion 7

[43] Criterion 2, indicator 12
[44] Criterion 6; indicators 33, 39, 40
[45] Criterion 6; indicators 31, 34
[46] Criterion 6; indicators 29, 30, 32, 44, 45

from forests is substantial, information is lacking on the trends in capacity of forests to provide for water supplies. The kinds and amounts of products consumed and the locations of production have shifted, altering kinds and amounts of regional employment and community support. Production is, to varying degrees, decentralized and decided by thousands of landowners and producers.

In addition to the growth of societal demand for wood, demands for other forest uses have also grown. Although different uses of forests are not necessarily mutually exclusive, there often is some competition among the various demands. This is especially true when contrasting wood production (harvesting trees) with uses such as recreation, cultural/spiritual, and biodiversity uses. During the 20th century, the United States created an institutional framework that guides how we seek to achieve the many goods and services we want from private and public forests.[47] Overall, U.S. citizens today seek a wider variety and larger quantity of goods and services from our forests than they did 50 years ago.

Many factors interact to influence how well we meet this multiplicity of demands. Some of the major factors are more intensive management of forests; technological improvements that increase production efficiency; adaptation of laws, regulations, and programs to steer private and public decisionmaking; and globalization of trade in raw materials and products.

Another consideration in understanding the status of sustainable forest management is the condition of forests, which includes elements such as health, productivity, and pattern.[48-50] These elements of forest condition are reflected in many of the criteria and indicators.

Forest health and productivity are highly interrelated with human socioeconomic activities toward forests. A host of forest management activities, supported by institutional frameworks, is directed explicitly toward maintaining or enhancing forest health and productivity.[51] Since 1950, net annual growth of forests in the United States has continued to increase, while mortality has been constant at a low level.[52] This trend reflects an overall productivity increase over the past 50 years that is attributable, at least in part, to forest management activities. Productivity also has remained high because forests have been relatively young, and young stands grow fast. Intensive plantation management aims to keep stands relatively young and fast growing. When stands grow older, productivity increases typically decline.

While much has been learned about managing forests and endemic pests to reduce their effects on forest health, outbreaks still occur when stand conditions encourage such outbreaks, or when external stresses, such as extended drought, make otherwise healthy stands more susceptible. Indicator 17 found that 20 percent of all forest area in the coterminous 48 States has diminished biological components caused by health factors.[53] In contrast to endemic pests, exotic insects and diseases with no natural enemies can be devastating, as was the case for Dutch elm disease, chestnut blight, and others. The increasing globalization of trade means that future pest introductions are likely.

Forest fire is another aspect of forest health that has been greatly affected by human activity, including igniting fires (intentionally or not), preventing fires, and suppressing fires.[54] Fire prevention and suppression successes during the 20th century were seen by many as highlights of U.S. forest management. This success contributed to maintaining the overall area of forest for timber production, enhancing productivity for a variety of uses, and protecting homes and communities.[55] At the same time, aggressive fire suppression altered fundamental ecological relationships in some forests and led to a perception that all fires are bad. Consequently, trends have emerged of increasing fire size and severity over the past 20 years, as well as increasing property damage.[56] Today, there is considerable public debate about how best to prevent fires and reduce property damage. This is an arena in which our perceptions about sustainability are being informed by new knowledge, and the institutional framework surrounding how we manage forest fires is evolving.

Other health impacts arise from external factors that appear regionally or locally, but not nationally. Historically, emissions from metal smelting have caused long-term, locally significant alterations to forests and croplands and, in some cases, precluding the regeneration of forests. More recently, the effects on forests of the deposition of sulfates and nitrates (acid rain), byproducts of fossil fuel combustion, have been studied along with ozone. Again, effects have been noted in some locales. Although not covered by any of the indicators, haze is also a significant issue in some forested viewsheds, such as the Grand Canyon and wilderness areas, where scenic beauty is highly prized. Models of global changes in temperature, arising from changes in atmospheric composition (so-called greenhouse gasses) suggest that changes in forest composition and the range of certain species may occur. These changes are not only affecting vegetation in forests, but are also altering water bodies, such as remote mountain lakes and streams, and the flora and fauna that live in them.

The pattern of forests on the landscape affects many indicators of sustainable forest management, and pattern, in turn, is influenced by many other factors related to land use. In terms of the criteria and indicators, pattern is addressed directly by measures of

[47] Criterion 7
[48] Criterion 3
[49] Criterion 2
[50] Criterion 1
[51] Criterion 7
[52] Mortality has remained nearly constant at 0.75 percent of growing stock volume.

[53] Criterion 3; indicator 17
[54] Criterion 3; indicator 15
[55] Criterion 1; indicators 1,2; and criterion 6; indicators 31. 34
[56] Criterion 3; indicator 15

fragmentation.[57] Human activities, especially since European settlement, have increased the fragmentation of American forests. Most U.S. forests still exist within a matrix that is predominantly forest; but huge, unbroken tracts of forest are much less common than they were before European settlement. As a result of habitat fragmentation, many forest-related species' existence is threatened or endangered.[58]

Fragmentation is a result of the societal demands we place on our forests. It is a consequence of our achieving other desirable outcomes, including wood and paper products, developed recreation facilities, urban environments and second home sites, convenient ground transportation, and productive agricultural land. Our institutional framework supports the achievement of these desirable outcomes. In addition, our framework is continuing to evolve toward a better balance between fragmentation of forests and other goals that we desire.[59] The framework currently includes laws, such as the Endangered Species Act; protected areas, such as national wildlife refuges and conservancy areas; independent forest certification systems; biodiversity advocacy groups; nongovernmental organizations that protect and manage forest habitats; and new knowledge and technology that enable meeting other demands on forests while minimizing fragmentation.

The issue of fragmentation, as framed by indicator 5, is the loss of large blocks of contiguous forests. Public feedback, however, suggests that this is an overly narrow focus. Other public concerns regarding fragmentation include the increasing difficulty of managing on a landscape basis when the available forest is split among an increasing number of owners, each with their own objectives (parcelization); the continuing sprawl of urban development into woodlands and the reduction in green space; and the longstanding concern that the existing legal institutional framework is further concentrating softwood timber production in intensively managed plantations.

So what does all this information mean? We do not suggest any conclusion about our current state of sustainability. As we mentioned earlier, the gaps in data, incomplete understanding of systems, and the importance of each individual's values in attaching meaning to the data preclude a definitive conclusion. Our view is that, rather than focusing on any single indicator, it is vital that the information be considered as a whole and interpreted in the total context of all the criteria and indicators. They are richly interwoven. As we learn more about how the environmental, social, and economic spheres function and create the changes, influences, and effects observed, we as a society are motivated to respond with dialog and policies. The value of the indicators, viewed as a group, is that they provide a common base of information for shared learning by all parties and an improved response. Ultimately, it is an individual matter to interpret the information, and our individual interpretations will lead to a collective societal response that will continue the evolution of the societal framework that surrounds the notion of sustainable forest management.

[57] Criterion 1; indicator 5
[58] Criterion 1; indicators 6, 7, 8
[59] Criterion 7

The Dialog to Date

Forest owners, managers, and citizens in general care about, and care for, the Nation's forests in many ways. Nationwide dialog about improving forest conditions began a long time ago in the United States. This dialog included both the private and public sectors.

Since the late 1800s seven major national meetings of forestry leaders, conservationists, policymakers, scientists, and other citizens have been convened in the United States by the private sector with public sector involvement (see sidebar below). This series of meetings to address forest issues, which occurred at critical periods in our history, and are now referred to as "The American Forest Congresses," influenced the forest policies of the Nation and the forest practices on public and private lands. *A Brief History of the American Forest Congresses* by Arthur V. Smythe, traces the influence of the first six Congresses held from 1882 to 1975, with the first congress credited with helping to "consolidate the forestry movement in the United States."[60]

The American Forest Congresses

American Forestry Congress	
Cincinnati, OH	April 1882
American Forest Congress	
Washington, DC	January 1905
American Forest Congress	
Washington, DC	October 1946
The Fourth American Forest Congress	
Washington, DC	October 1953
The Fifth American Forest Congress	
Washington, DC	October 1963
The Sixth American Forest Congress	
Washington, DC	October 1975
The Seventh American Forest Congress	
Washington, DC	February 1996

Source: *A Brief History of the American Forest Congresses* by Arthur V. Smythe, May 20, 1994.

After 1975, when The Sixth American Forest Congress was held, a number of events unfolded globally and within the United States that further shaped the journey of this country toward sustainable forest management. The World Commission on Environment and Development held in 1983 and the United Nations Conference on Environment and Development (also known as the Earth Summit) held in 1992 brought global attention to sustainable development. Following the Earth Summit, the Federal Government made commitments regarding a national goal of sustainable forest management. The Federal Government also explored using ecosystem management as "a proactive approach to ensuring a sustainable economy and a sustainable environment."[61]

The Seventh American Forest Congress, held in 1996, was called "A Citizen's Congress" and had the objective of "developing a shared vision, a set of principles, and recommendations that will ultimately result in policies for our nation's forests that reflect the American people's vision and are ecologically sound, economically viable, and socially responsible."[62] Over a year-long preparatory process, a steering committee representing a spectrum of interests used local roundtables, collaborative meetings, and other means to gather input on the vision, principles, and issues from stakeholders throughout the country. The Forest Congress participants, totaling more than 1,300, used the input to answer the question, "What common ground do we have with regard to America's forests?" The participants developed elements of a common vision and a set of principles, and canvassed themselves to tally their levels of agreement (see sidebar for top three vision elements receiving the highest levels of agreement).[63] Following the event, a transition team envisioned "inclusive local and national civil dialogues that lead to implementation of natural resource decisions consistent with the vision of the Seventh American Forest Congress."[64]

[60] A paper titled *A Brief History of the American Forest Congresses* written by Arthur V. Smythe, May 20, 1994, was distributed to attendees at the Nebraska Roundtable on January 11, 1995, Nebraska City, Nebraska. The Nebraska Roundtable resulted in a call for a Seventh American Forest Congress by the 60 leaders in attendance representing interests including environmental organizations, industry, public agencies, and grassroots organizations.

[61] An Interagency Ecosystem Management Task Force established in August 1993 released a report in June 1995 titled *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies*. A subsequent report published by the U.S. General Accounting Office, titled *Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach*, identified the barriers as problems with data, problems with interagency coordination, and insufficient collaboration with non-Federal parties.

[62] The keynote speech titled *It Could Be You!* was delivered by Arthur V. Smythe at the Nebraska Roundtable, January 11, 1995, in Nebraska City, NE.

[63] *Seventh American Forest Congress—Final Report*, dated April 2, 1996, details the levels of agreement for the 13 final vision elements, as well as for revised and draft principles.

[64] Memorandum dated June 17, 1996, from the transition team chair of the Seventh American Forest Congress includes *Highlights of the Seventh American Forest Congress Transition Team Meeting of May 30, 1996*.

Top Three Vision Elements from the Seventh American Forest Congress, 1996

In the future our forests...

1 ….will be held in a variety of public, private, tribal, land grant, and trust ownerships by owners whose rights, objectives, and expectations are respected and who understand and accept their responsibilities as stewards (received 90 percent level of agreement).

2 ….will be enhanced by policies that encourage both public and private investment in long-term sustainable forest management (received 89 percent level of agreement).

3 ….will sustainably provide a range of goods, services, experiences and values that contribute to community well being, economic opportunity, social and personal satisfaction, spiritual and cultural fulfillment, and recreational enjoyment (received 88 percent level of agreement).

Source: *Seventh American Forest Congress—Final Report*, April 2, 1996

Today, citizens of the United States continue dialog about sustainable forest and resource management, and are taking a variety of actions aimed at improving management and conditions. At the national level, for example, the Roundtable on Sustainable Forests is a multistakeholder forum of government and non-governmental interests that, according to its charter dated February 24, 1999, exists to "serve as a forum to share information and perspectives that will enable better decision making in the United States regarding sustainable forests."[65] The charter also states that the initial focus of the roundtable "is to implement and promote utilization of the criteria and indicators contained in the Santiago Declaration of the Montreal Process as a means of measuring national progress towards achievement of this goal." Other multistakeholder roundtables and forums focus on indicators related to rangelands, minerals and energy, water, and communities. Each of these multistakeholder processes is shaping change. There is growing interest in working across sectors on common issues and more integrated actions.

Roundtable on Sustainable Forests— Non-Federal Participants

The Roundtable on Sustainable Forests is a venue for communication, discussion, and dialog in which participation is open. Representatives of the following entities have demonstrated ongoing interest in roundtable activities by attending meetings and assisting with projects. Since its chartering in 1999, many more organizations have participated in specific roundtable activities.

American Forest and Paper Association
American Forest Foundation
American Forests
Audubon Society
Boise Cascade
Communities Committee of the Seventh American Forest Congress
Forest Stewardship Council—U.S. Working Group
Global Forest Policy Project
Great Lakes Forest Alliance
National Association of Professional Forestry Schools and Colleges
National Association of State Foresters
National Commission on Science for Sustainable Forestry
National Forests Foundation
National Network of Forest Practitioners
National Woodland Owners Association
NatureServe
Northeast Midwest Institute
Pinchot Institute for Conservation
Society of American Foresters
Sustainable Forestry Board
Sustainable Forestry Partnership
The Heinz Center
The Wilderness Society
World Wildlife Fund—U.S.

[65] Additional information about the Roundtable on Sustainable Forests is available on its Web site at http://www.sustainableforests.net.

