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¹ Presented in landscape format so that the tables included are easier to read.

USDA Forest Service, Northeastern Area and
Northeastern Area Association of State Foresters

**Base Indicators of Forest Sustainability:
Metrics and Data Sources for
State and Regional Monitoring**



United States
Department of
Agriculture



Forest Service
State and Private Forestry
Northeastern Area

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Base Indicators of Forest Sustainability: Metrics and Data Sources for State and Regional Monitoring

Prepared by:

USDA Forest Service
Northeastern Area
State and Private Forestry

and

Northeastern Forest Resource Planners Association

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Preface

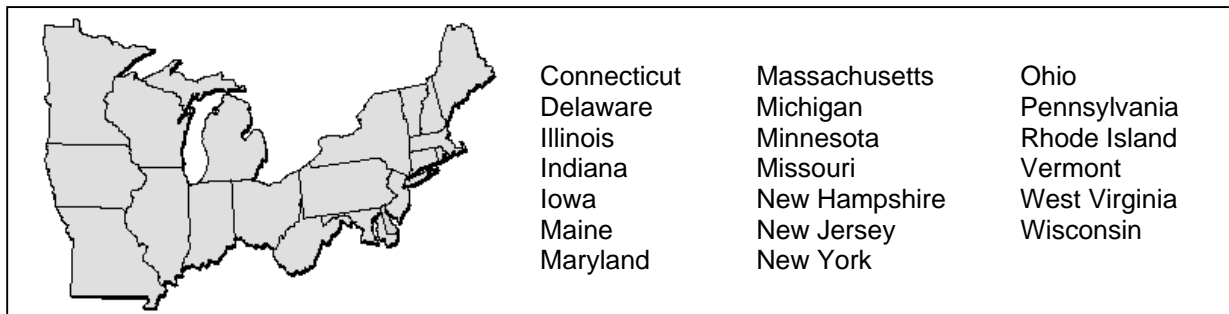
This document represents a collaborative effort between the USDA Forest Service, Northeastern Area, State and Private Forestry; the Northeastern Area Association of State Foresters; and the Northeastern Forest Resource Planners Association. The Forest Service and State resource professionals work to facilitate the collection, evaluation, and dissemination of information to foster the conservation and sustainable management of forest resources.

The **USDA Forest Service, Northeastern Area, State and Private Forestry (NA)**, commonly referred to as the Northeastern Area, is a unit of the Forest Service that serves the 20 States of the Northeast and Midwest, and the District of Columbia. It works in partnership with the State Foresters and State forestry agency staff to influence the wise management, protection, and sustainable use of rural to urban lands and to enhance the capacity of all forests to provide benefits for a growing America.

The **Northeastern Area Association of State Foresters (NAASF)** is a nonprofit organization that represents the directors of the State forestry agencies from each of the 20 States of the Northeast and Midwest, and the District of Columbia. It is one of three regional State Forester organizations that comprise the National Association of State Foresters and is committed to working with the Northeastern Area and others to provide better management, protection, and use of the forest lands they serve.

The **Northeastern Forest Resource Planners Association (NFRPA)** is a nonprofit organization that consists of the State forest resource planners from each of the 20 States of the Northeast and Midwest. It encourages and supports State forest resource planning programs and works to strengthen skills in planning and resource and policy analysis, while developing and maintaining a working relationship with the Northeastern Area Association of State Foresters, the Northeastern Area, and other organizations.

Figure 1. The Northeastern Area, the Northeastern Area Association of State Foresters, and the Northeastern Forest Resource Planners Association serve the 20 States of the Northeast and Midwest. The Northeastern Area and the Northeastern Area Association of State Foresters also serve the District of Columbia.



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NFRPA Members

Dan Devlin, Pennsylvania Bureau of Forestry

Susan Francher, New Hampshire Division of Forests and Lands

Jon Nelson, Minnesota Division of Forestry

Larry Pedersen, Michigan Division of Forest, Mineral, & Fire Management Division

Clarence Turner, Minnesota Division of Forestry

NAASF Criteria and Indicators Liaison

Austin Short, Delaware Department of Agriculture, Forestry Section

USDA Forest Service Staff

Constance Carpenter, Northeastern Area State and Private Forestry

Will McWilliams, Northeastern Research Station, Forest Inventory and Analysis

Margaret Miller-Weeks, Northeastern Area State and Private Forestry

Helen Thompson, Northeastern Area State and Private Forestry

Sherri Wormstead, Northeastern Area State and Private Forestry

Introduction

Managing forests sustainably involves recognizing interconnections among ecological, economic, and social systems, and preserving their multiple benefits now and well into the future. Many organizations are turning to a criteria and indicators (C&I) approach to assess and plan for forest sustainability. Under this approach, criteria define broad categories of sustainability, and indicators are specific measurements (quantitative or qualitative) within each category. A framework of criteria and indicators is a valuable tool when used for assessments, planning, issue management, inventory and monitoring, and communicating with others. In 1995, the United States joined 11 other countries in signing a document establishing a set of 7 criteria and 67 indicators to track the conservation and sustainable management of temperate and boreal forests. This set of criteria and indicators is commonly referred to as the Montreal Process C&I.

This document describes 18 indicators of sustainability and associated data sources that the USDA Forest Service, Northeastern Area (NA) and the 20 State forestry agencies in the Northeastern Area Association of State Foresters (NAASF) will use in ongoing monitoring efforts. The indicators, referred to as “base indicators,” address information needs common among State and multistate sustainability efforts and are organized according to the seven Montreal Process criteria of sustainability (box 1). The data sources and metrics recommended in this report are suitable for monitoring indicators at State, multistate, and regional scales.

To encourage the use of the seven criteria and base indicators across scales, NA and NAASF will compile data on the base indicators and report them on the Internet. The use of these common indicators, metrics, and data sources encourages cooperation and simplifies communication among multiple efforts and across State borders. Potential time and cost savings are also motivations for using common indicators and cooperating in data compilation and assessment. In addition, tracking common indicators with the same data across States and over time can help reveal cumulative effects.

The work in the 20-State region is intended to complement sustainability assessment activities at the national level. The base indicator set includes measures for each of the seven sustainability criteria but obviously does not include all possible measures. No list of indicators will meet the needs of all parties interested in sustainability; however, we believe that the majority of forest stakeholders, operating at regional and State scales, will find it useful to incorporate the base indicator data into their own assessments. And subsequently, as stakeholders supplement the base indicator set with other indicators and measures, a fuller picture of forest conditions and trends will emerge for more local assessments.

Box 1. NA/NAASF Base Indicators span the Montreal Process criteria and are recommended for use in NA-wide and State forest sustainability assessments.¹

Criterion 1: Conservation of Biological Diversity

1. Area of forest land relative to total land and area of reserved forest land
2. Extent of area by forest type and by size class, age class, and successional stage
3. Degree of forest land conversion, fragmentation, and parcelization
4. Status of forest/woodland communities and species of concern (with focus on forest-associated species)

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

5. Area of timberland
6. Annual removal of merchantable wood volume compared to net growth

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

7. Area and percent of forest land affected by potentially damaging agents

Criterion 4: Conservation and Maintenance of Soil and Water Resources

8. Area and percent of forest land with diminished soil quality
9. Area and percent of forest land adjacent to surface water and area of forested land by watershed
10. Water quality in forested areas

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

11. Forest ecosystem biomass and forest ecosystem and forest products carbon pools

Criterion 6: Maintenance and Enhancement of Long-term Multiple Socio-economic Benefits to Meet the Needs of Societies

12. Value and volume of wood and wood products production, consumption, and trade
13. Outdoor recreational facilities and activities
14. Public and private investments in forest health, management, research, and wood processing
15. Forest ownership and land use (including acres of specially designated land)
16. Employment and wages in forest-related sectors

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

17. Existence, type, and monitoring of forest management standards/guidelines
18. Existence, type, and frequency of forest-related planning, assessment, and policy review

¹ No priority or order is implied in the numeric listing of the criteria and indicators.

Recommended Metrics and Data Sources for NA/NAASF Base Indicators of Forest Sustainability

1. Area of forest land relative to total land area and area of reserved forest land

Overall Availability: Data are available and relatively easy to assemble and interpret.

Background: Forests provide a multitude of public values such as water purification, carbon dioxide removal, and aesthetics. The presence and amount of forests has a direct impact on a host of ecological, social, and economic factors such as wildlife populations, quality of life, and potential economic development. Certain wildlife species are dependent on a contiguous ecosystem or ecosystems of a certain minimum size. In addition to measuring forest land, this indicator also shows how much forest land is considered reserved. In its broadest sense, the area and proportion of forest ecosystems reserved in some form of protected condition provides an indication of society's interest in the preservation of forest ecosystems. Area of forest land and reserved forest land per resident population, another important measurement, can be calculated using available data.

Related Montreal Process Indicators

1.1.a. (#1) Extent of area by forest type relative to total forest area

2.a. (#10) Area of forest land and net area of forest land available for timber production

1.1.c. (#3) Extent of area by forest type in protected area categories as defined by IUCN or other classification systems

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Total forest area (acres)	USDA FS FIA	State, region ¹	5 year	The reporting cycle is staggered across States.
Total land area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.
Reserved forest land (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. Does not adequately measure private conservation forest lands.
Population	U.S. DOC Census Bureau	State, region	Annual	The census is conducted every 10 years, but population estimates are calculated annually.

¹ Region includes the 20 Northeastern and Midwestern States and the District of Columbia.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program for forest land relative to total land area and area of reserved forest land. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available starting in the 1950's. FIA defines “reserved” forest lands as those withdrawn from timber utilization by law or administrative regulation; they include predominantly public land, such as National Wilderness Areas, National Parks, and State parks.

In order to properly address total “protected” areas, other information sources that could be integrated with (or include) the traditional data should be considered, such as the World Wildlife Fund Protected Areas Database or the Gap Analysis Program. However, currently available sources do not provide adequate data for reporting trends. If we are, eventually, able to more comprehensively report “protected” areas, we should change the indicator wording to reflect this (i.e., replace “reserved” with “protected”). We need to stay aware of work at the national and regional levels to compile data on protected areas.

With population data from the U.S. Census Bureau, we can calculate and report area of forest land and reserved forest land per resident population. Although the national census is conducted every 10 years, reliable population estimates are calculated annually.

Some data are also available from the USDA Natural Resources Conservation Service (NRCS), National Resources Inventory (NRI). The NRI is a statistical survey of natural resource conditions and trends on non-Federal lands in the United States. It includes data for forest land area and total land, but not more detailed information about forest land. NRCS uses different methods and a different definition of forest than the Forest Service, so acreage figures may vary between the two sources. In order to minimize data collection efforts and to provide consistent measures for reference across the indicators, we decided only to report the FIA data. However, recognizing the NRI as a data source, we will aim to provide a link to these data on the online indicator reporting system.

Web Sites: USDA FS FIA: <http://fia.fs.fed.us>; U.S. DOC Census Bureau: <http://www.census.gov>

2. Extent of area by forest type and by size class, age class, and successional stage

Overall Availability: Most data are available and relatively easy to assemble and interpret; data for “successional stage” are not available for the whole region and are difficult to assemble/interpret.

Background: Many species are wholly or partly dependent on a particular successional stage. Therefore, all normally occurring successional stages should be present with sufficient area to support a diversity of species. In addition, in terms of human needs, forest type and forest age are important determinants of timber growth and yield, the occurrence of game animals, the presence of other nontimber forest products, and the forest’s aesthetic and recreational values. A balance of forest types at diverse successional stages is considered essential to providing forest landscapes that are both sustainable and capable of providing desired outcomes for both wildlife and human use.

Related Montreal Process Indicator

1.1.b. (#2) Extent of area by forest type and by age class or successional stage

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Area by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.
Size class by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.
Age class by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. Currently, only available for timberland areas.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program for area by forest type, size class by forest type, and age class by forest type. These data classify forest type based on the Society of American Foresters forest cover types. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available starting in the 1950’s.

In the long term, the National Vegetation Classification System (NVCS), a more ecologically based system, is being developed (it has been adopted by the Federal Geographic Data Committee). Testing and refinement of the NVCS is still necessary for the measurement

protocols to be effectively used in field inventories. The work underway to refine this system to an operational level is at least 2 years from completion.