Roundtable on Sustainable Forests—Federal Government Participants

The following Departments, through the agencies or bureaus within them, have actively participated in the Roundtable on Sustainable Forests. The interest of the agency or bureau in sustainable forest management is evidenced by the fact that they are signatories to the Federal Memorandum of Understanding on Sustainable Forest Management Data.

U.S. Department of Agriculture
Cooperative State Research, Education and Extension Service
Forest Service
National Agricultural Statistics Service
Natural Resources Conservation Service

U.S. Department of Defense
Office of the Deputy Under Secretary for Environmental Security

U.S. Department of the Interior
Bureau of Indian Affairs
Bureau of Land Management
National Park Service
Office of Policy Analysis
U.S. Fish and Wildlife Service
U.S. Geological Survey

National Aeronautics and Space Administration
Earth Science

Taking Initiative

This section of the report moves the discussion beyond an analytical assessment of the Criteria and Indicators (C&I) to illustrate the context for the breadth, depth, diversity, and scale of private and public initiatives to improve forest management and forest conditions in the United States.

The C&I provide a common framework for monitoring progress toward sustainable forest management. In the United States, the quest for continuously improving forest conditions is shared by many government agencies, nongovernmental organizations, private businesses, and literally millions of individuals who own, manage, or otherwise affect forests in rural and urban areas. These organizations and individuals can and do act independently, and democratic governance processes recognize and respect their rights and responsibilities.[66] Hence, the potential power of a unifying framework such as the C&I to inform and guide the actions of the large number of organizations and individuals that comprise the community of interest, or issue network, pursuing the goal of sustainable forest management.[67]

The demographic and political characteristics of the forests in the United States create a situation in which moving toward sustainable forest management, as framed by the C&I, involves shared aspirations and responsibilities. To underscore this point, this section of the report presents a number of private and public actions related to the goal of sustainable forest management. The intent in presenting these actions is to illustrate, not exhaust, the description of the types, scale, and diversity of the actions in the United States. They are not tied to any particular criterion or indicator.

The Basis for Shared Responsibilities

The United States encompasses about 2.3 billion acres; 749 million of those acres, or 33 percent, are forested. Public entities (Federal, State, county, and municipal governments and government agencies) have jurisdiction over 336 million acres, or 45 percent of forests in the United States; with the other 55 percent being held by private (including tribal) owners. The USDA Forest Service manages the most substantial share of public forest, roughly 44 percent of the total (Smith et al. 2001). About 10 million nonindustrial private forest owners (NIPFs) hold title to approximately 46 percent of the Nation's forest land, a figure that represents 84 percent of all privately owned forests (Smith et al. 2001). Furthermore, 90 percent of those nonindustrial private forest holdings are 100 acres or less (Birch 1996). This condition, which challenged the efforts to improve forest conditions on NIPF lands in the past through education and outreach, will continue to challenge efforts to promote sustainable forest management on these properties now and in the future. Firms involved in the timber industry own about 9 percent of forests in the United States and control 16 percent of all private forests (Smith et al. 2001). See figure 8 for more perspectives about ownership of forest lands in the United States.

Just as there is a great diversity among the types of owners of forests in the United States, management objectives vary substantially with ownership as well. At the Federal level, for example, while all agencies holding forest land may share an overarching goal of land stewardship, the USDA Forest Service management mandates differ from those of other Federal agencies within the U.S. Departments of the Interior, Defense, and Energy. Other public owners (State and local units of government) bring a unique approach to managing their forests. In the private sector, nongovernmental organizations that hold land for preservation purposes clearly differ from firms involved in producing wood and wood products. Tribal lands are included in the NIPF ownership and are managed for a variety of objectives. Finally, just as there are millions of owners,

[66] In the United States no 'national forest program' integrates the conservation and sustainable use of forest resources and values as presented in the Proposals for Action recommended by the Intergovernmental Panel on Forests established in 1995 by the United Nations Commission on Sustainable Development. International dialogs often assume a 'national program' exists.

[67] A community of interest includes people who interact and link through networks and values they share. The research methodology used to gather information from a panel of experts knowledgeable about the issue is provided in Appendix 2.

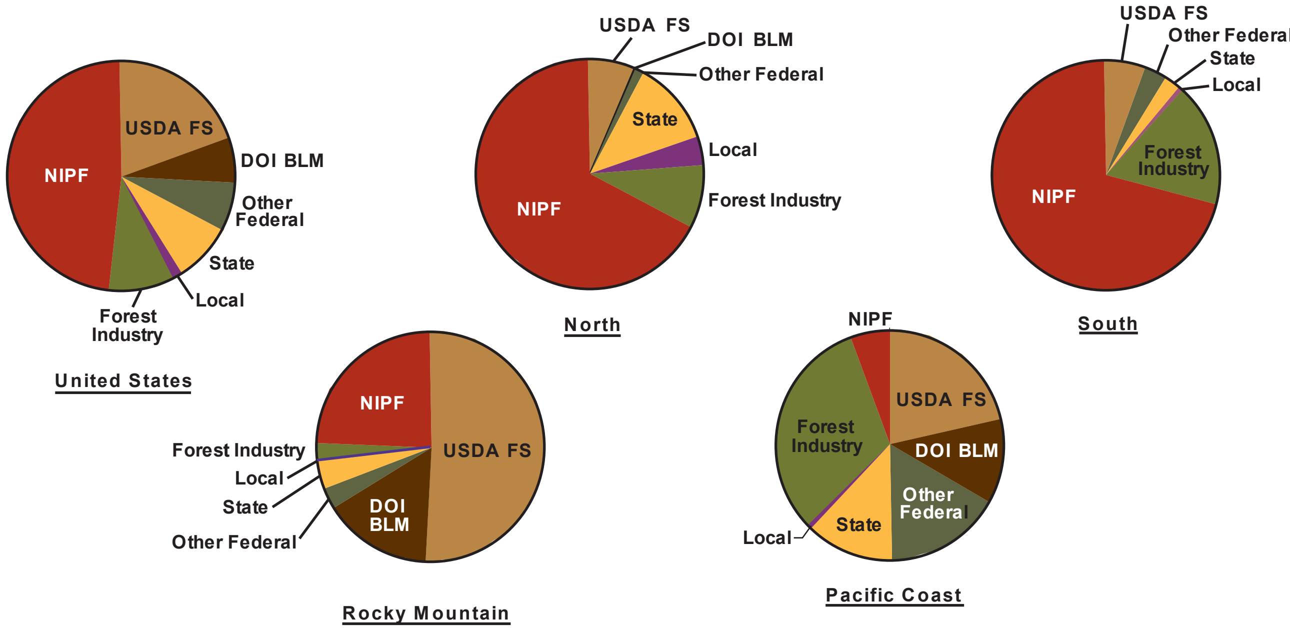


Figure 8. Forest land area in the United States by ownership, 2002. (Data from Smith et al. 2002.)

there are many individual management decisions being made that affect forests.

The government involvement in forest management activities also varies with jurisdiction. Federal forest and environmental statutes generally affect only Federal forests, with the exception of national clean water and endangered species laws that affect the management of both private and public lands. Several Federal agencies are responsible for managing federally owned lands as well as for administering programs to address forest-related concerns on other public or private lands. For example, the USDA Forest Service has no regulatory responsibilities over private lands but does carry out, in partnership with State agencies and others, a variety of financial and technical assistance programs. The goals of these programs are to improve forest conditions through fire prevention and suppression, insect and disease control, and cooperative efforts with NIPFs and communities (rural and urban). Traditionally, States have been responsible for regulating the management of State-owned and privately owned forest land within their borders. Currently, 10 States have comprehensive forest management practices acts that affect activities on private forests, with the other States involved through individual statutes most commonly designed to minimize nonpoint-source water pollution (Ellefson et al. 1995). Augmenting State involvement are counties and municipalities, which have become increasingly active in regulating private forest management through tree protection, road protection, and aesthetic ordinances (Spink et al. 2000; Martus et al. 1995). Since the mid-1990s, regulations affecting some Federal and State forest lands have been amended to include concepts of sustainable forest management. These regulations are the exception rather than the rule, however, and predominantly affect public forest acres.

Perhaps compounding the diverse array of ownership patterns, management objectives, and forest policies, the open political system in the United States allows for public participation at all levels of government (local including municipal, county, and other jurisdictions; State; tribal; and Federal) and in all three branches of government (executive, legislative, and judicial). This allows members of the general public access to a number of points in the political system at multiple levels, including through their elected and appointed officials; through legislative bodies at all levels; through circuit, appellate, and higher courts; and through Federal land management planning statutes.

One result of public participation at all government levels is the development of political interest groups by like-minded individuals that allow for greater political impact than would result from the same number of individuals working alone. In addition to pursuing nonpolitical work in areas of forest management, these groups often seek to affect public policy decisions at many spatial scales (Berry 1997). Such interest groups, along with government bureaus, private entities, and other interested individuals and groups, form a network around issues that are important to them at national, regional, State, county, and municipal jurisdictions (Heclo 1978). A key result of such issue networks is that the many stakeholders who are interested in sustainable forest management have access, both within their community of place as well as through their community of interest, to many politically influential groups and initiatives to improve forest management and forest condition in the United States.[68]

[68] A report on public outreach published by the USDA Forest Service defines 'communities of place' and 'communities of interest' as follows: Place-based communities consist of people who reside in and identify with a specific locality, interact socially, and cooperate to meet common needs; and interest-based communities include people who interact and link through networks and values they share.

Examples of Current Actions

The broad topic of "actions improving forest management and forest conditions" can be focused by the question—who is doing what in the United States? Through a research project done to carefully answer such a question, categories were developed to help identify the fullest range of actions examples possible.[69] The categories were stakeholders (who), instruments (what), and scale (where).[70]

Stakeholders are the groups and individuals who make up the sustainable forest management issue network and who actively participate in sustainable forest management issues and programs in the United States by banding together through either their community of interest or community of place, or both. Instruments are the tools that stakeholders use to accomplish their objectives. Scale represents the geographic areas in which stakeholders operate. It can be further subdivided into geopolitical areas and ecological regions to reflect that even though many efforts are based on watersheds, forest types, or other environmental attributes, stakeholders must also operate within the boundaries of various legal, institutional, and political landscapes. (See Appendix 2 for an example of scale parameters.)

The instruments currently used in the United States, as identified through the research and review processes and listed in Appendix 2, are briefly described below.

Public Policy

As with public attitudes toward forests and forest benefits, these public policies have evolved from single-resource ordinances regulating individual forest attributes, such as timber or a particular wildlife species, to multiobjective management statutes that focus on the sustainability of the entire forest. Policies can be distributive (such as allocating timber, wildlife, water, nontimber resources, recreation, and other forest goods and services), redistributive (such as managing programs that use financial subsidies or incentives to encourage private owners to adopt beneficial land management practices), and protective regulatory (which establish standards, limit certain actions, implement sanctions, and use other methods to regulate public and private forests). Federal statutes, such as the National Environmental Policy Act and the Wilderness Act, directly apply to federally managed forests and indirectly affect others. Laws such as the Endangered Species Act and the Clean Water Act, however, affect both public and private owners. States, counties, and municipalities regulate private forests via comprehensive State statutes such as Oregon's Forest Practices Act, through individual regulations such as State nonpoint-source water pollution statutes, and through best management practices programs. States and other jurisdictions also affect forest management through other policies such as transportation restrictions.

[69] See Appendix 2 for an explanation of the research methodology.
[70] See Appendix 2 for the complete lists.

The public policy instrument is broader than the collected forest-related laws, policies, and statutes, however, and includes efforts by interest groups to influence the policy process at all levels of government. These efforts can take the form of direct lobbying of Federal and State congressional committees, subcommittees, and individual lawmakers in the legislative branch, of appeals of management decisions by Federal and State executive branch agencies, and of participation in county and municipal meetings and processes. Public policy also includes Federal, State, county, and municipal tax policies, which are designed primarily to encourage (or at least to not unfairly penalize) long-term forest ownership by private individuals. Given the broad scope of this instrument, the multiple access points to the political system, the numerous interest groups and individual stakeholders motivated by sustainable forest management, and the number and diversity of statutes, the public policy instrument will continue to play an important role in the efforts to influence sustainable forest management in the United States.

Legal and Judicial Processes

The legal and judicial processes instrument focuses on enforceable provisions within the law that affect public and private forest management and on those aspects of the law that allow some private or public legal action. A primary objective of stakeholders who use this instrument is to clarify protective regulatory policy via the judicial opinions that make up case law. These processes can be small in scale, affecting the management planning on a single forest, or can be broad in scope, such as decisions mandating that the Secretary of the Interior designate critical habitat for an endangered species. Case law can result in new policy, such as the decision in the *West Virginia Division of the Izaak Walton League of America v. Butz*, which resulted in the passage of the National Forest Management Act (NFMA) in 1976.

Federal and State Government Programs

Many Federal and State government agencies in the United States administer programs aimed at improving forest and other natural resource conditions in accordance with their established missions, as well as statutory and program responsibilities. For instance, at the Federal level, these programs include, but are not limited to, agencies within the Departments of Agriculture, the Interior, Commerce, Defense, Energy, and Transportation, and the Environmental Protection Agency (EPA). Many agencies have programs that help private landowners manage forests and the forest attributes on their properties and that assist communities and businesses in rural and urban areas through a variety of outreach and assistance vehicles. Agencies use multiple methods (e.g., cost-sharing, training), employing a combination of technical and financial resources, as well as tax incentives, to encourage conservation of private and other nonfederally owned land and resources. Since agencies have to report on program impacts and results, there is an abundance of anecdotal information about these programs. Stakeholders have identified the need for more coordination among government programs and between the public and private sectors, however, and for increasing landowner and public understanding about the scope and effectiveness of programs to address important societal issues or target vulnerable places.