Currently, complete age class data are only available for timberland areas. In the past, FIA methodology for calculating age class varied slightly between FIA's Northeastern and North Central regions. In the Northeastern region, a forest stand was either assigned a specific age or was classified as a mixed-age forest. In the North Central region, mixed-age stands were not broken out but were assigned a specific age based on the dominant and co-dominant trees in the stands. Therefore, the North Central regional total underestimates the acreage of mixed-age stands; this should be noted along with the data. They now have a national standard to measure mixed-age stands consistently.

Successional stage is critical in terms of biodiversity and ecological function. At this point in time, however, only seven States² reportedly have data available for successional stage, and, to the best of our knowledge, successional stage data does not exist region-wide or nationwide. In addition, interpretation of successional stage is challenging due to issues such as scale and habitat. We recommend starting to address this data gap by researching the methods used by the seven States that cited having these data.

Web Site: USDA FS FIA: <http://fia.fs.fed.us>

² The following States cite data available for extent of area by successional stage: Massachusetts, Minnesota, New Jersey, Pennsylvania, Vermont, West Virginia, and Wisconsin.

3. Degree of forest land conversion, fragmentation, and parcelization

Overall Availability: Data for “conversion” and “parcelization” are available but require some additional work to assemble and interpret; some data for “fragmentation” are available but are difficult to assemble/interpret.

Background: The fragmentation of a forest into smaller, isolated pieces, or breaking the continuity of large forest communities into smaller dissimilar patches may disrupt ecological processes such as nutrient and water cycles, and reduce the availability of habitat for certain forest species. Fragmentation makes forests more susceptible to other forms of environmental degradation, including invasion by exotic species and predation problems. Forest isolation, characterized by significant distances between forest patches or habitat types, can interfere with pollination, seed dispersal, wildlife migration, and breeding. Parcelization (more landowners with smaller parcels) often fosters forest fragmentation and is an impediment to effective forest ecosystem management, diminishing the economic feasibility of conducting timber harvests and increasing the challenge of providing assistance to private forest landowners.

Related Montreal Process Indicator

1.1.e. (#5) Fragmentation of forest types

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Forest land conversion (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.
Forest land change (percent)	USDA NRCS, Natural Resources Inventory	State, region, ecological province	5 year	Provides forest land change to and from other land cover/use types. Inventory methods vary from USDA FS FIA methods.
Fragmentation: average patch size, amount of edge, inter-patch distance	USDA FS Southern Research Station; USDA FS FIA, Northeastern Research Station	State, region, ecological province	Periodic	Work at the national level needs refinement; regional work covers only the 13 Northeastern States. Data are for forest vs. nonforest only (of limited meaning where within-forest fragmentation is of greater concern). May include a connectivity metric. Based on 1992 data; newer data may not allow for comparable analyses.

Parcelization: average size of private land holdings	USDA FS FIA, National Woodland Owner Survey	State, region	5 year	Plus/minus 10% error at the State level. Collected on an annual rolling cycle, reporting averages every 5 years.
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Forest land conversion—Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program to measure forest land conversion (trend in overall forest land and nonforest land). The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available starting in the 1950’s. Data are also available from the USDA Natural Resources Conservation Service (NRCS), National Resources Inventory (NRI) for land use types, including cropland, pastureland, urban/developed land, and water. In addition to forest land that is converted to nonforest uses, these data allow us to track trends in land use types, such as crop and pastureland that convert to forest land, which offset forest conversions. The figures are based on data collected at sample sites. Sampling variation is present, but, according to NRCS, is generally small for State and national totals. Sampling variation may be significant, however, if using these totals to calculate 5- and 10-year changes. Margins of error are provided for all NRI estimates. The NRI has been conducted every 5 years since 1977 but is in transition to a continuous, or annual, inventory process. NRCS uses different methods and a different definition of forest than the Forest Service, so acreage figures may vary between the two sources. Despite concerns regarding reliability/accuracy, these data provide a more comprehensive look across the landscape not found elsewhere, and reporting percentages should adequately capture trends over time.

Fragmentation—Currently, there is no standard measure of fragmentation; all available measures are imperfect. Experimental work has been conducted by the USDA Forest Service, Southern Research Station to develop fragmentation metrics at the national level, including patch size, edge amount, inter-patch distance, and patch contrast. They used the MRLC (Multi-Resolution Land Characteristics Consortium) land cover data, which is based on 1992 Landsat Thematic Mapper satellite imagery. The data were not accurate when analyzing by the forest types in the MRLC data, so they were collapsed into one forested category. The data can be aggregated by ecoregion sections (they were not originally reported at that scale). Drawing on this national effort, the USDA Forest Service, FIA Program at the Northeastern Research Station is working on fragmentation metrics including patch size, number, and an edge/connectivity measure with the goal of identifying which fragmentation and context metrics should be linked with FIA plot data and monitored over time. In the future, they would like to look into fragmentation by forest type. They plan to report the data in a tabular format by various scales, including ecoregion. Although this work includes analysis for the 13 Northeastern States, the methods will apply to all States served by the Northeastern Area.³ A major limitation of both the national level work and this work by FIA at the Northeastern Research Station is that since the MRLC data is based on 1992 satellite imagery, it is already outdated and work to provide

³ The USDA Forest Service North Central Research Station is also conducting experimental pilot projects for measuring forest fragmentation.

the new MRLC data set will likely not be entirely compatible due to potential changes to the land cover categories. The updated MRLC data set is based on 2000 satellite imagery and will be available in 2004 at the earliest.

Substantial discussion and followup are required for addressing this metric. An approach based on ecoregions is preferred because analysis has shown that regional averages do not reflect local conditions. We recommend using at least ecological provinces for regional reporting and subsections at the State level. It is important to agree on what constitutes a patch (e.g., forest type, age class) and to establish a baseline of patch size, edge amount, inter-patch distance, and patch contrast. Additional information and research is required for interpretation of the data. Stay aware of national and regional level work to measure fragmentation; as technology advances, it is likely that adequate data will be available for regular reporting.

Parcelization—To measure parcelization, we can use the metric “average parcel size” and utilize data available from the USDA Forest Service, National Woodland Owner Survey. These data are reported every 5 years from an annual update cycle (rolling). Report distribution of land holding size (in a bar graph) or, with caveats in interpretation, average parcel size.

Web Sites: USDA NRCS Natural Resources Inventory: <http://www.nrcs.usda.gov/technical/NRI>; USDA FS Southern Research Station work: <http://www.srs.fs.fed.us/4803/landscapes/index.html>; USDA FS Northeastern Research Station work: <http://www.fs.fed.us/ne/rsb>; USDA FS National Woodland Owners Survey: <http://www.fs.fed.us/woodlandowners>

4. Status of forest/woodland communities and species of concern (with focus on forest-associated species)

Overall Availability: Data are available but require some additional work to assemble and interpret.

Background: Species and communities are critical components of biological diversity, and their status is an excellent measure of overall ecosystem health. Plant, animal, and community diversity contributes to nature’s resilience in the face of natural and human-caused changes. In addition, the loss of species and communities will be at a cost of unknown proportions.

Related Montreal Process Indicator

1.2.b. (#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

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Status of forest-associated species of concern relative to the total	NatureServe	State, region, ecological province	Annual	Need to identify forest-associated species. Report Federal and State listed and de-listed plant and animal species.
Status of forest and woodland communities of concern relative to the total	NatureServe	State, region, ecological province	Annual	Currently, data only available on globally imperiled forest and woodland associations.
Bird species population trends/relative abundance	USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey	Sub-regional	Annual	Requires additional work to identify the best method to report these data. There are limitations in these data related to the roadside survey methods. Rare species are difficult to track accurately (due to reduced sample sizes).

NatureServe and its member programs in the network of Natural Heritage programs develop and maintain information on the status of species, and forest and woodland natural communities. Found in all States, most natural heritage programs are operated by State

government agencies, universities, or The Nature Conservancy field offices. We can report out for rankings of (1) critically imperiled, (2) imperiled, and (3) vulnerable, with the option of looking at the status of species at global, national, and State scales.

States maintain their own listings of threatened and endangered species at the State level. These lists are not developed consistently across States, however, and would be difficult to compile and analyze for the region. For the status of plant and animal species, we recommend reporting NatureServe data according to national, ecological province, and State status, using State ranks for State-level reporting. Additional discussion and work is required to determine the best method to summarize these data for only “forest-associated” species. Draw on previous work in this area and work with NatureServe to define “forest-associated” or support the national level efforts to do this. We may want to measure the status of all species and then add the forest-associated component when it becomes available.

NatureServe has data available on the status of natural communities, allowing data on imperiled forest and woodland associations to be summarized. However, the NatureServe data only have status rankings at the global scale for ecological communities. Therefore, current data available are globally imperiled forest and woodland associations found within the 20 NA States (by State and region). Data may be limiting due to ecoregional variability. In addition, States use different community classifications. Although these communities are cross-walked to a regional standard, some communities do not fit the regional classification well. This should not be a big issue, however, at the 20-State regional scale.

NatureServe data are the best and most easily accessible data available and should be the primary source for this indicator. There is a rolling cycle of updates from States, and the online database is updated three times a year with an annual reporting cycle. Comparable historical data will not likely be available. Obtain all species and ecological communities data directly from NatureServe Explorer (Web site).

Bird population data and trend analyses data are available from the U.S. Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center. The North American Breeding Bird Survey (BBS) provides data on breeding bird populations along roadside routes across the continental United States and southern Canada. The 24.5-mile-long routes occur along secondary roads and are surveyed annually in June. During each survey, all birds seen or heard along the route are counted at 50 stops placed at 0.5-mile intervals. Roughly 1,140 randomly established routes across the 20 States served by NA allow examination of trends for hundreds of bird species from 1966 to present. These data can be grouped by breeding habitat (woodland, shrubland, grassland, wetland, urban). Due to limitations in the data at the State level and natural variations in bird species across the 20 States, it may be best to report these data on a subregional basis. There are some limitations in these data related to the roadside survey methods, and tracking population trends in rare species is particularly difficult because the monitoring programs measure increasingly reduced sample sizes of these species as they decrease in abundance. Also, trends over time may reflect the recovery or restoration of forests, which will hurt bird species that favor more open habitats. Additional work is required to determine the best way to report these data.

We looked into data available for other species; however, no sources with consistent data across States and collected over time were available. Data collected at the State level vary by species and are not consistent across the region. For this indicator, States may want to supplement the base set of metrics and data with additional data available at the State level for further assessment.

Web Sites: NatureServe: <http://www.natureserve.org/explorer>; USGS Breeding Bird Survey: <http://www.mp2-pwrc.usgs.gov/bbs/>

5. Area of timberland

Overall Availability: Data are available and relatively easy to assemble and interpret.

Background: The productive capacity of forests is important to current and future generations' need for wood products and related economic benefits. This indicator measures how much land may be available for timber production compared to total forest area.

Related Montreal Process Indicator

2.a. (#10) Area of forest land and net area of forest land available for timber production

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Timberland area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. Certain physical, economic, and social constraints to harvesting are not considered (overestimates actual timberland).
Total forest area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program for area of timberland and total forest area. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available starting in the 1950's. FIA defines timberland as forest land that meets minimum productivity standards (inherent capability to produce at least 20 cubic feet of wood fiber per acre per year) and is potentially available for harvest. FIA data related to timberland ignores physical constraints such as steep slope, economic constraints such as difficult access, and social constraints such as owner objectives. Along with reporting these data, include a list of known limitations or constraints that are pertinent to timberland availability. In addition, a small percentage of timberland area may include areas that are in fact protected.

For the assessments, consider supplementing FIA timberland area with data on landowner willingness to harvest from the USDA FS National Woodland Owner Survey. This survey is conducted nationwide, on an annual rolling basis, with a 5-year reporting cycle and target accuracies of plus/minus 10% error at the State level.

Web Sites: USDA FS FIA: <http://fia.fs.fed.us>; USDA FS, National Woodland Owner Survey: <http://www.fs.fed.us/woodlandowners>

6. Annual removal of merchantable wood volume compared to net growth

Overall Availability: Data are available and relatively easy to assemble and interpret.