Tribal Programs

Tribal programs exhibit a variety of instruments to address sustainable forest management goals. Some programs use tribe-to-tribe collaboration, such as efforts by the Intertribal Timber Council and the Native American Fish and Wildlife Society, to improve the management of natural resources on lands managed by American Indians and Alaska Natives. Others employ forest management guidelines, as used by several Indian tribes who manage their own forests to produce commercial timber harvests and jobs for their communities. Other tribes with little or no forest land have used tribal/Federal collaboration, such as a proposal to engage in joint management with the USDA Forest Service by conducting restoration programs on lands managed by the USDA Forest Service that have tribal spiritual significance. The signing of Executive Order 13175 in 2000 brought more attention to opportunities for strengthening government-to-government relationships between the U.S. Government and federally recognized American Indian and Alaska Native tribes. Many rights and privileges, such as hunting, subsistence, and gathering of plant resources, are associated with treaties. In addition, land and resources hold a special and unique meaning in the spiritual and everyday lives of many Native Americans.[71]

Data Collection, Inventory, and Analysis

Programs that collect, inventory, and analyze data have consistently proven important to efforts to understand historical trends and current conditions, forecast demands on forests, identify problems, assess program implementation progress and management, monitor health, and influence the public policy process. These efforts can be divided into public and private sector programs. The public sector programs include those mandated by law, such as the Resources Planning Act Assessment, the Forest Inventory and Analysis program of the USDA Forest Service, and the Natural Resources Inventory of the USDA Natural Resources Conservation Service, as well as those instituted by Federal agencies, including the National Spatial Data Infrastructure of the U.S. Geological Survey. Collaborative efforts by public entities include the work of the Federal Geographic Data Committee and the development of this report. Private databases exist for many purposes, from tracking timber prices, timber availability, and other attributes important to forest industry to classifying biological diversity to assist public and private conservation efforts.

Forest Management Certification

The private sector is advancing certification systems to provide a market-based approach to improving forest management. Certification is the process through which some entity evaluates the management practices of a particular forest property and assures markets and consumers that it meets their standards for a well-managed forest. This certification can be awarded by a neutral and independent third party or by a second-party program that enables an organization to endorse the practices of its affiliates or achieve a certain management standard as a condition of membership in the organization. Several certification systems operate in the United States and are a mix of for-profit, nonprofit, third-party, and second-party organizations. One estimate indicates that almost 17 percent of timber lands in the United States were enrolled in one of the five major certification programs in the spring of 1999 (Moffat 1999), with this total growing to almost 30 percent in the summer of 2002 (Moffat and Cubbage 2002). Large private industrial holdings make up most certified properties. The State forests (such as those in Pennsylvania) are the most predominant group among public sector enrollees, with the small NIPF properties constituting the smallest share.

Supply/Demand of Certified Forest Products

As with certification, this instrument represents a private sector, market-based approach to improving forest management by owners who have their timber harvested for industrial uses. Certified forest products are made from wood that originated from certified forests and whose manufacture can be traced by a chain of custody from retailers and wholesalers back to the land. Despite the estimate that nearly 30 percent of forests in the United States are certified, the supply of certified products is relatively low. To facilitate the transfer of such materials, and to increase their demand, a growing number of organizations are devoted to increasing the markets for certified forest products and to linking suppliers to wholesalers. Several stakeholder groups, whose primary interest lies in this marketing area, are located in the Western United States. Related to this overall effort are many new programs by large retailers that closely monitor their lumber and wood products suppliers and move toward offering consumers a greater number of certified materials.

Markets for Forest Products and Services

Given the predominance of private forest lands in the United States, markets for forest products can provide a significant financial incentive for owners to keep land in forest rather than convert it to nonforest uses. These markets can be split between nontimber and timber products, and between consumptive and nonconsumptive uses. Nontimber products and services are increasing in importance in the marketplace, and stakeholders are initiating programs to link suppliers with markets

[71] Executive Order 13175 was signed to "establish regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes."

and to promote management programs specifically to improve the abundance and quality of nontimber resources and benefits. While timber products remain an important aspect of the U.S. economy as a whole and a leading industry of many forested States, diverse efforts are under way to enable NIPFs and indigenous owners to retain land in low-intensity working forests. These include multiowner cooperatives and related programs that offer NIPFs an annuity in exchange for timber or other property rights for a set period of time.

Grants

Financial resources may be needed to improve conditions and encourage sustainable forest and resource management across jurisdictions and ownerships. Financial resources, for instance, are needed to build community and landowner capacity, implement and monitor ecosystem restoration projects, develop and use new technologies and products, and take advantage of market forces. Grants are a key to making financial resources available to invest in innovative and long-term efforts that might not be supported through normal market mechanisms. Although many grant resources are available from Federal and State government agencies, grants from nongovernmental organizations and private foundations are growing in importance.

Forest Management Guidelines

Because people purposefully manipulate forests to produce goods and services, forest management guidelines, as implemented by government and industry through their planning processes, are a management staple for certain forest attributes. A significant number of private programs focus on managing, regenerating, and restoring a particular sensitive forest type within an ecologically defined area or on improving and restoring environmental conditions in a subregion. In addition, the certification systems being advanced by private for-profit as well as not-for-profit organizations use principles and guidelines to impact forest management by landowners. Public sector initiatives are diverse, including programs that focus on NIPFs. NIPFs have varied reasons for owning forest land—owners of larger acreages tend to have timber production as an objective, while owners of smaller acreages tend to have more diverse objectives, including enjoyment of owning, recreation, and land used as part of the residence or farm.[72] Assistance through the Forest Stewardship Plan and Forest Legacy Program administered by the USDA Forest Service, for example, helps NIPFs refine their management objectives. Newer efforts, such as the Local Unit and Criteria and Indicator Development project of the USDA Forest Service, attempt to address the environmental, social, and economic dimensions of sustainability by developing sustainable forest management guidelines at regional and subregional levels for federally managed forests.

Land Acquisition for Conservation

Acquiring land for conservation purposes has grown in scope and complexity since private and other non-Federal programs first started making gains in this area in the 1970s. Private efforts include local, regional, State, and national land trusts that either directly purchase property they deem significant or acquire significant lands through donations and/or estate planning, or through legally acquiring development and other land use rights through conservation easements.[73] Public efforts have a long history as typified in the late 19th and early 20th centuries by designating public domain lands to form wildlife refuges, forest reserves, and national parks. Public efforts may also be exemplified by the Heritage Trust programs, which are active in most States. Additionally, public programs for conservation include programs for private landowners such as the Forest Legacy Program administered by the USDA Forest Service and the Farmland Protection Program administered by the USDA Natural Resources Conservation Service. Collaborative efforts can be public/public ventures, in which two or more agencies work jointly, or they can be public/private partnerships, as when a land trust transfers property to a public entity for long-term management. Such public/private partnerships combine the nimbleness of the private sector with the permanence of the public sector.

Forest Management Technology

Advances in technology have reduced some negative environmental impacts from harvesting systems and have increased efficiency in milling and processing lumber and other forest products. Specialized equipment that minimizes soil disturbance and captures more merchantable material than older systems is being employed by a greater number of industrial firms when they harvest timber and other types of industrial wood. Sawmills are increasingly designed to incorporate computer optimization technology that uses optical scanners and algorithms to maximize the recovery of merchantable material and minimize waste. Finally, structural wood products are being engineered to use wood chips, wood fiber, and glue to form panels, beams, and joists from material that was previously unusable for such purposes. Technological advances related to seedling survival and nursery practices also help improve the success of establishing new forest. Both arenas of technological change help keep land in forests and increase yields from intensively managed forests, particularly planted forests. Technical support is available from private consultants, extension staffs, universities, government agencies, and other service providers.

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[72] Landowner characteristics, attitudes, harvesting experience, tenure, and management planning are discussed in *Private forest-land owners of the United States, 1994*.

[73] The Land Trust Alliance uses the following definition of a ‘conservation easement’— permanently protects open space by limiting the amount and type of development that can take place, but continues to leave the land in private ownership. A conservation easement can be negotiated between a landowner and a government agency as well as between a landowner and a land trust.

Community Development

Community development activities aimed at improving forest stewardship and conditions and/or integrating concerns about natural resource management with community well-being in the United States include many diverse efforts, varying from small geopolitical-scale efforts to broad programs for communities regionally and nationally. Specific activities include small-scale, low capital, community-based ventures; large-scale industrial development; watershed management and restoration; land and resource planning; and inventory and monitoring. The types and scales of arrangements vary—with private measures predominantly in the East, public programs predominantly in the West, and public-private partnerships throughout the country. It seems that while many individual initiatives and programs affecting places (e.g., rural areas, municipalities, counties, watersheds) and stakeholders in all regions of the country are well known, in aggregate the distribution of these efforts is not known and the impact of the many independent efforts has not been assessed.

Collaboration and Facilitation

A growing number and diversity of collaborative efforts are under way at various scales in the United States, employing both informal and formal approaches. The continuum of collaborative activities involves a complex array of interests, including government officials and agencies, nongovernmental organizations, small businesses and large industry, forest landowners, forest managers, forest workers, community practitioners, individual citizens, and others. Collaboration and facilitation processes generally involve and/or result in increasing public awareness, building constituency support, transferring technology, leveraging and mobilizing expertise and resources, and managing forests and other natural resources. Although many collaboration experiences have been reported as anecdotal stories and case studies, there is growing interest in the United States among academics, public agencies, community groups, and other stakeholders to learn from the various experiences and to apply processes, technologies, and other tools being developed. Many people are also eager to better understand the usefulness and limitations of collaboration and facilitation for improving relationships, dealing with specific issues and situations, strategizing and planning at multiple scales, and integrating implementation efforts through partnerships or other arrangements.

Education and Outreach

Education and outreach programs have long been used to transfer technology to private landowners and communities. Among the most familiar of these are State cooperative extension programs that are typically directed by land-grant colleges and universities, some of which include programs aimed specifically at forestry. State extension programs rely on both county agent systems, in which individual site visits are combined with educational offerings for interested landowners and other individuals, and through short courses at universities and other locations. Related Federal efforts include the USDA Cooperative State Research Education and Extension Service, which educates, trains, and assists private landowners, State employees, and other practitioners and decisionmakers in the conservation, management, and use of forest lands. Many other agencies, nongovernmental organizations, and professional societies also have vital and unique roles in providing informal and formal education in the many subjects related to the multiple dimensions of sustainable forest and resource management. Licensing and credential programs are part of the continuing education provided to ensure practitioners and others have the necessary knowledge and skills.

Forest Research

There is a long history of forest-related research that is accomplished by public, private, and collaborative efforts. Specifically germane in this area are programs for analyzing such diverse topics as biodiversity, watershed management, restoration ecology, wildlife habitat management, forest productivity, forest policy, forest economics, and forestry-related social sciences. A recent analysis of the national capacity in forestry research linked the number of forestry scientists in the United States to each 'sustainable forest management' criterion, with 80 percent being associated with criteria 1 through 5, 15 percent with criterion 6, and 5 percent with criterion 7.[74] Research is accomplished through academic institutions, forest industry, and the public sector (especially USDA Forest Service Research and Development). A unique joint venture of USDA's Forest Service and Natural Resources Conservation Service, the National Agroforestry Center, focuses on cross-sectoral issues and applications in the United States. Numerous other research, extension, and teaching programs at public universities, private universities, private research institutions, and nongovernmental organizations are important contributors as well.

Striving…Not Yet Arriving

We are striving toward, but not yet arriving at, the national goal of sustainable forest management. The great many initiatives under way by forest owners, managers, and stakeholders in the United States demonstrate the robustness of our democratic governance traditions. Different instruments affect different systems differently. Through dialog and shared learning we need to better understand and describe the effects, then adapt successes to other situations. Multistakeholder processes can help foster better and faster learning, which in turn can help shape change.

[74] Statistics on the National Capacity in Forestry Research are provided for teaching, research, and extension.

Through the process of reporting on the 67 indicators of sustainable forest management, we have learned many things. The indicators provide a common language for dialog, and the report itself serves as a common base of information for shared learning. The report also provides factual information supporting actions on the ground leading to healthier forests and communities. The information in this report gives us a shared understanding of current resource conditions and a baseline against which to mark future progress in the continuing transition toward sustainability.

What Are the Challenges to Assessing the Sustainability of America's Forests?

This report represents a state-of-the-art baseline for reporting on the trajectory toward sustainable forests at the national scale. Still, many data gaps exist. We need clearer responsibilities and larger investments in monitoring the condition and use of America's forests. Specific challenges to assessing the sustainability of America's forests include:

- **Incomplete data**. Sustainable forest management is a function of the value that society places on indicators, individually and as a group, as well as the value assigned to particular indicator quantities, conditions, and trends. To make a definitive statement about sustainability, current information should be available for all 67 indicators. Data for 11 of the indicators is incomplete and data for 9 indicators was modeled. For a number of other indicators, the available data is more than 5 years old and in some cases much older. Consequently, a definitive statement about sustainability cannot be made within the context of these 67 indicators.