Background: This indicator compares removals to net growth of the forest. The notion of sustainable removals necessarily relies on the volume available for removal. To sustain inventory volume, the net growth of forests must equal or exceed removals. Growing stock volume is the volume in cubic feet of growing stock trees 5.0 inches in diameter at breast height and larger, measured from a 1-foot stump to a minimum 4.0-inch top diameter outside bark of the central stem or to a point where the central stem breaks into limbs. Trees and portions of the stem that are unusable due to defect (rough, rotten) are excluded from growing stock volume. Although it would be better if we were able to measure “annual removal of wood products compared to the volume determined to be sustainable,” there is little consensus on how to adequately measure this.

Related Montreal Process Indicator

2.d. (#13) Annual removal of wood products compared to the volume determined to be sustainable

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Net growth of growing stock on timberland and forest land (cubic feet)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States.
Removals of growing stock on timberland and forest land (cubic feet)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States.
Net growth to removals (ratio)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States. Caution should be used when interpreting this complex statistic.
Type of removals: harvest, land clearing (percent)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program to measure net growth and removal of growing stock on timberland and forest land. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Data are available starting in the 1950's; however, the methods have changed somewhat over time. Net growth and removals of growing stock can be reported as separate statistics and calculated as a net growth-to-removals ratio. Net growth of growing stock is equal to gross growth minus mortality. Mortality is the volume of trees that died since previous measurement. Removals data come from FIA sample locations. Mill studies supplement this information by providing the volume of roundwood and residues utilized by forest industry. Roundwood is defined as logs, bolts, or other round sections cut from growing stock and nongrowing stock sources.

The net growth-to-removals ratio is a measure that approximates the notion of sustainable production. When net growth exceeds removals (ratio greater than 1.0), the result is an increase in growing stock inventory volume. When removals exceed net growth (ratio less than 1.0), the result is a reduction in the merchantable volume of live tree stems. Since individual effects on growth, mortality, and removals influence this statistic, caution is required for interpretation. For appropriate interpretation of this metric, it is important to keep data current. For example, if older stands with high volume are converted to young stands containing trees less than 5.0 inches in diameter, the statistic will indicate unsustainable conditions. Once the young stands reach the 5.0-inch merchantability limit, net growth will increase, and, at some point in the future, will likely exceed removals.

All these data can be reported dating back to the 1950's for removals and net growth on timberland, and, more recently, for removals and net growth on all forest land. FIA defines timberland as forest land that meets minimum productivity standards (inherent capability to produce at least 20 cubic feet of wood fiber per acre per year) and is potentially available for harvest. The data related to timberland ignore physical constraints such as steep slope, economic constraints such as low timber prices, and social constraints such as owner objectives. Along with the data, note the known limitations or constraints that are pertinent to timberland availability, or refer back to NAASF indicator number 5 (area of timberland).

Removals of growing stock can be partitioned into removals due to harvest and removals due to landclearing. Removals due to landclearing are often referred to as "liquidation" harvests because forest land is converted to other land uses.

Since declines in growth may be due to increases in mortality, trend data for net growth and removals should be reviewed in conjunction with mortality data. These mortality data are reported as part of NAASF indicator number 7 (area and percent of forest land affected by potentially damaging agents).

Web Site: USDA FS FIA: <http://fia.fs.fed.us>

7. Area and percent of forest land affected by potentially damaging agents

Overall Availability: Data are available but require some additional work to assemble and interpret.

Background: This indicator identifies and monitors the area of forest affected by a variety of processes and agents, both natural and human-induced, that have the potential to degrade basic ecological processes in forests. Impacts include exotic and native insects and diseases; invasive plants; wildfire cycles; drought, storm, and flood occurrences; and land conversion. Many potentially damaging agents exist naturally as part of healthy forest ecosystems. When they reach high intensity/severity levels, however, they can become damaging to the long-term health of forests. By regularly examining potentially damaging agents, it may be possible to detect harmful changes and modify management strategies to reverse the change. Wildfire was a natural force that helped shape forest ecosystems over time. However, active policies of wildfire suppression throughout the 20th century have greatly contributed to vegetation changes, in some cases leading to vegetation conversions and in other cases causing forests to be more susceptible to large, destructive wildfires. Controlled fires are sometimes conducted to reduce fuel buildup and restore natural cycles. Under this indicator, we track the occurrence of wildfires and are looking for trends over time in the area of forests affected by wildfires.

Related Montreal Process Indicator

3.a. (#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, salinization, and domestic animals)

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Tree mortality (cubic feet)	USDA FS FIA	State, region,	5 year	The reporting cycle is staggered across States.
Biotic stressors: exotic/native insects and diseases, invasive plants, and animals (acres affected)	States via USDA FS FHM/FIA and Cooperative Forest Health Program	State, region, ecological province	Annual	Extent of information available varies by State. It is desirable to examine cumulative effects of biotic stressors.
Wildfire (occurrence, acres affected)	National Interagency Fire Center; USDA FS; Survey of States (NAASF)	State, region, ecological province	Annual	Data available from national and regional sources do not categorize forest land affected. Some States have data for forest affected by wildfire.

Weather phenomena: drought (severity), storm (occurrence, acres affected), flood (occurrence, acres affected)	NOAA National Climatic Data Center; States via USDA FS FHM/FIA and Cooperative Forest Health Program	State, region	Annual	Additional GIS processing is required to measure forest land affected by drought.
Forest land clearance (acres)	USDA FS FIA; USDA NRCS	State, region, ecological province	5 year	Measures forest land cleared for nonforest uses. FIA reporting cycle is staggered across States. Forest Service and NRCS inventory methods vary.

It would be best to integrate all variables into a cohesive picture of forest affected by damaging agents, supplemented by information specific to the main damaging agents. There have been some analyses conducted to measure relative exposure of forests to mortality and defoliation using USDA Forest Service data; however, more work is needed in this area (we should advocate for this). With the “such as” terminology and the dynamic nature of potentially damaging agents, we can report on the agents with the most impact in the 20 States served by NA and have the flexibility to adjust exactly what is measured over time. Due to the development of State GIS capacity, there may be widespread improvement in GIS data available for this indicator in the near future.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program to measure mortality. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available starting in the 1950’s.

To measure biotic stressors to forest land, State data are available from the survey component of the USDA Forest Service, Forest Health Monitoring (FHM)/Forest Inventory Analysis, Cooperative Forest Health Program for forest land affected by plants, animals, insects, and pathogens. Data are collected from all 20 States and reported annually. States provide additional data and information than is included in the report that we could utilize. Limited information is obtained from the FHM/FIA plot network for these data. Consistency and intensity of insect and disease surveys among States is a concern; however, metrics should get better in time. In addition to biotic stressors, States report acres of forest land affected by storm events. For all of these data, occurrences that are considered significant by the State forestry agency are assessed and reported.

For wildfire damage, data are available from the National Interagency Fire Center and the USDA Forest Service, Fire and Aviation Management Program for the number of wildfires and acres burned annually (or average annual per decade). These data are available by State and can be compiled for all 20 States. One limitation is that these data do not distinguish land cover type affected. Some reference

data are available, but they are spotty by region and State. Although not reported as part of the national wildfire reporting process, some States collect data on land cover type affected (and, therefore, have data on forest affected by wildfire). A survey of States is required if we are to obtain these data.

For climatic and weather related phenomena, we can measure drought, storm, and flood effects. Drought data are available using the Palmer Drought Severity Index from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center. These data are available annually by climate division (sub-State) and State back to 1895 and can be compiled for the region. Although widely accepted, one limitation is that there are no data for area of forest land affected by drought. Additional GIS processing and analysis is required to address this issue. If the time and skills are allotted, we could probably overlay forest land data from FIA or the National Land Cover Data with the drought severity data from NOAA to map forest affected by drought (consult the work done for the *2003 Report on Sustainable Forests*).

Data from the USDA Forest Service, FIA Program and the USDA Natural Resources Conservation Service (NRCS) are available that address forest land clearance and conversion to other uses. Refer to NAASF indicator number 3 (degree of forest land conversion, fragmentation, and parcelization) for the information about this metric and data sources.

In the future, we recommend exploring methods to look at the cumulative affects of damaging agents. For cumulative affects as a result of biotic stressors, we could try overlaying the top significant stressors in a GIS. Some experimental work of this nature is being conducted by the USDA Forest Service, Northeastern Area that we may be able to draw on in the future. In addition, the Forest Service is conducting risk mapping of biotic stressors. We could use this information for further analysis in the comprehensive assessment reports.

Web Sites: USDA FS NA: <http://www.na.fs.fed.us>; USDA FS FIA: <http://fia.fs.fed.us>; National Interagency Fire Center: <http://www.nifc.gov>; NOAA National Climatic Data Center: <http://lwf.ncdc.noaa.gov/oa/climate/research/monitoring.html>; NOAA Drought Monitoring: http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.html

8. Area and percent of forest land with diminished soil quality

Overall Availability: Data are available but require some additional work to assemble and interpret.

Background: Soil is an important component of all forest ecosystems. It has the ability to store carbon, provide substrate for roots, hold water, and host microorganisms that transform nutrients and pollutants. Any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and water quality of forest ecosystems. Soil qualities of concern include soil organic matter, erosion, compaction, and/or changes in other soil chemical or physical properties. Soil carbon, used as a proxy for soil organic matter, and soil pH are measured as general chemical indices of soil quality. 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. Compaction changes the ratio between air, water, mineral material, and organic matter in soil, which can negatively impact soil productivity.

National-level monitoring of forest soils is relatively new, and baseline data are available only at the research or watershed scale; little is known about historical values for soil properties in undisturbed forest ecosystems. We are interested in reporting by the area and percent of forest land; however, the sampling intensity of the USDA Forest Service, Forest Inventory and Analysis soil data currently collected is not adequate for measuring spatial distribution of soil properties at anything finer than the national or regional scale.

Related Montreal Process Indicators

- 4.a. (#18) Area and percent of forest land with significant soil erosion
- 4.d. (#21) Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties
- 4.e. (#22) Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Changes in soil pH (measure of soil chemical/nutrient status) (percent of plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. No historic baseline. Results difficult to interpret without additional information about landscape position, soil type, and vegetation.

Changes in soil carbon (percent of plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. No historic baseline.
Estimate of potential soil erosion rates (on plots) ⁴	USDA FS FHM/FIA (using WEPP ⁵ model)	Region	5 year	Low sampling intensity; limited to regional analysis. FIA data modeled using the WEPP model.
Bulk density (grams per cubic centimeter) (measure of compaction on plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. Lack of historical baseline.
Estimate of area exhibiting disturbance (percent of plot area)	USDA FS FHM/FIA	Region	5 year (annual updates)	Low sampling intensity; limited to regional analysis. Lack of historical baseline. Ecological significance of compaction is uncertain without additional information.

Data are available from the USDA Forest Service, Forest Health Monitoring (FHM) and Forest Inventory and Analysis (FIA) Programs. These data include measures of soil pH, soil carbon, estimated soil erosion, estimated soil compaction, and bulk density. Measured on a subset of FIA plots referred to as the FIA Phase 3 plots, the sampling grid is 1 plot to 96,000 acres. With the implementation of these soils protocols, FIA is still working on developing the best reporting format. The FIA soils protocols were designed for use with soils models for regional and national analysis. Since the sampling is not intensive enough to measure spatial distribution (expansion factors have not been developed), data will be reported by *percent of plots* (e.g., percent of plots with increased soil pH). The scale also limits the use of these data for State-level analysis (extent of limitation varies by State and depends upon the specific use of the data).

This indicator will take additional discussion and review for adequate use and interpretation of the data (due to the lack of reference or historical data and the very recent addition of soils measures to the FIA Program). USDA Forest Service scientists are working with USDA Natural Resources Conservation Service to develop soils maps and other tools needed to begin interpreting the ground plot soils information in a manner comparable to ecoregion sections.

Soil pH—Data for soil pH are available from the USDA Forest Service FIA and FHM Programs (analyzed from plot soil cores). Soil pH is often referred to as a “master variable” because it regulates nearly all biological and chemical reactions in the soil. It reflects the

⁴ In the long term, we are interested in using soil erosion limitation ratings from NRCS soils databases (such as the State Soil Geographic database—STATSGO) for comparison to FIA plot data (as a way to provide context for the plot data). The NRCS designation of woodland soils differs from definitions used in FIA; therefore, care must be taken when comparing data from these two sources.

⁵ WEPP: Water Erosion Prediction Project is a soil erosion model that is a joint effort of the USDA ARS, USDA FS, USDA NRCS, DOI BLM, and Purdue University.

weathering status, potential nutrient holding capacity, and fertility of different soil types. Soil pH is a primary factor in determining the productivity of the soil through its regulation of soil nutrient availability, aggregate stability, and microbial activity.

Soil Carbon—Because carbon concentrations are proportional to soil organic matter, the general spatial patterns are comparable. Organic carbon concentrations for the surface horizons are measured as part of the FIA and FHM Programs. In high pH soils, some fraction of total carbon may be derived from inorganic carbonates in the soil parent material. In order to reflect changes in soil carbon due to biological responses, data are presented for organic carbon concentrations only.

Soil Erosion—FIA/FHM data provide an estimate of bare soil in each subplot. Soil erosion is collected at the subplot level and aggregated to the plot level. Soil erosion rates can be estimated by using these FIA/FHM data with the Water Erosion Prediction Project model (WEPP). This erosion prediction model is based on factors that represent how climate, soil, topography, and land use affect soil erosion and surface runoff. The model is parameterized using a combination of field measurements collected on FIA plots (slope, slope length, percent ground cover) and includes a module for use in forest lands. Improved roads are excluded from FIA inventory plots, so the erosion predictions will only give us estimates of erosion on in-forest plots.

To put the FIA/FHM data in context, sensitivity of woodland soil units to erosive forces can also be assessed using woodland erosion limitation ratings derived from the USDA NRCS State Soil Geographic database (STATSGO). These ratings represent the probability that erosion damage may occur in a well-managed woodland as a result of site preparation, cutting operations, fires, and overgrazing.

Soil Compaction—FIA/FHM data provide a visual estimate of the amount of each subplot that exhibits evidence of disturbance and a description of the type of compaction. No measurements are made regarding the degree or intensity of compaction. Subsurface compaction more than a few years old may not be readily visible from the surface.

One of the most direct indices of soil compaction is bulk density, a measure of the ratio between the weight of solid particles and the total volume of soil. In general, roots grow well in soils with bulk densities of up to 1.4 g/cm³, and root penetration begins to decline significantly at bulk densities above 1.7 g/cm³. When the program has been fully implemented, bulk density will be measured on all FIA Phase 3 plots.

Interpretation of the ecological significance of this soil disturbance is limited because the impacts from compaction vary by site, due to factors such as soil texture, tree species tolerance to compaction, and reduced soil aeration.

Web Sites: USDA FS FIA: <http://fia.fs.fed.us>; USDA NRCS National Soil Survey Center (STATSGO & SSURGO databases): <http://soils.usda.gov>; USDA NRCS Water Erosion Prediction Project: <http://topsoil.nserl.purdue.edu/nserlweb/weppmain/wepp.html>

9. Area and percent of forest land adjacent to surface water and area of forested land by watershed

Overall Availability: Some data are available but are more difficult to assemble/interpret.

Background: Forests are especially important in regulating surface and ground water flow and maintaining water quality. Riparian forests (forests adjacent to bodies of water) slow the movement of pollutants into water bodies, regulate water temperature, and provide food and habitat for wildlife. The amount, location, and management of forest land strongly influence the quantity and quality of water in streams, lakes, wetlands, and ground water aquifers in watersheds.

Related Montreal Process Indicator

4.b (#19) Area and percent of forest land managed primarily for protective functions (e.g., watersheds, flood protection, avalanche protection, riparian zones)

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Forest land adjacent to surface water (acres, percent)	MRLC National Land Cover Data; U.S. EPA Office of Water, BASINS; (GIS processing by USDA FS NA, Durham, NH)	State, region, potentially other scales	Periodic	Requires additional research, discussion, and GIS processing. No regular reporting cycle. Current land cover data available (1992) are outdated; 2000 data should be available by 2004.
Forest land per watershed (percent)	MRLC National Land Cover Data; U.S. EPA Office of Water, BASINS; (GIS processing by USDA FS NA, Durham, NH)	State, region, watershed, potentially other scales	Periodic	Requires additional research, discussion, and GIS processing. No regular reporting cycle. Current land cover data available (1992) are outdated; 2000 data should be available by 2004.

Although feasible, adequately measuring this indicator will require additional research and discussion to consider the appropriate methods and scale to use with available data (e.g., need to verify the appropriate buffer distance for measuring forest land adjacent to surface water). GIS processing and analysis are required. We can work with Tom Luther at the USDA Forest Service, Durham, NH, Field Office using the best data available to create the necessary GIS and resulting data.

National Land Cover Data (NLCD), including forest land, are available through the Multi-Resolution Land Characteristics (MRLC) Consortium, which is sponsored by several Federal agencies (including USGS, U.S. EPA, USDA FS, NASA, and BLM). The first NLCD project utilized 1992 Landsat 5 Thematic Mapper satellite imagery to develop a nationally consistent land cover data set, which is readily available. A second NLCD project in development is based on 2000 Landsat 7 Enhanced Thematic Mapper Plus satellite imagery and should be entirely available in 2004.

Surface water and watershed data are available in the U.S. EPA BASINS 3.0 (Better Assessment Science Integrating point and Nonpoint Sources) database. BASINS is a multipurpose environmental analysis system for use by regional, State, and local agencies in performing watershed and water quality based studies. There are no concrete plans to update the BASINS datasets; however, the system has been refined and utilizes direct links to online data.

For acres and percent of forest land adjacent to surface water, we recommend using stream data from the BASINS database, measuring forest land within 150 feet of third order streams and *great ponds* (10+ acres). For percent of forest land per watershed, use the HUC (Hydrologic Unit Code) watershed data from the BASINS database (use the 8-digit HUC cataloging units generally referred to as sub-basin unless a different scale would be more consistent with the metrics decided upon for NAASF indicator number 10).

Some States have done GIS processing and analysis of this nature (including New Hampshire and Minnesota). When asked as part of the State survey, 12 States cited data available at the State level for this indicator. Most cited a DNR equivalent agency as the source for these data. We recommend researching these data and the methods used in order to validate and refine our work.

Web Sites: National Land Cover Characterization Project: <http://landcover.usgs.gov/nationallandcover.html>; U.S. EPA BASINS: <http://www.epa.gov/ost/basins>

10. Water quality in forested areas

Overall Availability: Adequate data are not currently available.

Background: Water resources include the physical features, habitat, and inhabitants of lakes, streams, wetlands, and riparian areas, as well as the water itself. Water is a basic element of productivity that is key to the health of many other forest resources. In turn, forested watershed processes are key to sustaining water quality, water supply, and watershed health.

Related Montreal Process Indicators

- 4.f (#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
- 4.g (#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

Recommendations

After looking into data sources for this indicator, it was determined that several water quality data sources exist with varying degrees of scope and consistency (described below). However, these available data are inadequate for measuring water quality in forested areas across States and at the regional level. Determining how to best measure water quality in forested areas for the purpose of this criteria and indicators effort will require additional discussion with specialists in this area and connection with related efforts at the national level.

One potential source of data in the future is the regional best management practices (BMP's) monitoring protocol currently under development by the USDA Forest Service and the Maine Department of Conservation with support from the NAASF and NASF Water Resources Committees and the U.S. EPA. This protocol monitors the effectiveness of water quality BMP's for timber harvest operations with a focus on water crossings and riparian areas, since disturbance in these areas have a greater potential to adversely impact water resources. Data are collected on sediment delivery into water resources, slash, stream shading, and hazardous materials. This effort evaluates BMP principles (rather than the BMP's) and incorporates a quality control system. Recording impacts with Global Positioning Systems will permit evaluation by watershed, political, or other boundaries. Quantitative data will provide a defensible measure of the impact of forest management activities on water resources and allow for computer modeling and risk and impact analysis. The protocol, which was revised as a result of the pilot test conducted in 10 States, will be further tested in an expanded second phase of the project. Since the U.S. EPA is accountable under the Clean Water Act to demonstrate that BMP's are effective in protecting water quality, it is very interested in this effort and is the likely implementation agency. We should track the progress of this effort.

Water quality data sources investigated for this indicator include the following:

- U.S. EPA Index of Watershed Indicators (IWI)—Released in 1997, 1998, and 1999, the IWI was an effort to characterize the condition and vulnerability of aquatic systems at the watershed level. The index was based on seven indicators related to the condition of water resources and nine indicators related to the vulnerability of water resources. However, the U.S. EPA Office of Water has stopped working on the IWI (the administration has shifted the focus to the Report on the Environment work).
- Other data reported by U.S. EPA—Watershed Assessment, Tracking, and Environmental Results (WATERS) is a new system that integrates information from various EPA Office of Water programs by linking 11 related databases to the national surface water network (National Hydrography Dataset). Databases linked to WATERS include the 305(b) water quality inventory (National Assessment Database), Total Maximum Daily Load 303(d) list (waters listed by the State as impaired), and water quality monitoring data (STORET). As updated information is added to each individual database, it immediately becomes available through WATERS. Most of these data represent information States and tribes report to EPA as required by the Clean Water Act. Although WATERS makes these data more accessible and easier to analyze, the methods vary by State (e.g., determining which water bodies are considered impaired). In addition, it is likely that data are not adequate for measuring water quality in forested areas.
- USGS National Water Quality Assessment (NAWQA)—Through the NAWQA Program, started in 1991, USGS scientists collect and interpret water quality data (such as sedimentation, electrical conductivity, temperature, and dissolved oxygen) in 20 major river basins across our region. The study areas are monitored on staggered 10-year cycles. The data are collected according to nationally consistent sampling and analytical methods, allowing water quality conditions in a specific locality or watershed to be compared to those in other areas and over time. These are the most consistent and comparable water quality data collected.⁶ The low sampling intensity, however, makes these data inappropriate for analyzing general trends in water quality across States or the region. Looking only at those measures collected in forested areas further reduces data available.
- Data available at the State level—When surveyed, 12 States cited data available at the State level for this indicator. Most cited a DNR equivalent agency as the source for these data. We do not have additional information about these potential data; however, it is likely they are not consistent nor are they adequate enough for regional reporting.

Web Sites: U.S. EPA Index of Watershed Indicators: <http://www.epa.gov/iwi/>; U.S. EPA Watershed Assessment Tracking & Environmental Results: <http://www.epa.gov/waters>; U.S. EPA Draft Report on the Environment: <http://www.epa.gov/indicators>; USGS National Water Quality Assessment: <http://water.usgs.gov/nawqa>

⁶ Data from USGS NAWQA were used for the *2003 National Report on Sustainable Forests* and the *Heinz Center Report on the State of the Nation's Ecosystems*.

11. Forest ecosystem biomass, and forest ecosystem and forest products carbon pools

Overall Availability: Data are available and relatively easy to assemble and interpret.

Background: Carbon cycling is an essential process in all ecosystems. Changes in cycling pathways and flows (outside of expected variances) may reflect major alterations in forest ecosystems. In addition, forest ecosystems are one of the largest reservoirs of both biomass and carbon. Therefore, managing forests to store carbon reduces the net amount of carbon dioxide that can accumulate in the atmosphere, which may reduce the possibility of human-induced climate change. Since climate change can significantly disturb the ecological balances that have produced the type and distribution of forests we have today, trends in this indicator are important to guide strategies in forest management as a means to help monitor and stabilize global climate.

Related Montreal Process Indicators

- 5.a (#26) Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages
- 5.b (#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)
- 5.b (#28) Contribution of forest products to the global carbon budget

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Forest ecosystem biomass (megatonnes; megagrams or metric tons per hectare) ⁷	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.
Forest carbon pools (megatonnes)	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.

⁷ Units commonly used to measure carbon and biomass are megatonnes (Mt) or megagrams (Mg). A megatonne equals 1 million metric tons; a megagram equals 1 million grams, equivalent to 1 metric ton.