  Even if data was available for all indicators, making a definitive statement about sustainability would require a collective assessment of the values for all the indicators. At present, an incomplete understanding exists regarding the importance that society places on each of the indicators. Central to achieving this understanding is a value-based dialog founded in part on indicator quantities, conditions, and trends.

- **Lack of subnational data**. The American public is interested in forest sustainability at multiple scales—local, community, regional, and national. A national-scale report inevitably obscures the importance of extreme conditions that exist in some localities. Currently, only a few indicators have data available to describe subnational trends. For most of the 67 indicators, the data is national with some regional coverage, which means a breakdown for all regions is not possible. Only the data for timber indicators in criterion 2 is generally complete, current, reliable, and available regionally or statewide. Opportunities exist, however, to develop databases and indicator analyses to better understand local conditions. We need to have the ability to "scale up" this local and regional information to better understand national trends, while at the same time ensuring that information on local and regional "hot-spots" is fully displayed.

- **Diversity of forest ownership**. The mosaic of forests in the United States is owned and managed by a mix of owners—government and nongovernment. About one-third of the Nation's forests are federally owned, and forest management decisions are made by a number of Federal agencies, including the USDA Forest Service. The balance is controlled by non-Federal public agencies and nongovernmental interests, including 10 million private landowners—individuals, families, companies, tribes, and others—who share responsibility for managing the Nation's forests. Many other factors also affect the management and use of forests, including Federal, State, and local laws and regulations; private property rights; and public land management policies. The aggregate impact of these factors is critical to understanding forest sustainability.

- **Integrated and interdependent concept**. The criteria and indicators (C&I) are a construct to help us understand the sustainable forest management concept. Sustainable forest management is a highly integrated and interdependent concept. The environmental, economic, and social spheres exert joint, simultaneous, and inextricable influences on forests. Opportunities to shape one sphere affect the others. We need to think more about sustainable forest management in the context of linkages among the three spheres. We think certain inputs are important: population, preferences, and values in social systems; income, consumption, and trade in economic systems; and natural resource stocks and flows in environmental systems. Yet, we do not know enough about how forests function within the environmental sphere and in how the three interlinked spheres function, thereby affecting or being affected by forests, especially at the national aggregate level.

Dialog fostered by the report will help focus future investments on filling the gaps that promise the biggest gain in understanding forest sustainability. Better data will lead to better dialog on the sustainability of America's forests, which will in turn lead to better decisions.

What Can Be Done To Improve the Understanding and Reporting of Forest Sustainability?

We have learned much about the C&I from producing this national report and from the First Approximation Report (USDA Forest Service 1997).[75 & 76] Substantial stakeholder and scientific input has come through a series of workshops organized by the Roundtable on

[75] http://www.pwrc.usgs.gov/brd/Chapter5CI.htm
[76] http://www.fs.fed.us/global/pub/links/report/candi.htm

Sustainable Forests and its predecessors. Suggestions for specific improvements in the reporting of forest sustainability are included in the Data Report supporting this document report and in the reports of the workshops.[77 & 78]

What Information Needs To Be Gathered?

Indicator 61 summarizes the information available for each indicator, identifying where additional data is needed.[79] Three broad categories are described: data frequency, coverage, and reliability. Data is characterized as (1) having few gaps (generally complete nationally, less than 5 years old, and reliable); (2) having several gaps (not consistent nationally, slightly dated, and not measured frequently enough); (3) having numerous gaps (from inconsistent or nonexistent sources, more than 15 years old, or partial, with no consistent plan for remeasurement); or (4) constructed using various modeling approaches. The data for the 67 indicators span the spectrum from full coverage, to one-time studies, to very anecdotal information. Few indicators have a full suite of data that is recent, national in scope, and collected frequently. The most persistent gap is the lack of systematic, repeated national data collection.

The Federal memorandum of understanding (MOU) on sustainable forest management data establishes a mechanism for cooperation among Federal agencies having data responsibilities pertinent to the sustainable forest management goal announced in Presidential Decision Directive NSC-16 and endorsed in the Santiago Declaration.[80] The MOU provides a common interagency forum for Federal coordination to resolve issues integral to the ongoing collecting, analyzing, reporting, and disseminating of data and information related to the C&I. The MOU also provides a process for helping Federal agencies develop this national report. Twelve agencies have signed the MOU. The Sustainable Forest Data Working Group of the Federal Geographic Data Committee (FGDC) has responsibility for implementing the MOU.[81 & 82]

The Data Report and the technical workshops identified many issues (appendix 3) with available information on the C&I.[83 & 84] The Sustainable Forest Data Working Group has selected the following four high-priority issues for attention. Of course, progress will depend on the resources available.[85]

1. **Clarify the definitions of forest and rangeland**. Defining these terms is a long-standing, difficult, and contentious issue. The definition is fundamental to any discussion of forests because it categorizes the land base that is inventoried. Currently, definitions of forest and rangeland overlap among Federal agencies, resulting in total land area estimates that exceed the actual combined area. Good conceptual definitions exist, as does general agreement on typical forests and rangelands. Agreement is needed, however, on operational definitions at the boundaries—land with some trees as well as some grasses and shrubs—to compare data and estimates. The Oregon Demonstration Project (Goebel et al. 1998) found a difference of 10 to 15 percent in the areas of rangelands and forests using the varying definitions that exist among Federal agencies. The differences relate to what is a tree and how many are needed for a forest. Species such as pinion pine and juniper can be classified as either trees or shrubs because their growth habits vary. One definition requires at least 25 percent crown cover for a forest while another requires only 10 percent. A stakeholder group including representatives of the Roundtable on Sustainable Forests, Sustainable Rangeland Roundtable, Federal agencies, and professional societies is working on developing standard definitions acceptable to both forest and rangeland groups.[86]

2. **Define taxonomy, measures, and values for nontimber forest products and services**. Examples of nontimber products include berries, worms, mushrooms, cedar bark, flowers, grasses, seeds, tubers, and herbs. Hunting, fishing, other recreational pursuits, and mining in the Nation's forests are highly profiled and valued activities. In most cases, data regarding the types, quantities, and market values of nontimber products removed from the various forests are either highly sporadic or nonexistent. Accurate forest inventories should include the resources being used or removed, the rate of removal, and the quantity being removed. More precise accounting of these types of information is essential, in many cases, to evaluate forest sustainability.

3. **Develop a national strategy for monitoring human community and economic indicators relating to the social, economic, and cultural impacts of forests and forest management on regions and communities**. The cultures and economies of many communities are closely linked to the forests that surround them, and they need to be considered as part of sustainability. Information about the cultural and spiritual significance of American forests to various groups is available, but only in a qualitative format. Social scientists have developed techniques through which the value people place on the recreational and esthetic benefits of forests can be qualitatively estimated. No one has found a way, however, to assign a quantitative weight to cultural and spiritual values. Fully understanding these variables will require interaction with communities through case studies and immersion. The results of such efforts will remain

[77] http://www.sustainableforests.net/
[78] http://www.fs.fed.us/research/sustain/
[79] http://www.fs.fed.us/research/sustain/
[80] http://www.pwrc.usgs.gov/brd/SFDmou.htm
[81] http://www.pwrc.usgs.gov/brd/sfd.htm
[82] http://www.fgdc.gov/
[83] http://www.fs.fed.us/research/sustain/
[84] http://www.sustainableforests.net/C&I_workshops/ci_workshops.html
[85] http://www.pwrc.usgs.gov/brd/sfd.htm

[86] http://www.pwrc.usgs.gov/brd/Definitions.htm

qualitative, but they will identify attributes of the forests that transcend quantitative analysis and inform forest sustainability. The Communities Committee of the Seventh American Forest Congress is working on this issue.[87]

4. **Define forest fragmentation indicator composition**. Within the framework of the criteria and indicators that determines the structure of this report, fragmentation (indicator 5) describes one aspect of biodiversity (criterion 1). Therefore, in this report fragmentation is specified as a measure of forest patch size because the size and arrangement of forest patches influence habitat suitability for different species. Other specifications of fragmentation as an indicator of biodiversity are possible. Other definitions of fragmentation as indicators of different criteria are also possible. For example, fragmentation of the forest estate into ownership parcels of different sizes can influence forest management and productivity (criterion 2), socioeconomic variables (criterion 6), and institutional variables (criterion 7). A more holistic definition (or multiple definitions) of fragmentation that reflects these influences is needed, along with protocols for measuring fragmentation according to the new definition.

The following issues also deserve particular attention.

- **Resolve database management, consistency, and integration**. Little has been done nationally to ensure standardization of databases. In addition, critical resource information, such as metadata, is often lacking. For example, the methodologies used to determine plot location, such as Global Positioning System (GPS) information, and the calibration of measurement tools are critical to achieving accurate repeat measurements. Finally, format structures remain nonstandardized. Incompatibilities make it impossible to combine and transform data without introducing considerable uncertainty into results.

- **Improve measurement of biological diversity**. Current monitoring emphasizes trees and birds because they are interesting and easy to monitor. Monitoring programs should be expanded to survey important taxa that are not currently monitored and should include rare species and specialized habitats that are often missed. Where feasible, vital rates as well as population levels should be monitored for taxa to provide early warning of changes and to provide insights about the cause. Direct measurement of genetic diversity should be used for species at risk of losing genetic diversity, instead of relying on surrogate indicators. New methods should be developed to monitor changes in species ranges that are not well tracked by current methods. These improvements will enable monitoring of critical components of forest ecosystems and provide early warning of problems by monitoring more-sensitive components.

[87] http://www.communitiescommittee.org/

- **Implement the National Vegetation Classification (NVC) system and convert existing systems**.[88] The NVC system is the Federal standard for vegetation classification, but agencies have not yet fully implemented it. Using the same classification system is essential for sharing data. Agencies and organizations are strongly encouraged to adapt the NVC system as soon as possible and to crosswalk their current information into the NVC system. Where problems exist with the NVC system, efforts should continue to reach consensus on improvements.

- **Implement Forest Health Monitoring (FHM) and Gap Analysis Program (GAP) nationally**.[89 & 90] FHM is a national program designed to determine annually the status of, changes in, and trends in indicators of forest condition. The FHM uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems. FHM has been implemented in 34 States. GAP is a scientific means for assessing the extent to which native animal and plant species are being protected. The goal of GAP is to keep common species common by identifying those species and plant communities that are not adequately represented in existing conservation lands. National GAP coverage is scheduled to be completed in fiscal year 2005. These programs provide exceptionally useful information for analyzing sustainability.

- **Improve measurements of carbon budgets**. Two critical reasons for carbon management are maintenance of forest health and strategies to mitigate climate change. The importance of carbon—carbon storage, carbon sequestration, carbon cycling, and turnover—in ecosystems is beyond question. Total carbon is not currently measured directly, so it is estimated, using proxy variables and models. Measurements and models need to be improved and expanded. More information on land use and its history and on life expectancy of wood products and decay rates is needed. We know that many forest soils, hence carbon, in the United States have been degraded by past use, especially when such soils were periodically cleared for crop production or livestock grazing. Over time, many such areas (for example, in the East) have reverted to forest cover and are currently in a recovery stage in which surface and subsurface soil horizons are in a state of aggradation. In some areas of the West, systems are not recovering, even with removal of the perturbation (for example, Glen Canyon, AZ). In fire-suppressed ecosystems, a buildup of live and dead wood may result in more carbon than is typically found in the ecosystem. More research is needed to understand and mimic levels of forest carbon that result in healthy forests and a stable climate.

[88] http://biology.usgs.gov/fgdc.veg/
[89] http://www.na.fs.fed.us/spfo/fhm/
[90] http://www.gap.uidaho.edu/

Should a Conceptual Model Be Developed To Understand Sustainability?

Sustainability is a highly integrated and interdependent concept. It is difficult to understand how systems (environmental, economic, and social) function, especially at the national aggregate level. Developing a conceptual model would help us understand and communicate the relationships within and among social, economic, and environmental systems.

Each of us has a somewhat different concept of how social, economic, and environmental systems work and how the components are related, and we may each emphasize different components based on our perspectives and experiences. Using a collaborative approach, a conceptual model provides a vehicle for resolving differences and reaching consensus among various stakeholders.

Finally, a conceptual model would also document the relationship between the measured indicators and forest sustainability through the development of reference values. Reference values specify for each indicator a range or threshold that describes desired future conditions consistent with achieving forest sustainability.

In describing the conceptual basis for the Northwest Forest Plan, Noon et al. (1999) present a six-step process for identifying and validating indicators.[91]

> "To select indicators that reflect underlying ecological structure and function requires well-developed conceptual models of the resources of concern.... The model should demonstrate how the system works, with particular emphasis on anticipated system responses to stressor input. The model also should indicate the pathways by which the system accommodates natural disturbances and how the system may acquire resilience to disturbance... As a general goal, management will strive to maintain ecological processes. These functions, however, are often difficult or impossible to measure directly. Conceptual models should identify structural and compositional elements of the resources affected by, and affecting, the underlying processes.... Measurements and inferences from biological systems are affected by the scale of observation. Therefore, to determine the appropriate scale for measuring an indicator, the temporal and spatial scales at which processes operate and resources respond must be estimated (at least to a first approximation) and clearly identified in the conceptual model." (Noon et al. 1999: 33)

The USDA Forest Service's Local Unit Criteria and Indicators Development (LUCID) team conducted a pilot study that appraised the feasibility of monitoring sustainability systems at the forest management unit scale.[92] Because sustainability issues involve multiple scales, achieving the national goals of sustainability rest, in large part, on actions that are carried out at the local or forest management unit scale. The LUCID team (Wright et al. 2002) found that conceptual models were very useful in the following:[93]

- Clarifying team members' understanding of how things are related;
- Identifying areas of uncertainty, including how things are related (for example, direction);
- Identifying missing monitoring components or gaps;
- Identifying critical monitoring components and redundancies;
- Requiring team members to be specific about what and why elements were included; and
- Communicating complex ideas in a more straightforward, graphic means.

The Northwest Forest Plan and LUCID study are two examples that stress the importance of understanding the relationships among economic, social, and environmental systems as the first step in evaluating indicators. A conceptual model is an important tool in gaining that understanding and communicating the role of the C&I in measuring progress toward sustainability.

What Should Be Done To Review and Revise the Criteria and Indicators?

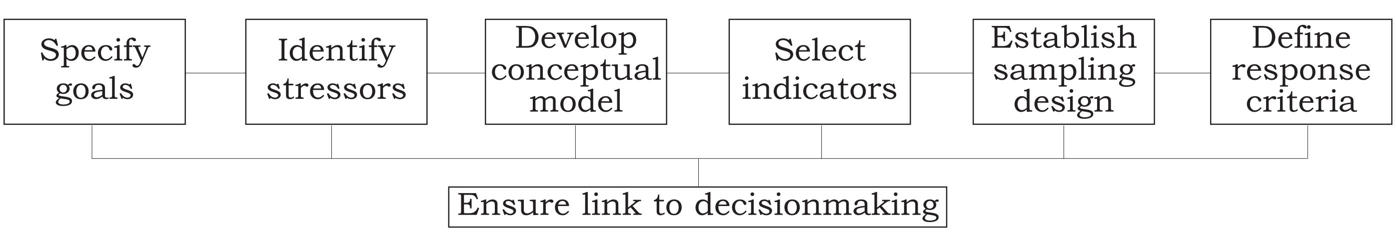
The 12 Montreal Process countries agreed to not change the C&I until after the countries issue their 2003 reports. With the experience of producing the U.S. report, we can begin the process of reviewing the effectiveness of the C&I in measuring progress toward sustainability. We can also draw on the experience of the Sustainable Rangeland Roundtable and Sustainable Minerals Roundtable, which are developing a similar set of criteria and indicators, and on the experience of the other countries in the Montreal Process.[94] The Heinz Center report on The State of the Nation's

[91] http://www.nature.nps.gov/im/monitor/gtr_437.pdf

[92] http://www.fs.fed.us/institute/lucid/

[93] http://www.fs.fed.us/institute/lucid/final_report/LUCID_Management_Edition.pdf

[94] http://www.cnr.colostate.edu/RES/srr/; http://www.unr.edu/mines/smr/



Steps in the design of a monitoring program (Noon et al. 1999)

Ecosystems provides another broad set of indicators, as does the Interagency Working Group on Sustainable Development Indicators.[95 & 96]

The authors and the participants at the workshops have suggested a number of improvements. We anticipate that any changes will be evolutionary and not revolutionary, because it will be important to be able to compare future estimates with the estimates in this report and because many stakeholders have interests in the current C&I. A number of areas exist, however, in which the C&I can be improved. For example, the technical workshops found that none of the indicators measure genetic diversity, and those labeled "genetic diversity" actually measure other aspects of species diversity.[97] The review and revision of the C&I should be a collaborative process involving the domestic and international stakeholders. The domestic stakeholder group that developed the C&I has largely evolved into the Roundtable on Sustainable Forests, and that group would provide a good forum for the review and revision.[98] Federal agency efforts to review and revise the C&I should be coordinated through the Sustainable Forest Data Working Group of the Federal Geographic Data Committee, which is responsible for implementing the Federal MOU on Sustainable Forest Management Data.[99]

What Should Be Done To Improve Regional and Local Access to Information?

A major issue at the stakeholder workshop in Portland, OR, was the need to provide C&I information at the regional and local levels.[100] This report provides information at the national level. We need to provide the same information at the regional and local levels to support sustainable forest management. In addition, we need the ability to "scale up" local and regional information to better understand national trends, while at the same time ensuring that information on local "hot spots" is not lost. The USDA Forest Service's LUCID project has made some progress at the forest management unit level, but its C&I differ from the national C&I.[101] Although important scale issues in moving from the national level to the regional and local levels must be considered, compatible indicators at the different levels would be very desirable.

The data used for the national report exist at the regional and local levels for only a few of the indicators (see indicator 61). For indicators in which regional and local levels do not exist, data is sometimes collected but is not available in an accessible form. According to indicator 61, a total of 9 indicators use modeled data and another 11 have data that is incomplete. For most (39) indicators, the data is regional with some national, which means a breakdown for all regions is not possible. At this time, 59 of the 67 indicators do not allow for complete reporting of regional data.

While regional reports probably would be possible, the need for reports at smaller and smaller scales will always exist, and the number of possible reports would be prohibitive. A better approach would be to improve accessibility of the data at local levels and provide an automated procedure for summarizing and analyzing the data at that level. This is already possible with some datasets; but producing a report on all the indicators at a local level would be especially challenging because of the difficulty in accessing and merging all the data. Considerable effort would be required to make data for all the indicators available at the regional and local levels, but much interest in that information continues.

What Can Be Done To Advance Sustainable Forest Management in the United States?

With this report, we begin an important national dialog on how we can improve our ability to assess forest sustainability, and how public and private landowners can use existing knowledge in the management of our Nation's forests. This national dialog should address the following questions:

- How can we demonstrate through results on the ground our commitment to sustainable forest management?
- How can we develop the public trust and confidence necessary to achieving those results?
- What can we do to broaden and deepen the collaboration embodied by the Roundtable on Sustainable Forests?
- How can we help the public better understand forest sustainability and what needs to be done to improve it?
- How can we bring the principles of sustainability to bear on policies and programs?
- What should we do to improve the collection, analysis, and reporting of each indicator?
- How can we use the findings of this report to better understand the interactions within and among economic, social, and environmental systems?

This report provides factual information. It explains what we know and do not know about forest sustainability. But this report will cause no change by itself. People—landowners, land managers, stakeholders, members of the public—cause changes to occur.

Our actions speak louder than words. This report gives us a golden opportunity to better understand sustainable forest management and to immediately begin doing what we know needs to be done on the ground to improve forest sustainability.

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[95] http://www.heinzctr.org/ecosystems/
[96] http://www.sdi.gov/
[97] http://www.sustainableforests.net/C&I_workshops/ci_workshops.html
[98] http://www.sustainableforests.net/
[99] http://www.pwrc.usgs.gov/brd/sfd.htm
[100] http://www.sustainableforests.net/C&I_workshops/Summary_Review_WS_Portland_0206.PDF
[101] http://www.fs.fed.us/institute/lucid/

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Appendix 1—Glossary

age-class
A category into which the average age or age range of trees or other vegetation is divided for classification or use. Age-class is usually used in reference to even-aged stands of trees. It represents the dominant age of the main body of trees in a stand. In some mixed-aged stands, age-class can be used to describe the age of the dominant/codominant cohort of canopy trees.

air pollutants
Gases, particles, or aerosols generated from management or combustion activities (industry, transportation, agriculture, management, etc.) that are released into the atmosphere, transported, and deposited in human and natural ecosystems. Air pollutants may be absorbed by forest ecosystems without effects (sink) or exceed the absorption capacity and have a deleterious effect on processes or components.

biological diversity
The variability among living organisms from all sources, including, among other things, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems

biomass (woody)
The mass of the woody parts (wood, bark, branches, twigs, stumps, and roots) of trees (alive and dead) and shrubs and bushes, measured to a specified minimum diameter (d.b.h.). Includes above-stump woody biomass, and stumps and roots. Excludes foliage.

broadleaf (synonym: hardwood or deciduous species)
A dicotyledonous tree, usually broad-leaved and deciduous.

carbon absorption
The incorporation of the element carbon from the atmosphere into plant tissue.

carbon budget
The inventory of the element carbon in carbon pools and the balance of exchange between the pools in the area of study.

carbon cycle
The sequence of transformations whereby carbon dioxide is fixed as carbon or carbon compounds in living organisms by photosynthesis or chemosynthesis, liberated by respiration and/or death and decomposition of the fixing organism, used by heterotrophic species, and ultimately returned to its original state to be used again.

carbon pool (or stock)
The absolute quantity of carbon held within a pool at a specific time. Examples of carbon pools are aboveground forest biomass, soil, wood products, and the atmosphere.

carbon release
The emission of the element carbon from organic matter into the atmosphere.

climate change
The actual or theoretical changes in global climate systems occurring in response to physical or chemical feedback, resulting from human or naturally induced changes in planetary terrestrial, atmospheric, and aquatic ecosystems.

conifer (synonym: softwood, evergreen, or needleleaf species)
A coniferous tree, usually evergreen, having needles or scale-like leaves.

criterion
A category of conditions or processes by which sustainable forest management may be assessed. A criterion is characterized by a set of related indicators that are monitored periodically to assess change.

cultural need
Material goods, settings, or other state of being deemed necessary to achieve a desired lifestyle by individuals and groups sharing common values and identities. Often forest products, special sites, spiritual relationships with forests, or other connections with forests are part of what defines a culture and its lifestyle.

damage to forest
Disturbance to the forest that may be caused by biotic or abiotic agents, resulting in death or a significant loss of vitality, productivity, or value of trees and other components of the forest ecosystem.

diminished biological components
A reduction in the diversity of biological species. An ecosystem is considered to have both biotic and abiotic elements. Many species of microflora or insects are important to soil building, plant reproduction, or nutrient cycling. The biotic elements are dynamic in occurrence and will change in response to natural vegetation succession or artificially induced changes. The concept of diminished biological components reflects reductions or shifts in biological processes in a given forest relative to what might be expected, based on an undisturbed, similar reference site.

direct employment
The number of jobs created by public and private firms in the process of producing a good or service. In the process of producing the good or service, however, the primary firm also generates secondary economic activity in other sectors of the economy. The jobs created by this secondary economic activity are referred to as indirect employment.

ecosystem

A dynamic complex of living organisms (plant, animal, fungal, and micro-organism communities) and the associated nonliving environment with which they interact.

ecological processes

Processes fundamental to the functioning of a healthy and sustainable ecosystem, usually involving the transfer of energy and substances from one medium or trophic level to another.

ecosystem diversity

Describes the variety of different ecosystems found in a region. A categorization of the combination of animals, plants, and micro-organisms, and the physical environment with which they are associated is the basis for recognizing ecosystems.

endangered species

A taxon is endangered, but not critically endangered, when it is facing a very high risk of extinction in the wild, as defined by any of the following criteria:

a) Population reduction in the form an observed, estimated, inferred, or suspected reduction of at least 50 percent over the last 10 years or 3 generations, whichever is longer, or a reduction of at least 50 percent, projected or suspected to be met within the next 10 years or 3 generations, whichever is longer.
b) Extent of occurrence estimated to be less than 5,000 km2 or area of occupancy estimated to be less than 500 km2, including any two of the following: (1) severely fragmented or known to exist at no more than five locations; (2) continuing decline, inferred, observed, or projected; or (3) extreme fluctuations in extent of occurrence, area of occupancy, number of locations or subpopulations, or number of mature individuals.
c) Population estimated to number fewer than 2,500 mature individuals and either (1) an estimated continuing decline of at least 20 percent within 5 years or two generations, whichever is longer, or (2) a continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of a severely fragmented population (i.e., no subpopulation estimated to contain more than 250 mature individuals) or in all individula of a single subpopulation.
d) Population estimated to number fewer than 250 mature individuals.
e) Quantitative analysis showing the probability of extinction in the wild is at least 20 percent within 20 years or five generations, whichever is longer.

erosion (soil)

The wearing away of the land surface by running water, waves, or moving ice and wind, or by such processes as mass wasting and corrosion (solution and other chemical processes).

exotic species (synonym: nonindigenous species)

Any species growing or living outside its natural range of occurrence. Normally this refers to species purposely or accidentally introduced into countries or regions where they do not historically occur.

extinct species

A species for which there is no reasonable doubt that the last individual has died or when exhaustive surveys in known or expected habitat throughout its historic range have failed to record an individual.

forest available for timber production

Forest land that is producing or is capable of producing industrial wood and is not withdrawn from timber utilization by statute, administrative regulation, or formal conservation reserve purposes. Includes forest with conditions suitable for timber production even if so situated as to not be immediately accessible for logging.

forest ecosystem

A dynamic complex of plant, animal, and micro-organism communities, and their abiotic environment interacting as a functional unit, where the presence of trees is essential. Humans, with their cultural, economic, and environmental needs are an integral part of many forest ecosystems

forest goods

Things from the forest that are useful and beneficial, and that have intrinsic value or economic utility. Includes all flora and fauna, mineral, and water resources occurring or originating in the forest.

forest land

Land with a specified minimum tree crown cover and generally more than the specified minimum area, including land that formerly had such tree cover and that will be naturally or artificially regenerated. The trees should generally be able to reach a minimum specified tree height at maturity in situ. It may consist either of closed forest formations in which trees of various stories and undergrowth cover a high proportion of the ground, or of open forest formations with a continuous vegetation cover in which tree crown cover exceeds the minimum percent. Young natural stands and all plantations established for forestry purposes, which have yet to reach the minimum crown density or tree height, are included under forest, as are areas normally forming part of the forest area that is temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest.