Change in forest carbon pools (megatonnes per year)	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.
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Data are available from the USDA Forest Service, Northern Global Change Research Program in cooperation with the National Council for Air and Stream Improvement (NCASI). An online application, Carbon OnLine Estimation (COLE), allows reporting on forest ecosystem biomass, forest ecosystem and wood products carbon pools, and change in forest carbon pools by State, region, and ecological province. We can report total carbon pool data or report by forest type. With the new USDA Forest Service, Forest Inventory and Analysis (FIA) Program inventory, data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data are available beginning in the 1950's. Forest soil carbon data for changes in forest carbon pools will be available in the future.

The data are compiled from a scientifically based sample, designed to provide reliable volume and area data at a predetermined level of precision. Studies indicate that estimates for total carbon stocks for private forests in the United States are within 4 percent of the median, using an 80 percent confidence limit. For individual States, the accuracy will be lower. Work is underway to calculate confidence limits for these data.

To fully measure total forest ecosystem biomass and carbon pools, more samples of down dead wood and forest floor soil carbon are necessary than are currently being collected.

Long-term land use history is also an important variable needed to estimate carbon in forests accurately, particularly soil carbon. Historical land use statistics will be incorporated in the final version of the estimates.

Web Sites: USDA FS Northern Global Change Research Program: <http://www.fs.fed.us/ne/global>; National Council for Air & Stream Improvement, Carbon OnLine Estimation: <http://ncasi.uml.edu/COLE>

12. Value and volume of wood and wood products production, consumption, and trade

Overall Availability: Most data are available and relatively easy to assemble and interpret; data for “trade” (or wood flow) are more difficult to assemble/interpret.

Background: This indicator measures the value, quantity, and consumption of various types of wood products extracted from forest lands. These measures reflect the importance of forest resources in supplying raw materials for manufacturing and the value that society places on the production of wood and wood products. To consider the complete cycle of wood and wood products utilization, it is also useful to consider trade (imports and exports), or wood flows, at regional and State levels. However, wood flow data are not calculated on a regular basis at these scales (only at the national level) and would require further data manipulation.

In addition to the metrics listed, there are many nontimber forest products, such as maple syrup, ginseng, and Christmas trees, that are economically and/or culturally important to those who harvest them. Limited data are available for nontimber forest products and they are beyond the scope of this indicator (requiring additional work and a change to this indicator or addition of a new indicator).

Related Montreal Process Indicators

6.1.a. (#29) Value and volume of wood and wood products production, including value added through downstream processing

6.1.c. (#31) Supply and consumption of wood and wood products, including consumption per capita

6.1.e. (#33) Degree of recycling of forest products

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Value of wood products production (by industry)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.
Value added in wood products production (by industry)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.

Volume of roundwood production on all land	USDA FS FIA and TPO (as reported in RPA)	State, region	5 year	Reporting cycle for North Central States may vary from that for Northeastern States (10 years in the past). The statistics are updated more often for some States.
Per capita consumption of roundwood (volume)	AF&PA via USDA FS Forest Products Lab; U.S. DOC Census Bureau	Region	Annual	Rough estimate calculated from the national estimated per capita consumption rate and regional population statistics.
Recovered paper (utilization rate or total)	AF&PA via USDA FS Forest Products Lab	State, region	Annual	Adequate data may not be available at the State level for all States (due to disclosure issues).

Value of wood products production—Data are available by State and region for the value of production and value added of wood products production from the Economic Census, which is conducted every 5 years by the U.S. Census Bureau. The Census Bureau also conducts an Annual Survey of Manufacturers (a probability-based sample) each year in which an economic census is not conducted. Value added is derived by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of production. This measure is generally considered to be the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas.

The economic census has been conducted every 5 years since 1967. Starting in 1997, however, there was a switch from the Standard Industrial Classification (SIC) System to the North American Industry Classification System (NAICS), making the new data not directly comparable to those from previous years. The major wood-related sectors include wood product manufacturing, paper manufacturing, and wood furniture subsectors within furniture manufacturing (e.g., wood office furniture manufacturing). The Census Bureau used to collect comparable data for logging; however, with the switch to NAICS, they are no longer collecting value data for this sector. County Business Patterns payroll data collected by the Census Bureau may be used to extrapolate the value of production for the logging sector.

The Census Bureau cannot publish data that could reveal the identity or activity of an individual business, resulting in some missing data in reports that are broken out by State or for categories of industries that have few firms. Overall, the data should be adequate at State and regional levels for the wood and paper products sectors. However, missing data due to disclosures may be of more concern for reporting the disaggregated wood-related sectors in furniture manufacturing. Therefore, the data should be checked for degree of completeness related to this disclosure issue.

Volume of roundwood production—Roundwood is defined as logs, bolts, or other round sections cut from growing stock and nongrowing stock sources. Nationally, data to measure the volume of roundwood production comes from three sources: (1) the USDA Forest Service, Forest Inventory Analysis (FIA) Program collects volume of removals information based upon forest inventory plot data; (2) the Timber Product Output (TPO) Database Retrieval System, developed by FIA, estimates roundwood products based upon mill

survey data that is collected by FIA and its partners from within and outside the Forest Service; and (3) the Timber Demand and Technology Research Work Unit within the USDA Forest Service, Forest Products Laboratory compiles production, trade, consumption, and price statistics annually by taking primary product statistics and extrapolating back to estimate roundwood production (only at the national scale). There are efforts underway to reconcile the statistics between these three sources and methods.

As drawn on for the Renewable Resources Planning Act (RPA) reports, data for the volume of timber production are available by State and region from the USDA Forest Service, FIA Program and the FIA Timber Product Output database. Data from the latter identify the type of roundwood products harvested, based on the type of primary processing and the resulting end product (sawlogs, veneer logs, pulpwood, composite products). Fuelwood is encompassed in the figures for roundwood production. It is important to recognize that the volumes of growth and removals from growing stock reported as part of forest inventories are different from these estimates of the volume of roundwood from all lands. The reporting cycle for these data varies by State and region, but calculated values for all States are computed every 5 years for the RPA reports. (As calculated values, these also may differ from published reports for individual States.) The FIA North Central region collects TPO data from most States at least every 5 years (and for some States every 2–3 years), whereas the FIA Northeastern region collects TPO data from States every 10 years (however, they are moving towards a more frequent cycle). Data should be available at State and regional levels.

Per capita consumption of roundwood—National wood products consumption data are available from the USDA Forest Service, Forest Products Laboratory. The data are drawn from a number of sources, compiled on an annual basis, and reported roughly every 2 years. The national rate of consumption per capita will be used along with population data from the U.S. Census Bureau to estimate per capita consumption for our region. This rough estimate provides a gauge of sustainability, despite actual consumption rates varying across the United States due to personal tastes and industry composition. Other data are not readily available to track the balance between our region’s wood supply and demand.

Recovered paper (degree of recycling)—The American Forest & Paper Association (AF&PA) compiles paper, paperboard, and wood pulp statistics on an annual basis. Certain data are obtained, analyzed, and reported by the USDA Forest Service, Forest Products Laboratory. Since other “recycling” statistics are not currently available, we could potentially report the paper recovery rate or total recovered paper from this data source. The paper recovery rate is the ratio of the total recovered paper used in paper and paperboard mills relative to the total product produced. The regions normally reported by the Forest Products Laboratory do not coincide with the 20 States served by NA; therefore, it is uncertain which data will be available for our purpose. However, Forest Products Laboratory economist James Howard thought data might be available for most States in the AF&PA reports he obtains. If we can obtain adequate data for recovery rate, it is all we would need for this metric. Otherwise, we should probably report out amounts of material recovered. In addition to paper and paperboard recovery, recycling information for solid wood is becoming more available, and we may be able to report this component in the future.

Trade (wood flow)—To consider the complete cycle of wood and wood products utilization, it is also useful to consider trade (both imports and exports), or wood flows, at regional and State levels. Some data are available in the USDA Forest Service, FIA Timber Product Output databases. Each FIA region (e.g., North Central and Northeastern) maintains a separate database. We should be able to take the results from each database and adjust for wood flows between the two regions to develop wood flow estimates for the 20-State region. The frequency of updating these data is quite variable by State and there is no regular reporting cycle (although calculations could at least be timed with the 5-year RPA cycle). Additional discussion and compilation are required to address this metric.

Web Sites: U.S. Census Bureau: <http://www.census.gov>; American FactFinder database: <http://factfinder.census.gov>; Timber Product Output Database: <http://www.ncrs.fs.fed.us/4801/TimberProducts/index.htm>; USDA FS Forest Products Laboratory: <http://www.fpl.fs.fed.us/econ>; recent timber statistics report: <http://www.fpl.fs.fed.us/documnts/FPLrp/fplrp595/fplrp595.htm>; nontimber forest products: <http://www.sfp.forprod.vt.edu>

13. Outdoor recreational facilities and activities

Overall Availability: Data for “activities” are available but require some additional work to assemble and interpret; some data for “facilities” are available but are difficult to assemble/interpret.

Background: An assessment of the wide range of demands for and supplies of recreational resources is essential to long-range forest planning and policy formulation. Facilities for forest-based recreation provide opportunities to participate in outdoor recreation and may enhance the outdoor recreation experience. Such facilities include a wide array of public and private trails, campgrounds, picnic areas, and interpretive centers, in addition to parks and other specially designated areas (e.g., game or hunting areas).

Changes in the level of outdoor recreational activities and the use of recreational facilities will have many implications, from policy and development issues through social and cultural trends. Changes in these levels may impact other land uses, forest fragmentation, and wildlife habitats. Because of the diversity in recreational activities, it is important to incorporate a wide variety of metrics to ensure adequate monitoring of trends and identification of possible impacts relating to sustainable forest management. This also implies that (1) a further synthesis of the metrics and data reported may be appropriate to foster proper interpretation of trends, and (2) to keep this indicator current, special effort must be given to routinely updating it through pursuing the latest research results and reporting on recreational trends.

Related Montreal Process Indicators

6.2.b (#36) Number and type of facilities available for general recreation and tourism, in relation to population and forest area

6.2.c (#37) Number of visitor days attributed to recreation and tourism, in relation to population and forest area

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Recreational areas (type, number, acres)	Survey of States (NAASF); USDA FS Eastern Region; NASPD	State, region	Periodic	Recommend a survey of States at least every 5 years. NASPD data (reported annually) only cover areas managed by State park agencies. No established reporting cycle for other data.
Trails (miles)	Survey of States (NAASF); USDA FS Eastern Region; NASPD	State, region	Periodic	Recommend a survey of States at least every 5 years. NASPD data (reported annually) only cover areas managed by State park agencies. No established reporting cycle for other data.

Campgrounds (number, number of sites)	Survey of States (NAASF); USDA FS Eastern Region; published campground guides	State, region	Periodic	Recommend survey of States and compilation of data from other sources every 5 years.
Outdoor recreational participants and activity days by activity	USDA FS Southern Research Station, National Survey on Recreation and the Environment; USDI F&WS, Fishing, Hunting, and Wildlife-Associated Recreation	State, region	5 year	Does not directly measure recreation in forested areas. Need to decide which outdoor recreation activities to track.

States were surveyed as to the existence of data pertaining to outdoor recreation. While data metrics and terminology varied widely across States, a slight majority of States indicated they had some data on a wide range of facilities, from horse trails to campgrounds. Despite the lack of consistency, it is believed that capturing and displaying these data may help to “tease out” trends, stimulate the reporting of additional data, and refine the overall future reporting of recreation-related metrics. Additionally, it is these State-based data that the States served by NA have the most control over.

Direct measures and data are largely unavailable for State recreational facilities in forested settings. Some data on State recreational facilities are available from the National Association of State Park Directors (NASPD), which reports on recreational areas and trails annually. These data include only areas managed by State park agencies, however, and do not identify recreational facilities in forested settings. To more comprehensively measure State recreational facilities in forested settings, including miles of trails and number of campgrounds and campsites in State forests and parks, it is recommended to supplement the NASPD data through a State survey every 5 years.