Limiting measures for qualification as forest land vary by country. Current minimum area, cover, and tree height needed to be classified as forest by country:

Country	Minimum area	Minimum tree crown cover	Minimum tree height
Argentina	0.5 ha	10%	5 m
Australia	0.5 ha	20%	2 m
Canada	0.5 ha	20%	5 m
Chile	0.5 ha	25%	2 m
China	0.5 ha	20%	2 m
Japan	0.3 ha	30%	5 m
Mexico	25 ha	10%	3 m
New Zealand	0.5 ha	20%	6 m
Russia	0.5 ha	30%	varies
South Korea	NA	NA	NA
UnitedStates	0.5 ha	20%	5 m
	(1.0 acre)	20%	(16.4 ft)
Uruguay	0.25 ha	NA	NA

NA=Not available

forest services
Forest services are composed of:
- — Protection (against soil erosion by air or water, avalanches, mud and rock slides, flooding, air pollution, noise, etc.)
- — Social and economic values (hunting and fishing; other leisure activities, including recreation, sport, and tourism.)
- — Esthetic, cultural, historical, spiritual, and scientific values (including landscape and amenity)

forest type
A category of forest defined by its vegetation, particularly composition, and/or locality, as categorized by each country in a system suitable to its situation. The broadest general groups are:
- — Broad-leaved (hardwoods)
- — Coniferous (softwoods)
- — Mixed broad-leaved and coniferous

forest-dependent species (flora and fauna)
Any species that needs forest ecosystems and their conditions for all or part of its requirements of food, shelter, or reproduction. That is, any species that could not survive or reproduce in the absence of forest ecosystems is forest dependent. Migratory species that use the forest during migration, and forest species dependent on them, will also be considered as forest dependent.

forest management plan (or equivalent)
A written scheme of forest management, aiming at defined management goals, which is periodically revised. These include:

A. forest management plans
Information (in the form of text, maps, tables, and graphs) collected during (periodic) forest inventories at operational forest units level (stands, compartments), and operations planned for individual stands or compartments to reach the management goals.

B. equivalents
Information collected on forest area, at forest management or aggregated forest management unit level (forest blocks, farms, enterprises, watersheds, municipalities, or wider units), and strategies/management activities planned to reach the management or development goals.

forest soil
Soil with characteristics resulting from, or emphasized by, tree cover. (See soil.)

fragmentation
Describes one aspect of habitat capacity. Refers generally to the reduction in size of forest patches with coincident decreases in forest connectivity and increases in patch isolation and amount of forest edge. The fragmentation of a forest into small pieces may disrupt ecological processes and reduce the availability of habitat.

genetic diversity
Describes the variation of genetic characteristics found within a species and among different species.

gross domestic product (GDP)
A measure of country output composed of the market value of the goods and services produced by labor and property located in the country. Because the labor and property are located in the country, the suppliers (that is workers and, for property, the owners) may be either country residents or residents of the rest of the world. Gross product, or gross product originating (GPO), by industry is the contribution of each private industry and of government to the nation's output, or gross domestic product (GDP). An industry's GPO, often referred to as its "value added," is equal to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) minus its intermediate inputs (consumption of goods and services purchased from other industries or imported). The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), rev. 2.

growing stock
The living tree component of the standing volume on forest land. Generally, the central stem volume of trees of a specified minimum dbh measured from 0.3 m (1 foot) above the ground to a specified limiting top diameter.

Limiting measures for qualification as growing stock vary by country. Current minimum dbh and limiting top diameter needed to be classified as growing stock by country:

Country	Minimum Dbh	Limiting top diameter	Volume is reported
Argentina	10.0 cm	10.0 cm (o.b.*)	NA**
Australia	10.0 cm	10.0 cm (u.b.***)	underbark
Canada	10.0 cm	NA	NA
Chile	5.0 cm	5.0 cm (o.b.)	underbark
China	NA	NA	NA
Japan	4.0 cm	4.0 cm (o.b.)	NA
Mexico	NA	NA	NA
New Zealand	NA	NA	NA
Russia	8.0 cm	8.0 cm (o.b.)	underbark
South Korea	NA	NA	NA
United States	12.7 cm	10.2 cm	underbark
	(5.0 in)	(4.0 in o.b.)	underbark
Uruguay	NA	NA	NA

** overbark **NA=Not available *** underbark*

growth (net annual) (synonym: net annual increment)
Average annual volume over a given reference period of gross increment minus natural losses of all trees of a specified minimum DBH.

habitat
The natural environment of a living organism, primarily determined by vegetation, climate, soils, geology, and topography.

indicator
A measure (measurement) of an aspect of a criterion. A quantitative or qualitative variable that can be measured or described and that, when observed periodically, demonstrates trends.

indigenous communities
Communities of people descended from the first inhabitants of a nation or subnational region.

indirect employment
The result of two types of economic transaction. First, jobs are created in secondary firms that provide materials, supplies, goods, and services to the primary firm. Second, employees of primary firms spend their wages and salaries in the local economy, which generates activities in the local retail and service sectors.

IUCN classes for definition

Category I. Strict nature reserve/wilderness. An area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring; or a large area of unmodified or slightly modified land and/or sea, retaining its natural characteristics and influence, without permanent or significant habitation, which is protected and managed to preserve its natural condition.

Category II. National park. A natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area, and (c) provide a foundation for spiritual, scientific, educational, recreational, and visitor opportunities, all of which must be environmentally and culturally compatible.

Category III. Natural monument. An area of land and/or sea containing specific natural or natural/cultural feature(s) of outstanding or unique value because of its inherent rarity, representativeness, or aesthetic qualities, or cultural significance.

Category IV. Habitat/species management area. An area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species.

Category V. Protected landscape/seascape. An area of land, with coast or sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological, and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance, and evolution of such an area.

Category VI. Managed resource protected area. An area of land and/or sea containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while also providing a sustainable flow of natural products and services to meet community needs.

land area
An area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river food plains; streams, sloughs, estuaries, and canals less than 60 meters (200 feet) wide; and lakes, reservoirs, and ponds less than 1.8 hectares (4.5 acres) in area.

long term
Occurring over or involving a relatively long period of time. In natural resources, generally periods of 50 years or more.

merchantable
Trees of a size, quality, and condition suitable for marketing under given economic conditions, even if so situated as to not be immediately accessible for utilization.

monitoring
The periodic and systematic measurement and assessment of change of an indicator.

mortality (annual)
The average annual volume of sound wood in trees that died from natural causes during a specified year or on average during the period between inventories.

native species (synonyms: indigenous species, autochthonous species)
Usually, a species known to have existed on a site before the influence of humans. It depends on the temporal and spatial context of analysis, since long-established exotic species are often considered to be native by default.

new and improved technologies
Refer to changes to these methods that might improve the efficiency and/or effectiveness of their actions. The definition is deliberately broad to allow for changes relating to industrial methods and values as

well as to nonwood and nonextractive activities in the tourism, recreation, and indigenous food sectors.

nonconsumptive forest use
Forest uses that do not lead to the physical extraction of products from the forests. They might include recreation, photography, birdwatching, education, and contemplation or meditation.

nonmarket valuation
Valuation of goods and services not allocated through traditional markets.

nonmerchantable
A species that has no known commercial uses for wood products. Merchantability is usually judged according to the suitability of a species for pulp, paper, lumber, or specialty wood products. Both native and exotic tree species can be considered merchantable tree species.

nontimber forest products (synonym: nonwood products)
Includes game animals, fur-bearers, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat and fuel wood, forage, etc. In this context, such products do not include services provided by forests, such as water regulation, biodiversity conservation, recreational or spiritual values, and carbon release offsets.

persistent toxic substance
A relatively nondegrading pollutant that after discharge becomes a long-term component of soils, aquatic systems, and other materials. Upon exposure, ingestion, inhalation, or assimilation into any organism, the substance can cause death or disease, mutations, deformities, or malfunctions in such organisms or their offspring.

plantation
Forest stands consisting almost exclusively of planted trees of native or exotic species, and managed to generally maintain this composition at maturity. Management practices may include extensive site preparation before planting and suppression of competing vegetation. Forests that fall outside this classification are not necessarily natural forests.

population
1. The number of organisms of the same species inhabiting the same area that potentially interbreed and share a common gene pool.
2. The total number of organisms over a large cluster of areas, such as a physiographic region or a nation.

productive capacity
A classification of forest land in terms of potential annual cubic-measured volume growth of trees per unit area at culmination of mean annual increment in fully stocked forest stands.

protected area
A geographically defined area that is designated or regulated and managed to achieve specific conservation objectives. Specific objectives include:
1. Strict nature reserves/wilderness areas
2. National parks
3. Natural monuments
4. Habitat/species management areas
5. Protected landscape/seascape
6. Managed resource areas

(See IUCN classification system.)

protective function
An attribute of a policy or management decision that serves to preserve the essential components or processes of ecosystems, or specific components of an ecosystem, to maintain a desired quality and quantity of a resource commodity.

range of historic variation
The range of spatial, structural, compositional, and temporal variation of ecosystem elements (plants, soils, animals) within a period specified to represent 'baseline' conditions.

rare species
A species regarded as having low abundance and/or small range.

rate of return
On an investment, the income provided by the investment divided by the amount of money invested.

recycling
Wood fiber or other wood components in any form that are processed after initial use to regain material for human use.

removals (annual)
The net volume of trees, live or dead, of a specified minimum diameter (generally the same as for growing stock) removed from the forest during a specified year, or average for a reference period, by harvesting or cultural operation such as thinning or stand improvement, or by land clearing. Includes the volume of trees or parts of trees that are part of a harvest operation but are not removed from the forest.

representative species
Species with habitat dependencies typical of a group of similar species, which are likely to respond to changes in availability of those habitats or resources. Examples include species dependent on mature forests, air quality sensitive species, wetland-dependent species, hollow tree-dependent species, and thermoregulation-dependent species. Selected species are relatively easy to identify and monitor.

sedimentation
The deposition of eroded soil materials suspended in the water of creeks, lakes, or other water bodies. Sedimentation takes place when water velocity falls below a point at which suspended particles can be carried.

small portion (regarding species range)
Dependent on the initial (original or some level agreed as baseline) distribution of the species. Species with very limited natural ranges (which suggests they are a relict population or have very specific habitat requirements) cannot tolerate the percentage reduction

in habitat that a widely distributed species can. Small might, therefore, be defined for relict populations as the majority of existing range or, for species with large populations and wide distribution, a lower percentage of the historical population distribution.

social need
Human-to-human relationships or widely accepted behaviors viewed as necessary to normal functioning and welfare of a society. A society may be made up of a number of different cultures that may have much more specific needs. In relation to forests, access to recreational opportunities may be viewed as a social need.

soil
The top layer of the Earth's surface consisting of unconsolidated mineral or organic materials derived from geological material and dead, organic matter. These components are modified by biological, chemical, and physical processes.

soil chemical properties
The elemental and structural composition of the soil, modified by climate, weather, plants, soil insects, and microbes. They directly affect cycling of nutrients and toxic compounds, and are the basis for a healthy and sustainable forest ecosystem.

soil erosion
The movement of soil materials from one place to another. The movement of soil due to natural processes should be distinguished from that related to forest harvesting, road construction, or other human impacts. Note: Significant erosion needs to be defined by each country and with respect to variation between different landscapes and soils.

soil organic matter (SOM)
The carbon and other nutrients from decomposing plant materials that form an organic layer above mineral soil, and eventually mix with weathered parent rock to form soil. SOM enhances the nutrient and water-holding capacity of soil and improves nutrient cycling and water quality.

species at risk
Federally listed endangered, threatened, candidate, and proposed species and other species for which loss of viability, including reduction in distribution or abundance, is a concern.

species diversity
Describes the number and variety of species (flora and fauna) in a given area.

spiritual need
Human connectivity to others of any species or form whereby the perceived relationship is one of community or belonging. In relationship to forests, a spiritual need may involve being able to achieve a feeling of belonging to a broader forest community through activities leading to habitat improvement or other altruistic endeavors.

stream flow
The quantity of water in a watershed based on precipitation quantity and the ability of the watershed to store and slowly release water. Typically characterized by seasonal periods of high or low water flow. Changes in high or low flow patterns are indicative of changes in precipitation patterns and/or changes in the integrity of watersheds that affect its ability to absorb and regulate water flow patterns.

stream timing
The seasonal patterns of high and low water flows based on precipitation patterns. Changes in timing of stream flows are indicative of changes in precipitation patterns or watershed integrity.

subsistence
The harvesting or growing of products directly for personal or family livelihood. Subsistence needs generally include foodstuffs, fuel wood, clothing, and shelter. Subsistence goods can be considered any goods that are substitutes for a market good.

successional stage
A characteristic of many ecosystems that experience a change in structure and/or species on a given site in relation to time since a major disturbance. Where they occur, seral stages include early successional vegetation through to later successional stages. In many cases, the successional stages reflect a shift from the dominance of shade-intolerant species to that of shade-tolerant species.

sustainable forest management
The stewardship and use of forests and forest lands in such a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, and vitality, and their potential to fulfill, now and in the future, relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems.