In order to receive funding through the Land and Water Conservation Fund, States are required to develop a Statewide Comprehensive Outdoor Recreation Plan (SCORP). The reporting requirements are broad and general, with no core set of data required; therefore, SCORP documents are not consistent across States, ranging from comprehensive inventories of the whole State to strategic plans that focus on specific areas. In addition, the National Park Service, the submittal agency, does not compile data as a result of this process. It is not practical to filter through each State report to compile data for the region; however, the SCORP’s can be a good data source at the State level and may be utilized by individual States to complete the State survey.

Data are available to measure forest-related Federal recreational facilities from the USDA Forest Service, Eastern Region, including the number and acres of recreational areas, miles of trails, and the number of campgrounds and campsites. There are additional efforts at the national level to compile information on Federal recreational areas, including a new initiative to provide data online. This work may provide appropriate data for all Federal recreational facilities; we should stay informed on the progress of such efforts.

In addition to data available through State surveys and from the USDA Forest Service, data are potentially available on private campgrounds and campsites through a few private sources, including Woodall's Campground Guide, Kampgrounds of America (KOA), and AAA Travel Agency. Many States also have campground associations that publish free guides annually, often including all Federal, State, and private campgrounds, that we should also look into. However, these sources may not allow compilation of data for camping facilities in forested areas. We recommend looking further into these sources to compile a more complete list of camping facilities.

Data are available from the USDA Forest Service, National Survey on Recreation and the Environment (NSRE) to measure outdoor recreational activities. The NSRE is conducted every 5 years, and data on participation by activity can be obtained for a number of outdoor recreational activities that can take place in forested settings, such as hiking, birdwatching, fishing, and camping (we need to determine which activities to measure). These data do not directly measure recreational activities in forested areas, but may in the future. Similarly, the U.S. Fish & Wildlife Service's Fishing, Hunting, and Wildlife-Associated Recreation survey is published every 5 years. It contains data broken out by State and sub-State areas that could be used as a basis for delineating forest area information, but it does not address trail or campground use.

Web Sites: USDA FS Infra (infrastructure) database: <http://pcs27.f16.r6.fs.fed.us/infra>; National Association of State Park Directors: <http://www.naspd.org>; USDA FS Southern Research Station recreation related research: <http://www.srs.fs.fed.us/trends>; USDI F&WS National Survey of Fishing, Hunting, and Wildlife Associated Recreation: <http://fa.r9.fws.gov/surveys/surveys.html>

14. Public and private investments in forest health, management, research, and wood processing

Overall Availability: Data are available and relatively easy to assemble and interpret.

Background: This indicator measures society’s short- and long-term commitment to forest health, management, forest products processing and manufacturing, and research. Investments in forest management and in new knowledge through research and development build the capacity to improve the practice of forest management in economic, social, and environmental terms. Most of the data available for this indicator capture public investments. For these dollar value investments data, it is important to note that increasing the expenditure of resources does not necessarily increase investment quality.

Related Montreal Process Indicators

6.3.a. (#38) Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism

6.3.b (#39) Level of expenditure on research and development, and education

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Federal funding in forest health and management	USDA FS NA	State, region	Annual	
State forestry program funding	NASF State Forestry Statistics; USDA FS NA	State, region	Periodic	No established reporting cycle—varies from 2 to 5 years.
Forestry research funding at universities	USDA Cooperative State Research, Education, and Extension Service	State, region	Annual	
USDA Forest Service Research funding	USDA FS Research and Development	Region	Annual	
Capital expenditures by wood product manufacturers (by industry)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.

Forest health and management—To measure Federal investment in forest health and management, data are available for funding of USDA Forest Service forest health protection programs and funding provided for forest health to State forestry programs. These data are

available annually by State and region and can be reported in different categories (e.g., forest health management, cooperative fire protection, cooperative forestry, Forest Legacy Program).

For State investments in forest management, State forestry program funding data are available from the National Association of State Foresters, as part of their State Forestry Statistics, which are collected periodically. The USDA Forest Service, Northeastern Area also maintains and reports (in the State forest resource fact sheets) total State forestry program budget data.

Forest related research—To measure investments in forest-related research, data are available from the USDA Cooperative State Research, Education, and Extension Service (CSREES) for research funding at forestry universities on an annual basis for each State. Compiled annually in their Current Research Information System (CRIS), these data include funding amounts and sources (public and private) for forestry research at forestry universities. In addition, data are readily available for funding of USDA Forest Service Research and Development conducted within the 20 States served by NA. Although “investments in research” is listed separately from the other categories, investments in research could also be considered indirect investments in forest health and management.

Forest-related processing and manufacturing—Investments in forest-related processing and manufacturing can be measured with data on capital expenditures by wood product manufacturers, available by State and region from the Economic Census, which is conducted every 5 years by the U.S. Census Bureau. The Census Bureau also conducts an Annual Survey of Manufacturers (a probability-based sample) each year in which an economic census is not conducted. Total capital expenditures include new and used expenditures for (1) permanent additions and major alterations to manufacturing establishments, and (2) machinery and equipment used for replacement and additions to plant capacity if they were of the type for which depreciation accounts are ordinarily maintained.

The economic census has been conducted every 5 years since 1967. Starting in 1997, however, there was a switch from the Standard Industrial Classification (SIC) System to the North American Industry Classification System (NAICS), making the new data not directly comparable to those from previous years. The major wood-related sectors include wood product manufacturing, paper manufacturing, and wood furniture subsectors within furniture manufacturing (e.g., wood office furniture manufacturing). The Census Bureau used to collect comparable data for logging; however, with the switch to NAICS, they are no longer collecting capital expenditures data for the logging sector.

The Census Bureau cannot publish data that could reveal the identity or activity of an individual business, resulting in some missing data in reports that are broken out by State or for categories of industries that have few firms. Overall, the data should be adequate at State and regional levels for the wood and paper products sectors. However, missing data due to disclosures may be of more concern for reporting the disaggregated wood-related sectors in furniture manufacturing. Therefore, the data should be checked for degree of completeness related to this disclosure issue.

Web Sites: USDA FS NA: <http://www.na.fs.fed.us>; NASF State Forestry Statistics: <http://www.stateforesters.org/SFstats.html>; U.S. Census Bureau: <http://www.census.gov>; American FactFinder database: <http://factfinder.census.gov>; USDA CSREES: <http://www.reeusda.gov>; Current Research Information System (CRIS): <http://cris.csrees.usda.gov>; USDA FS Research and Development: <http://www.fs.fed.us/research/briefpapers.html>

15. Forest ownership and land use (including acres of specially designated land)

Overall Availability: Data for “ownership” are available and relatively easy to assemble/interpret; data for “land use,” including specially designated areas, are available but require some additional work to assemble and interpret.

Background: This indicator measures who owns forest land, which is important to making informed decisions about forests. Public and private owners often have different goals and assumptions, differences that are reflected in management priorities and practices. This indicator also measures the amount of forest land in different management categories and specially designated areas, including those that are designed to protect ecological, cultural, and/or social values. It is important to consider the degree to which the specially designated status is secure. How a forest is managed influences the goods and services that it provides. Protecting forest land from permanent conversion, particularly to urban development, is vital to the sustainability of forest ecosystems. For sustainability, it is important to track forest land areas that are protected from urban development but where sound forestry is still permitted. In addition, it is useful to track trees/forests within urban areas, since they provide multiple benefits to the people in these densely populated areas.

Related Montreal Process Indicators

- 1.1.c. (#3) Extent of area by forest type in protected area categories as defined by IUCN or other classification systems
- 1.1.d. (#4) Extent of areas by forest type in protected areas defined by age class or successional stage
- 4.b. (#19) Area and percent of forest land managed primarily for protective functions (e.g., watersheds, flood protection, avalanche protection, riparian zones)
- 6.4.a. (#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
- 7.1.e. (#52) (Extent to which the legal framework) provides for the management of forests to conserve special environmental, cultural, social and/or scientific values

Note: The Montreal Process indicators do not measure forest land ownership

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Forest land ownership (acres)	USDA FS FIA, National Woodland Owner Survey; NASF State Forestry Statistics	State, region	5 year	FIA data are collected on an annual rolling cycle, reporting averages every 5 years. Plus/minus 10% error at the State level. NASF data are collected periodically from State forestry agencies.

Reserved forest land (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴ Does not adequately measure private conservation forest lands.
Specially designated public forest land: Federal, State, some county (acres by IUCN category ⁸)	CBI/WWF Protected Areas Database and UCLA Managed Area Database, via USDA FS FIA	State, region	Periodic	No established reporting cycle. The Forest Service is working with these databases at the national level to measure forest land protected. May require an accuracy check for the data in our region.
Specially designated State land: forests, parks, natural areas, old growth forest, others (acres by category)	Survey of States (NAASF)	State, region	Periodic	No established reporting cycle. Recommend survey of States every 5 years.
Private land with public conservation easements: Forest Legacy areas (acres), State government easement programs (acres)	USDA FS Forest Legacy Program; Survey of States (NAASF)	State, region	Annual, periodic	Forest Legacy data reported annually. No established reporting cycle for State government easement programs. Recommend survey of States every 5 years.
Forest land in State current use/tax reduction programs	Survey of States (NAASF)	State, region	Periodic	No established reporting cycle. Recommend survey of States every 5 years.
Urban forest (acres)	USDA FS	State, region	Annual	

Forest ownership data are available from the USDA Forest Service National Woodland Owner Survey. Ownership categories reported include Federal, State, local, corporate/business, and family. These data are reported every 5 years from an annual update cycle (rolling). Data for forest ownership are also available periodically from the National Association of State Foresters as part of their State forestry statistics.

Data are available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program for area of reserved forest land. The FIA Program, which works through the States to collect data, is converting to a continuous annual inventory. Data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years. The reporting cycle of 5 years is staggered across States. Historical data

⁸ International Union for the Conservation of Nature (IUCN) categorizes protected areas according to six management categories (e.g., strict nature reserve/wilderness area, managed resource protected area). The United Nations Environmental Program, World Conservation Monitoring Center has a Protected Areas Program in collaboration with IUCN, which manages a worldwide protected areas database following the IUCN categories. The UCLA managed areas database was the primary source for the U.S. data in this international database.

are available starting in the 1950's. FIA defines "reserved" forest lands as those withdrawn from timber utilization by law or administrative regulation; they include predominantly public land, such as National Wilderness Areas, National Parks, and State parks. Data are also available from the USDA Forest Service for acres of forest within urban areas.

The Conservation Biology Institute (CBI)/World Wildlife Fund (WWF) Protected Areas Database and the UCLA Managed Area Database are sources that together provide data for Federal- and State-owned protected land, as well as some data for county, city, and private reserves. The CBI/WWF Protected Areas Database categorizes protected areas according to the IUCN categories. The USDA Forest Service has been working with these data and the FIA forest area map to measure acres and spatial distribution of forest and nonforest land within protected areas. We recommend obtaining and checking this data for accuracy and completeness for our 20 States and continuing to track the progress of this work at the national level.

Although some data for State-owned specially designated areas are included in the above protected areas database work, additional data can be obtained directly from the States through a survey of States by NAASF. These data, including State forests, parks, natural areas, old growth forests, and other specially designated areas, would be useful for initial reporting and to aid in checking the accuracy of the above data source. Many States have GIS data available. With this information, we recommend working with the national level protected areas database effort to ensure that the data on protected areas are complete for the 20 States served by NA.

Data on public (Federal and State) specially designated lands are more readily available than data on private conservation lands. Information about private conservation of forests, however, is of utmost importance in our region since such a large percentage of forest land is privately owned in the States served by NA. There are a number of nonprofit organizations that work on land conservation, including the Land Trust Alliance, The Nature Conservancy, the Trust for Public Land, and the Conservation Fund. However, much of their data is proprietary and not classified by land cover type (forest, grassland, etc.), making it a difficult and costly task to compile a total picture of private land conserved. Some data for private lands with public conservation easements are available from the USDA Forest Service, Forest Legacy Program; additional data can be obtained through a survey of States by NAASF for lands in State government easement programs.

To supplement the limited data on privately owned forest land that is specially designated, we recommend obtaining data on forest land in State current use/tax reduction programs as part of an NAASF survey of States.

In addition to the sources listed, the U.S. Geological Survey, Gap Analysis Program (GAP) plans to regionalize all State data sets, which include area (acres) of land by management intensity categories (including public and private land). The GAP work varies widely by State, however, in extent of data included, resolution, and plans for updating. It would be helpful to compile the specifics on the GAP work within each State. National GAP data is being incorporated into the CBI/WWF Protected Areas Database.

Further consideration will be made as whether to report or link to data on acres forest land under forest certification programs (e.g., Sustainable Forestry Initiative or Forest Stewardship Council).

Web Sites: USDA FS National Woodland Owners Survey: <http://www.fs.fed.us/woodlandowners>; USDA FS FIA: <http://fia.fs.fed.us>; NASF State Forestry Statistics: <http://www.stateforesters.org/SFstats.html>; CBI/WWF Protected Areas Database: http://www.consbio.org/cbi/what/pad_2001/pad.htm; USDA FS Forest Legacy Program: <http://www.fs.fed.us/na/durham/legacy>; USGS Gap Analysis Program: http://www.gap.uidaho.edu/About/what_is_gap_analysis.htm

16. Employment and wages in forest-related sectors

Overall Availability: Data are available and relatively easy to assemble and interpret for most sectors.

Background: This indicator measures the contribution of the forest sector in providing employment at State and regional levels. Forest-related jobs are an important social value of forests. The utilization of wood fiber from our forests provides the foundation for many rural economies and community stability. It also enables the achievement of forest management objectives such as providing habitat for wildlife and maintaining forest health. While primary wood manufacturing sectors are located in or near more heavily wooded areas, secondary manufacturing often is located closer to markets in more urban areas. Trends in public sector forestry employment also provide an indication of the importance society places on sustainable forestry.

Data sources sometimes refer to wages as earnings. The term wages is used here to avoid earnings being misinterpreted as company earnings.

Related Montreal Process Indicators

6.5.a. (#44) Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment

6.5.b. (#45) Average wage rates and injury rates in major employment categories within the forest sector

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Wood product manufacturing employees (by industry and as a proportion of total manufacturing employment)	U.S. DOC Census Bureau, Economic Census and County Business Patterns	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector only collected as part of the County Business Patterns data. Potential for missing data due to disclosures policy.
State forestry employees	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle; varies from 2 to 5 years.
USDA Forest Service employees	USDA FS HRM	Region	Annual	
Wood product manufacturing production worker wages or wages per hour (by industry)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.

Wood product manufacturing annual payroll (by industry and as a proportion of total manufacturing payroll)	U.S. DOC Census Bureau, Economic Census and County Business Patterns	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector only collected as part of the County Business Patterns data. Potential for missing data due to disclosures policy.
State forestry employee salaries	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle; varies from 2 to 5 years.

Data are available for wood product manufacturing employment by State and region from the economic census, which is conducted every 5 years by the U.S. Census Bureau. We can report employees, production worker wages, and/or wages per hour by industry. The economic census has been conducted every 5 years since 1967. Starting in 1997, however, there was a switch from the Standard Industrial Classification (SIC) System to the North American Industry Classification System (NAICS), making the new data not directly comparable to those from previous years. The major wood-related sectors include wood product manufacturing, paper manufacturing, and wood furniture sub-sectors within furniture manufacturing (e.g., wood office furniture manufacturing). The Census Bureau used to collect comparable data for logging; however, with the switch to NAICS, they are only collecting data on payroll and employment as part of the County Business Patterns.

The Census Bureau cannot publish data that could reveal the identity or activity of an individual business, resulting in some missing data in reports that are broken out by State or for categories of industries that have few firms. Overall, the data should be adequate at State and regional levels for the wood and paper products sectors. However, missing data due to the disclosure issue may be of more concern for reporting the disaggregated wood-related sectors in furniture manufacturing. Therefore, the data should be checked for degree of completeness related to this disclosure issue. The Census Bureau also conducts an Annual Survey of Manufacturers (a probability-based sample) each year in which an economic census is not conducted.

Forest management employment and salaries data are available for State forestry personnel from the National Association of State Foresters as part of their State Forestry Statistics, which are collected periodically. Data for USDA Forest Service personnel are available annually from the USDA Forest Service, Human Resources and Management.

Forest-related recreation earnings and employment is difficult to measure, and data are not readily available. Proprietary information is probably compiled by the recreation industry, but is not available for reporting. We should continue to research and network to stay informed on potential data to measure employment in this important forest-related sector.

The USDA Forest Service developed and uses a database with software for community impact analysis called IMpact analysis for PLANing (IMPLAN). IMPLAN contains various economic variables, including employment-related data available by State and county. In line with Montreal Process indicator number 44, which references “indirect employment,” a benefit of using IMPLAN is that it generates estimates of indirect impacts (multiplier or “ripple effects”), thereby providing a more accurate indication of the size of forest-

related sector employment and wages. This can be especially important for evaluating particular project proposals and at the sub-State level. At this time, for our purposes, we have chosen to emphasize the reporting of trends in estimates of direct wages and employment published by the Census Bureau. However, the USDA Forest Service, Inventory and Monitoring Institute uses IMPLAN and obtains updated data annually. They can provide data upon request and/or can train NA staff to use the software. We should review the utility of this option in the future.

Web Sites: U.S. Census Bureau home page: <http://www.census.gov>; American FactFinder database: <http://factfinder.census.gov>; U.S. Census Bureau County Business Patterns: <http://www.census.gov/epcd>; NASF State Forestry Statistics: <http://www.stateforesters.org/SFstats.html>; USDA Forest Service HRM: <http://fsweb.wo.fs.fed.us/hrm/> (internal Web site); Minnesota IMPLAN Group <http://www.implan.com>

17. Existence, type, and monitoring of forest management standards/guidelines

Overall Availability: Data are available but require some additional work to assemble and interpret.

Background: Forest management standards/guidelines, such as best management practices, set standards governing forest planning, management, and operational activities on the ground. Forest management standards/guidelines that are well designed, properly applied, and effective are essential to the sustainability of forest resources. Examples of natural resource values subject to State government monitoring of forest management standards include water quality, riparian, wetland, soil productivity, wildfire, effects of insects and diseases, aesthetics, wildlife habitat, reforestation, cultural and historic resources, and recreational.

Related Montreal Process Indicator

7.1.d. (#51)(Extent to which the legal framework) encourages best practice codes for forest management

7.4.a. (#60) Availability and extent of up-to-date data, statistics, and other information important to measuring or describing indicators associated with criteria 1–7

7.4.b (#61) Scope, frequency, and statistical reliability of forest inventories, assessments, monitoring, and other relevant information

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Categories of forest management standards/guidelines (natural resource values or problem areas)	Survey of States (NAASF); Minnesota Agricultural Experiment Station	State, region	Periodic	Research-based reporting. No set reporting cycle.
Program type (e.g., voluntary, regulatory)	Survey of States (NAASF); NASF State Forestry Statistics; Minnesota Agricultural Experiment Station	State, region	Periodic	Research-based reporting. No set reporting cycle.
Monitoring (by type of monitoring; e.g., implementation, effectiveness)	Survey of States (NAASF); Minnesota Agricultural Experiment Station Future potential: regional BMP monitoring protocol (USDA FS; U.S. EPA)	State, region	Periodic	Research-based reporting. No set reporting cycle. Regional BMP monitoring protocol is still in development.

As found in the survey of States, all the States reporting have forest management standards/guidelines. Forest management standards/guidelines are implemented by individual States with a variety of program types and methods. Data currently available from

the States allow consideration of the categories of forest management standards/guidelines (natural resource values or problem areas addressed), program type (regulatory, voluntary, technical assistance, incentives, etc.), and monitoring efforts (monitoring of implementation, effectiveness, etc). State monitoring of forest management standards/guidelines tends to focus on implementation. Effectiveness monitoring, where conducted, is primarily qualitative with a wide range of interpretations among States. It is important to emphasize the principles on which forest management standards/guidelines are based and to monitor the degree of implementation/compliance.

A research group at the Minnesota Agricultural Experiment Station (Department of Forest Resources at the University of Minnesota) has compiled and analyzed this type of information on forest management standards/guidelines over the past decade (1992, 1997). We recommend utilizing these data as a baseline and proposing that NAASF conduct a survey of States periodically (every 5 years) to obtain updated information on a more regular basis. Other information about forest management standards/guidelines has been researched and compiled by the American Forest & Paper Association, the National Council on Air and Stream Improvement, the National Association of State Foresters, and the U.S. Environmental Protection Agency. It is important for us to consult these findings and keep track of future work in this area.

The National Association of State Foresters also conducts a survey of each State forestry program periodically. The resulting data, referred to as the State Forestry Statistics, usually include information about forestry-related legislation. These data could be useful for looking at new State legislation effecting the implementation and monitoring of forest management practices/guidelines.

In addition, there is a regional best management practices (BMP) monitoring protocol currently under development by the USDA Forest Service and the Maine Department of Conservation with support from the NAASF and NASF Water Resources Committees and the U.S. EPA. This protocol monitors the effectiveness of water quality BMP's for timber harvest operations, with a focus on water crossings and riparian areas, since disturbance in these areas has a greater potential to adversely impact water resources. Data are collected on sediment delivery into water resources, slash, stream shading, and hazardous materials. The team working on this effort recognizes State agency barriers, such as time, cost, and a reluctance to change BMP specifications and monitoring teams, and aims to overcome these barriers by evaluating BMP principles (rather than the BMP's) and incorporating a quality control system. Recording impacts with Global Positioning Systems will permit evaluation by watershed, political, or other boundaries. Quantitative data will provide a defensible measure of the impact of forest management activities on water resources and allow for computer modeling and risk and impact analysis. Ten States participated in the first phase of pilot testing. The protocol, which was revised as a result of the pilot test, will be further tested in an expanded second phase of the project. Since the U.S. EPA is accountable under the Clean Water Act to demonstrate that BMP's are effective in protecting water quality, it is very interested in this effort and is the likely implementation agency. We should track the progress of this effort.

Web Site: NASF State Forestry Statistics: <http://www.stateforesters.org/SFstats.html>

18. Existence, type, and frequency of forest-related planning, assessment, and policy review

Overall Availability: Data are available but require some additional work to assemble and interpret.

Background: Well-focused and technically sound plans, assessments, and policy that consider the range of forest values and are coordinated with a variety of forest-related sectors are critical to comprehensively evaluate trends and conditions in the diverse sectors that affect forests. Forest resource plans and assessments can provide the process and information needed to be proactive and achieve the goals of forest sustainability.

Related Montreal Process Indicators

7.1.b. (#49)(Extent to which the legal framework) provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with the relevant sectors

7.2.b. (#54)(Extent to which the institutional framework supports the capacity to) undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination

Recommendations

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Frequency and extent of State forest resource planning and assessment	Survey of States (NAASF/NFRPA)	State, region	5 year	No established reporting cycle. Recommend survey of States every 5 years.
Existence of laws and policies requiring State forest-related planning/assessment	Survey of States (NAASF/NFRPA)	State, region	5 year	No established reporting cycle. Recommend survey of States every 5 years.
Existence of active State forestry advisory committees	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle—varies from every 2 to 5 years.
Forest planning on non-industrial private forest land (acres)	USDA FS PMAS	State, region	Annual	
Forest planning on national forest land (status, acres)	USDA FS Eastern Region	State, region	Annual	

State forest resource planning, assessment, and policy review—Nationally, this is an area with little comprehensive and regularly updated data. However, recent surveys provide current information and can be updated over time to report on the status of State forest resource planning and assessment, including the range of forest values addressed, and related laws and policies.

The University of Minnesota's Department of Forest Resources is assisting the Northeastern Forest Resource Planners Association (NFRPA) in conducting a comprehensive survey of the types and extent of planning being undertaken by State forestry agencies (with some funding from the USDA Forest Service). Information gathered includes important aspects of State forest resource planning, such as the scope, focus, and outcomes of planning; processes and tools used; resources devoted to planning; who in the State is involved in forest resource planning; and the future demand for planning. The survey provides data on the extent that economic, ecological, and social considerations are addressed in State forest resource plans, including:

- Economic Considerations—wood products manufacturing, nonwood forest products, recreation and tourism
- Ecological Considerations—ecosystem/species diversity, wildlife habitat, forest ecosystem health, soil and water resources
- Social Considerations—cultural uses and values, consumption patterns/trends, community stability/quality of life

Additional information on planning, assessment, and policy review are available as a result of a survey conducted by the NFRPA/NA C&I Work Group. Information collected in this survey include the frequency and scope of statewide forest resource plans and assessments, the frequency of and legal impetus for formal forest policy reviews, the existence and type of advisory committees for State forest policy, and the existence of laws or other documents related to sustainability. Data on the existence of an active State forestry advisory committee is also available from the National Association of State Foresters (NASF) as part of their State Forestry Statistics, which are collected periodically.