The criteria and indicators are intended to provide a common understanding of what is meant by sustainable forest management. Each is of equal importance. They provide a framework for describing, assessing, and evaluating a country's progress toward sustainability at the national level and include measures of:

1. Conservation of biological diversity;
2. Maintenance of productive capacity;
3. Maintenance of forest ecosystem health;
4. Conservation and maintenance of soil and water resources;
5. Maintenance of forest contribution to global carbon cycles;
6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of society; and
7. Legal, institutional, and economic frameworks for forest conservation.

threatened species
Plant or animal species likely to become endangered throughout all or a significant portion of their range within the foreseeable future.

value added
(See gross domestic product.)

viable breeding population
A species consisting of self-sustaining and interacting populations that are well distributed through the species' range. Self-sustaining populations are those that are sufficiently abundant and have sufficient diversity to display the array of life history strategies and forms to provide for their long-term persistence and adaptability over time.

visitor use day
Generally, each person recorded or estimated as visiting a forest site for tourist or recreation purposes is counted as a 'visitor day.' The definition of 'visitor day' may differ among countries and, therefore, the definition should be presented with the data.

vulnerable species
A species that because it is very rare and distributed only locally throughout its range, or because it has a restricted range (even if abundant at some locations) is considered to be facing a high risk of extinction in the wild.

wood consumption
The amount of roundwood provided from domestic sources and other countries needed to make wood and paper products for domestic consumption.

wood products
Logs, bolts, and other round timber generated from harvesting trees for industrial or consumer use. Includes wood chips generated from round timber for industrial use.

wood supply
The amount of roundwood provided from domestic sources to meet domestic consumption needs.

Appendix 2—Methodology

A Delphi process was used to generate subcategories within the instruments, stakeholders, and scale main categories and to identify examples of on-the-ground action. Delphi is a procedure for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled feedback (Ziglio 1991). Delphi was selected for two main reasons. First is due to Delphi's strengths (1) when a problem, such as illustrating examples of sustainable forest management (SFM) actions, does not lend itself to precise analytical techniques but can benefit from subjective judgments by a group of experts on a collective basis, and (2) when the problem at hand has no monitored history or little adequate information on its present and future development. Second is due to Delphi's addition of academic rigor and transparency, which provides needed objectivity and expertise to augment the capacity of report managers.

The Delphi process supporting the development of this report had three distinct phases: (1) A panel of experts was identified; (2) A series of questionnaires was drafted and administered; and (3) Delphi panelists established an exhaustive set of subcategories of SFM action areas and a list of action examples for most subcategories to illustrate the diversity, breadth, and depth of instruments and stakeholders at multiple spatial scales. The Delphi output was slightly modified based on input from peer reviewers, public comments, and by participants in two workshops. The Delphi and the review processes generated a significant amount of the material presented in this section of the report. As such, the results presented in this appendix represent the collected judgment of a large number of forestry professionals.

Results

Results were generated in two main areas. First was a set of multiple subcategories within the three main categories of stakeholders, instruments, and scale (see the next three pages of this appendix for a full list of all categories and subcategories). Second was a list of approximately 150 examples of current actions in the United States. The individual examples presented in this appendix and used to describe the diversity within the stakeholders category were drawn from this list of 150 examples. Their inclusion does not constitute endorsement or approval of their methods or approaches. When reviewing the content of this section of the report, it is important to note that there can be significant overlap between some subcategories, making it possible for examples to be germane in several instances. We intend to make the entire list of 150 examples available as part of an on-line database and clearinghouse for sustainable forest management information.

Category: Instruments

Public Policy
- Distributive
- Protective regulatory
- Redistributive
- Tax
- National
- State
- Local

Legal and Judicial Processes

Federal and State Government Programs
- Landowner assistance
- Tax programs
- Cost-share programs
- Training programs

Tribal Programs

Data Collection, Inventory, and Analysis
- Public sector
- Private sector

Forest Management Certification
- Private industrial landowner
- Private nonindustrial landowner
- Public landowner
- Locally determined C&I

Supply/Demand of Certified Forest Products
- Primary customers
- Retail customers

Markets for Forest Products & Services
- Non-timber
- Timber
- Fiber/pulp
- Recreation
- Nonconsumptive use

Grants
- Private foundations
- NGOs

Forest Management Guidelines
- Industrial landowners
- Nonindustrial landowners
- Public landowners

Land Acquisition for Conservation
- Private efforts
- Public efforts
- Collaborative efforts

Forest Management Technology
- Low impact harvesting technology
- Computer optimization

Community Development
- Small scale, low capital
- Large scale, industrial development
- Watershed councils
- Partnerships
- Resource/land planning programs
- Inventory and monitoring

Collaboration and Facilitation
- Resource leveraging
- Technology transfer
- Constituency building
- Public awareness
- Forest management

Education and Outreach
- Forestry
- Environmental sciences
- Social sciences
- Extension programs

Forest and Related Research
- Biodiversity
- Economics
- Policy
- Productivity
- Restoration ecology
- Social sciences

Category: Stakeholders

Federal Government Entities
- Primary objective forest management
- Forest management secondary objective
- Congressional committees and subcommittees

Federal Regulatory Agencies
- Forest owning
- Forest regulating

State Government Entities
- Forestry agencies
- Wildlife agencies
- State park agencies
- Environmental agencies

Tribes
- Federally recognized
- Federally unrecognized

Nongovernmental Organizations
- National
- Regional/local
- Environmental/conservation
  o Advocacy groups
  o Policy development groups
  o Landowners and managers
  o Research groups
- Utilization/Development
  o Advocacy groups
  o Policy development groups
  o Landowners and managers
  o Research groups
- Associations and societies
  o Foresters
  o Ecologists
  o Economists
  o Loggers

Community groups

Forest Industry
- Forest products companies
- Equipment manufacturers
- Chemical companies
- Nurseries-botanicals, restoration species and native species suppliers
- Nontimber products producers

Forest Products Customers
- Developers and builders
- Forest product retail distributors
- Retail purchasers

Landowners
- Nonindustrial private landowners
  o Large (>100 acres)
  o Small (< 100 acres)
- Forest products industries
- Institutional owners
  o Financial
  o NGO landowners
- Conservation groups

Recreation User Groups
- Fishers
- Hikers/campers
- Hunters
- Off road vehicle users
- Tourism interests

Academia
- Forest science
- Natural resources
- Wildlife and fishery science
- Environmental science

Grant-Making Foundations

Partnerships
- Private sector
- Public/private sector

Category: Scale/Region: Geopolitical

- National
- State
- Local/municipal/county
- Eastern
- South
- Midwest/Lake States
- Rocky Mountain
- Northern
- Intermountain
- Southwestern
- Pacific Northwest
- Pacific Southwest

- Alaska
- Caribbean (Puerto Rico, U.S. Virgin Islands)
- South Pacific (Guam)

Category: Scale/Region: Ecoregions

- Polar Domain
- Tundra Division
- Subarctic Division
- Humid Temperate Domain
- Warm Continental Division
- Hot Continental Division
- Subtropical Division
- Marine Division
- Prairie Division
- Mediterranean Division
- Dry Domain
- Tropical/Subtropical Steppe Division
- Tropical/ Subtropical Desert Division
- Temperate Steppe Division
- Temperate Desert Division
- Humid Tropical Domain

For a better resolution map, see: http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html

Examples of Actions—Stakeholders Employing Different Instruments at Various Scales

Federal Government Entities

Northeastern Area State and Private Forestry: Criteria Indicators and Indicator Development, http://www.na.fs.fed.us/sustainability

The role of the Northeastern Area of the USDA Forest Service and the States in sustainable forest management is presented in four basic implementation approaches and associated actions. (1) Adopt criteria and indicators as a framework for sustainability; (2) Support inventory, monitoring, and assessment programs and partnerships; (3) Evaluate existing and potential State and Private Forestry conservation, management, and protection services and partnerships; and (4) Provide opportunities for professional and public education and communication.

Federal Regulatory Agencies

The U.S. Department of the Interior Fish and Wildlife Service (USFWS) Safe Harbor Program, http://endangered.fws.gov/recovery/harborqa.pdf

Safe harbor agreements are voluntary arrangements between USFWS and cooperating non-Federal landowners. The agreements benefit endangered and threatened species while giving the landowners assurances from additional restrictions. Following the development of an agreement, the USFWS will issue an "enhancement of survival" permit to authorize any necessary future incidental take to provide participating landowners with assurances that no additional restrictions will be imposed as a result of their conservation actions. Any non-Federal landowner can request the development of a safe harbor agreement.

State Government Entities

Oregon Department of Forestry, Report on Criteria and Indicators of Sustainable Forest Management at the State Level, http://www.oregonsolutions.net/A_govt/forestry_report.cfm

The Oregon Department of Forestry developed its First Approximation Report for Sustainable Forest Management on the criteria and indicators for the conservation and sustainable management of temperate and boreal forests developed through the Montreal Process. Sixty-seven indicators are used to describe the seven criteria, and the report outlines the availability of data needed to describe those indicators for Oregon. Oregon is the first State in the Nation to develop this type of report on sustainable forest management.

Tribes

Indigenous Community Enterprises, http://www.cba.nau.edu/ice

The project is working with members of the tribal government, chapter houses, and local entrepreneurs to develop a manufacturing process that can create low-cost hogan structures for families on the Navaho Nation who currently need such dwellings. The Navajo Hogan/Roundwood Manufacturing Project has four interrelated goals: (1) create culturally congruent (hogan-shaped) housing that addresses the affordable housing needs of elders and other members of indigenous communities of northern Arizona; (2) create meaningful living wages jobs that enhance the capacity of individuals and communities through building marketable skills and resources; (3) develop an economic infrastructure that can catalyze the development of additional economic enterprises; and (4) use the byproducts of forest restoration activities taking place in traditional-use lands to create housing and other marketable products.

Non-Governmental Organizations (NGOs)

Forest Stewards Guild, http://www.foreststewardsguild.org

The mission of the Forest Stewards Guild is to promote ecologically responsible resource management that sustains the entire forest across the landscape. The guild provides a forum and support system for practicing foresters and other resource management professionals working to advance this vision.

Great Lakes Forest Alliance, http://www.lsfa.org

The Great Lakes Forest Alliance is a forum for fostering and facilitating cooperative efforts that enhance management and sustainable use of the public and private forest lands in Michigan, Minnesota, Wisconsin, and Ontario, Canada. The alliance believes that through cooperation the States and province can achieve benefits for their citizens greater than if each worked alone. To that end, the alliance promotes the involvement of all those concerned with the region's forests to improve cooperation and coordination in forest policy and programs.

Ponderosa Pine Forest Partnership, http://ocs.fortlewis.edu/ppfppage.htm

Participants in the Ponderosa Pine Forest Partnership include Montezuma County, Colorado; the USDA Forest Service; the Colorado Division of Wildlife; Colorado State University; and the Colorado Timber Industry Association. This collaborative effort aims to develop a sound restoration prescription via adaptive management—attempting new management methods, analyzing the outcome, and modifying subsequent efforts to develop a restoration prescription that accomplishes the goals of the partnership.

Community Groups

La Jicarita Enterprise Community, http://www.newmex.com/~simpson/ljec/index.html

La Jicarita Enterprise Community, Inc., is establishing community networks for the purpose of developing for-profit companies in northern New Mexico. Serving the areas of Taos County, Southern Rio Arriba County, and Mora County, La Jicarita serves as the representative to the U.S. Department of Agriculture for rural development in these areas, which have been designated as one of 33 Enterprise Communities in the United States.

Forest Industry

MeadWestvaco Corporation Cooperative Forest Management (CFM) Program, 843-851-4666

The CFM Program offers to nonindustrial forest landowners forest and wildlife management expertise through MeadWestvaco's Multiple Use Forest Management System, which is designed to enhance soil, water quality, wildlife, and timber. By partnering with nonindustrial landowners, MeadWestvaco has applied the management system to approximately 2 million acres of land through the CFM Program.

Forest Products Customers

Certified Forests Products Council, http://www.certifiedwood.org

The Certified Forest Products Council is an independent, not-for-profit, voluntary initiative committed to promoting responsible forest products-buying practices throughout North America in an effort to improve forest management practices worldwide. To that end, the Certified Forest Products Council actively promotes and facilitates the increased purchase, use, and sale of third-party independently certified forest products. The council also promotes the transition away from forest products originating in forests that have been identified as endangered through a scientifically credible, land-based assessment process. In addition, the council encourages its members to promote the appropriate and efficient use of wood and wood fiber, and to support the development and use of alternative products.

Landowners

The Nature Conservancy Forest Bank Program, http://www.forestbank.org

The mission of The Nature Conservancy Forest Bank program is to work in partnership with private landowners to promote the economic productivity of working forests while protecting the ecological health and natural diversity of the landscapes in which they occur.

Recreation User Groups

Tread Lightly! http://www.treadlightly.org

Through education, restoration, and research the not-for-profit organization, Tread Lightly! empowers generations to enjoy the outdoors responsibly. Tread Lightly!'s goal is to increase public awareness and encourage responsible outdoor practices so that the great outdoors will be accessible, open, and well preserved for years to come.

Academia

Northern Arizona Ecological Restoration (ER) Institute, http://www.eri.nau.edu/default1.htm

The ER Institute is a new unit within the School of Forestry, funded by the Arizona Legislature beginning in fiscal year 1998. The goal of the ER Institute is to support ecological restoration through education and research, and by providing a common forum for open, objective consideration of ecological restoration issues. The ER Institute approaches this goal by integrating education and research, as well as by seeking to reach out to practitioners and the public.

Grantmaking Foundations

Surdna Foundation, http://www.surdna.org

The Surdna Foundation's Environment Program has chosen four focus areas in which it believes it can make a meaningful contribution in the United States: (1) biological diversity and the human communities that depend on it; (2) realigning human and natural systems; (3) transportation and urban/suburban land use; and (4) energy.

Partnerships

Four Corners Sustainable Forests Partnership, http://www.fourcornersforests.org

The Four Corners Sustainable Forests Partnership is a collaborative effort among businesses, Federal agencies, local governments, tribal organizations, and nonprofit groups. The partnership has established a grants program that funnels Federal funds approved by Congress to communities and projects that demonstrate and implement creative solutions to the forest restoration and economic needs of the region. The Regional Integrated Resource Assessment, completed in 1999, includes regional forest conditions, available resource supply, and existing and potential markets and business opportunities. The partners have also begun a regional network of people to identify strategic actions, share information, and provide technical assistance.

Appendix 3—Criteria and Indicators Data Issues

Many opportunities exist for improving the reporting of the C&I. These data issues were identified by the authors in the Data Report and by participants at three technical workshops sponsored by the Roundtable on Sustainable Forests in March and May 2000.[102 & 103] The following examples of issues might be addressed on an interagency basis to improve data management and availability to monitor and report on the Montreal Process Criteria and Indicators.

Criterion 1: Conservation of biological diversity

- Establish common protocols for data collection, management, and analysis, including common geographic aggregation units to facilitate data sharing and combined analyses.
- Define historic baselines and thresholds of change that can serve as sustainability targets to facilitate discussions of the current level of sustainability and the risk of future changes.
- Implement the National Vegetation Classification (NVC), the Federal standard, in existing forest inventories to monitor area change among forest types and age-classes within forest types.
- Implement monitoring programs to survey important ecosystem types (their amounts and arrangement) and taxa (their distribution and abundance) that are not currently monitored. Standard monitoring programs should be expanded to include specialized habitats and rare species, which are often missed.
- Explore the feasibility of monitoring vital rates (birth, death, immigration, emigration) to supplement estimates of population levels.
- Change the focus from monitoring forest-dependent species to monitoring all forest-associated species.
- Establish direct measurements of genetic diversity and explore the feasibility of using them to supplement surrogate indicators such as the number of species that occupy a small portion of their former range.
- Define the relationship between each indicator and the basic elements (ecosystem, species, genetic) of biodiversity, because the individual indicators measure several elements.
- Use repeated breeding bird atlases and atlases for other taxa to monitor changes in species ranges.
- Incorporate information about roads, ownership, forest type, and age-class in fragmentation metrics, and revise the suite of fragmentation metrics in light of the experimental analysis for the 2003 report.
- Establish a partnership whereby annual State fish and wildlife agency estimates of populations and harvest of important game animals can be easily incorporated into a national database.

Criterion 2: Maintenance of productive capacity of forest ecosystems

- Collect data on the amount of available land for wood consumption.
- Expand FIA data (as compared to the international definition for the indicator) by including trees less than 5 inches in diameter (breast height), including various noncommercial species, and not limiting volume calculations to merchantable trees.
- Expand and refine growth and removal data and use modeling to provide predictions at the regional and national level.
- Collect data on a wide spectrum of nontimber forest products.
- Expand available information on the parcelization (ownership fragmentation) of forest land.
- Have FIA include trees less than 5 inches in diameter and nontimber species as growing stock. Develop reliable conversion (English to metric) factors for growth equations.
- Clarify the classification of natural vs. plantation forest, particularly in the Western United States.
- Update data sets on the removal of wood products. Obtain access to proprietary data and data from nonindustrial private owners and from industrial landowners. Improve understanding of conversion to different land uses or forest types and exports of wood products.
- Develop protocols for collecting data on harvest of nontimber forest products at a national scale and develop protocols for determining the sustainability of harvest levels.

Criterion 3: Maintenance of forest ecosystem health and vitality

- To effectively measure the area of forest affected by processes or agents beyond the range of historic variation, expand FHM, GAP, and other databases to provide national coverage and intensify existing databases to provide adequate temporal and spatial intensity.
- The spatial coverage (particularly for forest areas) provided by the underlying measurement programs is generally inadequate for most of the air pollutant deposition variables. Spatial coverage for biological impacts, however, is mostly adequate where they are in place (though improvement by adding variables is possible), but adequate coverage for the entire United States is not currently provided. Improve the measurement protocol for dry deposition by using newly developed technologies (e.g., nitric acid concentration with passive samplers). Take advantage of opportunities for improving measurement technologies for evaluating effects of ozone on forest health.

Criterion 4: Maintenance of soil and water resources

- Define for forest soils the tolerable rates of erosion that allow for protection of water quality and maintenance of forest site productivity.

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[102] See http://www.fs.fed.us/research/sustain/.
[103] See http://www.sustainableforests.net/C&I_workshops/ci_workshops.html.

- Establish a uniform reporting system for compliance with best management practices (BMPs).
- Assess the effectiveness of BMPs at the regional scale and refine recommendations concerning their applicability and effectiveness.
- Address stream sediment data, which is often not collected because of cost, remoteness of some locations, and lack of regulations requiring them.
- Evaluate installing BMPs in areas managed primarily for protective functions and which may not have many BMPs installed since BMPs are generally used where land activities are most intense. BMP installation and compliance may not have much applicability for measuring "area and percent of forest land managed primarily for protective functions."
- Evaluate the problems associated with determining the historic level of variation on stream gauges since most records have not been kept long enough to be able to provide good estimates of historic variation beyond about a 20-year return period.
- Begin reporting USDA Forest Service watershed data at the national level.
- Develop baseline data on soil conditions, including adequate measures of soil organic matter.
- Do not use BMPs as a primary measure of diminished soil organic matter because the effectiveness of BMPs has not been established.
- Develop regional/local standards for soil quality.
- Encourage States to collect biological water-quality indicators using consistent protocols to allow for comparison/collation of data nationally. EPA has upgraded the STORET database to include biological measures.
- Establish additional baselines for the entire United States from which to measure “significant variance.”
- Improve water quality databases to indicate whether data was collected from forested or other areas.
- Establish a national database so individual national forest units can collect biological stream data using a standard national protocol.

Criterion 5: Maintenance of forest contribution to global carbon cycles

- Address inadequate geographic coverage (e.g., the Western United States and Alaska). Possibly expand survey crews in those regions and use cost-effective sampling methods, such as remotely sensed data.
- Measure all relevant carbon pools (soils and coarse woody debris, in particular).
- Compile knowledge of land use history and the current state of land use.
- Develop current data that adequately provides national contemporaneous data for year-specific estimates.
- Employ techniques such as remote sensing to enable wider geographic coverage within a relatively short timeframe for some of the variables of this criterion, within an acceptable level of uncertainty. Further develop flux-tower technology to estimate or validate forest carbon change estimates.
- Collect data on the life expectancy of wood products in use, decay rates of wood products in landfills, and wood waste from the construction and manufacturing of wood products. Alternatively, or in addition to, design and implement a statistically designed survey of carbon in harvested wood.
- Provide more support to improve methods or expand inventories to provide more accurate estimates for indicators in this criterion.

Criterion 6: Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies

- Secure a commitment to continued funding for the National Private Land Owners Survey (NPLOS) or an equivalent survey that specifically addresses availability of land for recreation.
- Establish an ongoing inventory system to provide data on the number and type of recreation lands and facilities available for general recreation and tourism.
- Establish closer collaboration among Federal and State agencies to measure recreation visitation.
- Establish interagency and intergovernmental collaboration to define and maintain a database that specifically inventories and tracks trends in protected lands.
- Critically analyze indirect valuation through benefit transfer approaches, which are controversial, to make sure that value estimates are defensible. Empirical estimates of non-use value using the contingent value or other valuation methods are still not widely accepted unless specifically designed to apply to a specific site, situation, or feature.
- Specifically define the terms "direct employment," "indirect employment," "forest dependence," "forest sector," and "community."
- Eliminate the confusion between economic dependency and community well-being found in prior notes, the First Approximation Report, and the 2003 report.
- Develop inventory, monitoring, trade, consumption, management, and subsistence studies of nontimber forest products at regional and national levels. Nontimber forest product supply, consumption, value, employment, wages, and subsistence use have been studied piecemeal in the United States. Nontimber forest products contribute millions to the U.S. economy.

Criterion 7: Legal, institutional, and economic framework; capacity to measure and monitor changes; and capacity to conduct and apply research and development for forest conservation and sustainable management

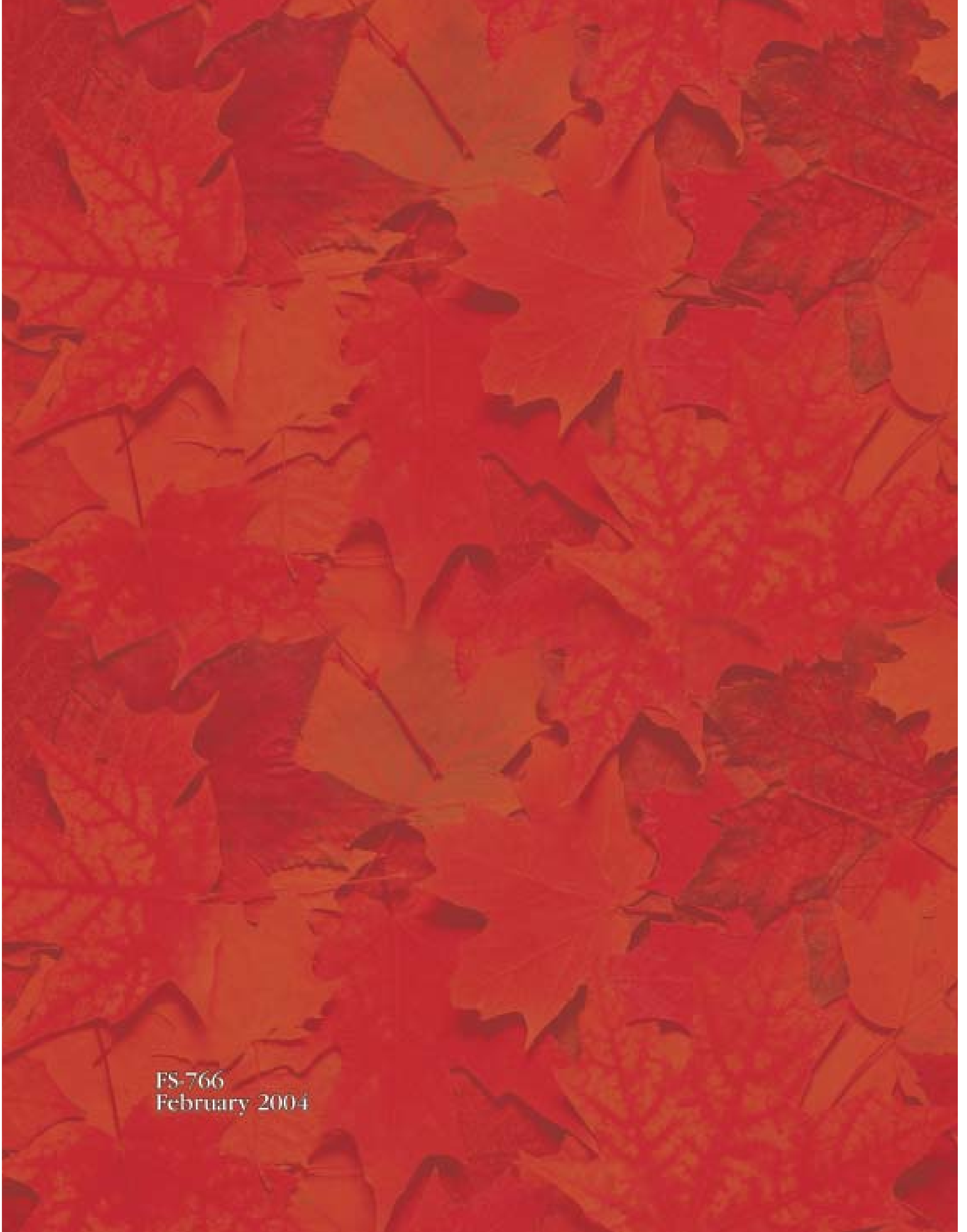
- Develop comprehensive, up-to-date compilations of local government ordinances applicable to this criterion.
- Develop data on the legal mechanisms available to provide security for property rights against conflicting and overlapping claims to land areas and/or resources on both public and private lands. Examples include the extent of forest land rights of indigenous peoples, and the extent to which allotments to private landholders comprise property rights.
- Improve the limited analytical methods used to describe the impacts of regulations and policies on investments and forest sustainability.
- Address the problems that exist in accessing data, including inaccessibility of Federal and State revenue

data sets, cost limitations linked to institutional structure, differential income tax treatment based on the classification of land ownership, conflict in Federal laws that limit conservation and forestry investment, overlapping areas of responsibility among different Federal agencies, and the need for investment decisions to be made at the lowest level (on the land).

- Develop econometric trade models that are robust at the gross scale and on a finer scale where significant impacts are driving links between sustainable forest management and trade policies. Explore additional economic and institutional measurements.
- Coordinate assessments on local, State, or regional levels to ensure institutional commitment to synthesis. Develop inventories for these assessments with consistent protocols for data collection and sampling designs.
- Expand indicators to fully capture the extent to which the economic framework in the United States supports the goals of conservation and sustainable management of forest resources.
- Develop institutional strategies or guidance to ensure consistent implementation of trade analysis reflecting environmental and resource management impacts.
- Develop a comprehensive system for tracking, classifying, and documenting forestry research activity at the national level.

Other Issues

- Create a Web-based directory of the many sustainability efforts at the national, regional, and local levels to foster communication and networking among these efforts.



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