We should use the results of the NFRPA survey, the C&I Work Group survey, the NASF State Forestry Statistics, and reference information to guide decisions on what to measure over time and to report baseline data on the frequency and extent of State forest resource planning, assessment, and related laws and policies. Portions of the NFRPA survey can be used as a template for future updates. It will take further discussion to develop the categories of information to report, which will enable us to portray a broad sense of how many States are doing what kind of planning. Since States have different needs and conduct forest-related planning and assessment in various ways, we need to be careful with the way these data are reported (e.g., perhaps summarizing the status of State forest plans in text, rather than presenting it in tabular form). We recommend that NAASF/NFRPA conduct a survey of States every 5 years to update the information.

In addition to planning and assessment by State forestry agencies, various units of State government may conduct forest-related planning and assessment. Although this cross-sectoral involvement is important, data are not available to address this component.

Forest resource planning on non-industrial private forest land—Through the Performance Measurement Accountability System (PMAS), the USDA Forest Service collects information from State forestry agencies about forest resource planning on private (non-industrial) lands. Data submitted by the States include forest stewardship plans and plan acres, forest management plans and plan acres, and revised forest stewardship plans and plan acres. These data have been collected annually and stored in PMAS since 1996.

Forest resource planning on national forest land—The USDA Forest Service is responsible for land use and management planning under authorities specified in the National Forest Management Act of 1978. Data are available from the USDA Forest Service, Eastern Region on the status of plans (identified as Land Resource Management Plans) for national forests in the States served by NA. Plans for national forests are to be revised at least every 15 years.

Web Sites: USDA FS, NA Sustainability Program: <http://www.na.fs.fed.us/sustainability>; NASF State Forestry Statistics: <http://www.stateforesters.org/SFstats.html>; USDA Forest Service, PMAS: <http://www.spfnic.fs.fed.us/pmas> (password secured site); National Forest planning in the Eastern Region: http://www.fs.fed.us/r9/projects/plan_revision/; USDA Forest Service Ecosystem Management Coordination: <http://www.fs.fed.us/emc/nfma/>

Appendix A. Table of Metrics and Data Sources for NA/NAASF Base Indicators of Forest Sustainability^{1,2}

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
1. Area of forest land relative to total land and area of reserved forest land				
Total forest area (acres)	USDA FS FIA	State, region ³	5 year	The reporting cycle is staggered across States. ⁴
Total land area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴
Reserved forest land (acres) ⁵	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴ Does not adequately measure private conservation forest lands.
Population	U.S. DOC Census Bureau	State, region	Annual	The census is conducted every 10 years, but population estimates are calculated annually.
2. Extent of area by forest type and by size class, age class, and successional stage				
Area by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴
Size class by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴
Age class by forest type (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴ Currently, only available for timberland areas.
3. Degree of forest land conversion, fragmentation, and parcelization				
Forest land conversion (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁴

¹ Proposed wording edits to the indicators are incorporated into this listing. No priority or order is implied in the numeric listing of the criteria and indicators.

² See the acronym glossary following the table (page 59) for definitions.

³ Region includes the 20 Northeastern and Midwestern States and the District of Columbia.

⁴ FIA data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years.

⁵ FIA reserved forest lands include those withdrawn from timber utilization by law or administrative regulation.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Forest land change (percent)	USDA NRCS, Natural Resources Inventory	State, region, ecological province	5 year	Provides forest land change to and from other land cover/use types. Inventory methods vary from USDA FS FIA methods.
Fragmentation: average patch size, amount of edge, inter-patch distance	USDA FS Southern Research Station; USDA FS FIA, Northeastern Research Station	State, region, ecological province	Periodic	Work at the national level needs refinement; regional work covers only the 13 Northeastern States. Data are for forest vs. nonforest only (of limited meaning where within-forest fragmentation is of greater concern). May include a connectivity metric. Based on 1992 data; newer data may not allow for comparable analyses.
Parcelization: average size of private land holdings	USDA FS FIA, National Woodland Owner Survey	State, region	5 year	Plus/minus 10% error at the State level. Collected on an annual rolling cycle, reporting averages every 5 years.
4. Status of forest/woodland communities and species of concern (with focus on forest-associated species)				
Status of forest-associated species of concern relative to the total	NatureServe	State, region, ecological province	Annual	Need to identify forest-associated species. Report Federal and State listed and de-listed plant and animal species.
Status of forest and woodland communities of concern relative to the total	NatureServe	State, region, ecological province	Annual	Currently, data only available on globally imperiled forest and woodland associations.
Bird species population trends/relative abundance	USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey	Sub-regional	Annual	Requires additional work to identify the best method to report these data. There are limitations in these data related to the roadside survey methods. Rare species are difficult to track accurately (due to reduced sample sizes).

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
5. Area of timberland				
Timberland ⁶ area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁷ Certain physical, economic, and social constraints to harvesting are not considered (overestimates actual timberland).
Total forest area (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁷
6. Annual removal of merchantable wood volume compared to net growth				
Net growth ⁸ of growing stock on timberland and forest land (cubic feet)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States. ⁷
Removals of growing stock on timberland and forest land (cubic feet)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States. ⁷
Net growth to removals (ratio)	USDA FS FIA	State, region, ecological province	5 year	The reporting cycle is staggered across States. ⁷ Caution should be used when interpreting this complex statistic.
Type of removals: harvest, land clearing (percent)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ⁷
7. Area and percent of forest land affected by potentially damaging agents				
Tree mortality (cubic feet)	USDA FS FIA	State, region,	5 year	The reporting cycle is staggered across States. ⁷

⁶ FIA defines timberland as forest land that meets minimum productivity standards (inherent capability to produce at least 20 cubic feet of wood fiber per acre per year) and is potentially available for harvest.

⁷ FIA data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years.

⁸ Net growth of growing stock is equal to gross growth minus mortality. Mortality is the volume of trees that died since previous measurement.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Biotic stressors: exotic/native insects and diseases, invasive plants, and animals (acres affected)	States via USDA FS FHM/FIA and Cooperative Forest Health Program	State, region, ecological province	Annual	Extent of information available varies by State. It is desirable to examine cumulative effects of biotic stressors.
Wildfire (occurrence, acres affected)	National Interagency Fire Center; USDA FS; Survey of States (NAASF)	State, region, ecological province	Annual	Data available from national and regional sources do not categorize forest land affected. Some States have data for forest affected by wildfire.
Weather phenomena: drought (severity), storm (occurrence, acres affected), flood (occurrence, acres affected)	NOAA National Climatic Data Center; States via USDA FS FHM/FIA and Cooperative Forest Health Program	State, region	Annual	Additional GIS processing is required to measure forest land affected by drought.
Forest land clearance (acres)	USDA FS FIA; USDA NRCS	State, region, ecological province	5 year	Measures forest land cleared for nonforest uses. FIA reporting cycle is staggered across States. ⁹ Forest Service and NRCS inventory methods vary.
8. Area and percent of forest land with diminished soil quality				
Changes in soil pH (measure of soil chemical/nutrient status) (percent of plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. No historic baseline. Results difficult to interpret without additional information about landscape position, soil type, and vegetation.
Changes in soil carbon (percent of plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. No historic baseline.

⁹ FIA data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Estimate of potential soil erosion rates (on plots) ¹⁰	USDA FS FHM/FIA (using WEPP ¹¹ model)	Region	5 year	Low sampling intensity; limited to regional analysis. FIA data modeled using the WEPP model.
Bulk density (grams per cubic centimeter) (measure of compaction on plots)	USDA FS FHM/FIA	Region	5 year	Low sampling intensity; limited to regional analysis. Lack of historical baseline.
Estimate of area exhibiting disturbance (percent of plot area)	USDA FS FHM/FIA	Region	5 year (annual updates)	Low sampling intensity; limited to regional analysis. Lack of historical baseline. Ecological significance of compaction is uncertain without additional information.
9. Area and percent of forest land adjacent to surface water and area of forested land by watershed				
Forest land adjacent to surface water (acres, percent)	MRLC National Land Cover Data; U.S. EPA Office of Water, BASINS; (GIS processing by USDA FS NA, Durham, NH)	State, region, potentially other scales	Periodic	Requires additional research, discussion, and GIS processing. No regular reporting cycle. Current land cover data available (1992) are outdated; 2000 data should be available by 2004.
Forest land per watershed (percent)	MRLC National Land Cover Data; U.S. EPA Office of Water, BASINS; (GIS processing by USDA FS NA, Durham, NH)	State, region, watershed, potentially other scales	Periodic	Requires additional research, discussion, and GIS processing. No regular reporting cycle. Current land cover data available (1992) are outdated; 2000 data should be available by 2004.
10. Water quality in forested areas				
Adequate data are not currently available.				

¹⁰ In the long term, we are interested in using soil erosion limitation ratings from NRCS soils databases (such as the State Soil Geographic database—STATSGO) for comparison to FIA plot data (as a way to provide context for the plot data). The NRCS designation of woodland soils differs from definitions used in FIA; therefore, care must be taken when comparing data from these two sources.

¹¹ WEPP: Water Erosion Prediction Project is a soil erosion model that is a joint effort of the USDA ARS, USDA FS, USDA NRCS, DOI BLM, and Purdue University.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
11. Forest ecosystem biomass, and forest ecosystem and forest products carbon pools				
Forest ecosystem biomass (megatonnes; megagrams or metric tons per hectare) ¹²	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.
Forest carbon pools (megatonnes)	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.
Change in forest carbon pools (megatonnes per year)	USDA FS Northern Global Change Research Program	State, region, ecological province	5 year	Insufficient sampling intensity of down dead wood and forest floor soil carbon. The modeling approach to transform volumes to carbon adds elements of uncertainty.
12. Value and volume of wood and wood products production, consumption, and trade				
Value of wood products production (by industry) ¹³	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.
Value added ¹⁴ in wood products production (by industry) ¹³	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.
Volume of roundwood ¹⁵ production on all land	USDA FS FIA and TPO (as reported in RPA)	State, region	5 year	Reporting cycle for North Central States may vary from that for Northeastern States (10 years in the past). The statistics are updated more often for some States.

¹² Units commonly used to measure carbon and biomass are megatonnes (Mt) or megagrams (Mg). A megatonne equals 1 million metric tons; a megagram equals 1 million grams, equivalent to 1 metric ton.

¹³ North American Industry Classification System categories: wood products manufacturing, paper products manufacturing, and wood furniture manufacturing

¹⁴ Value added is derived by subtracting the cost of materials, supplies, containers, fuels, purchased electricity, and contract work from the value of production.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Per capita consumption of roundwood (volume)	AF&PA via USDA FS Forest Products Lab; U.S. DOC Census Bureau	Region	Annual	Rough estimate calculated from the national estimated per capita consumption rate and regional population statistics.
Recovered paper (utilization rate or total)	AF&PA via USDA FS Forest Products Lab	State, region	Annual	Adequate data may not be available at the State level for all States (due to disclosure issues).
13. Outdoor recreational facilities and activities				
Recreational areas (type, number, acres)	Survey of States (NAASF); USDA FS Eastern Region; NASPD	State, region	Periodic	Recommend a survey of States at least every 5 years. NASPD data (reported annually) only cover areas managed by State park agencies. No established reporting cycle for other data.
Trails (miles)	Survey of States (NAASF); USDA FS Eastern Region; NASPD	State, region	Periodic	Recommend a survey of States at least every 5 years. NASPD data (reported annually) only cover areas managed by State park agencies. No established reporting cycle for other data.
Campgrounds (number, number of sites)	Survey of States (NAASF); USDA FS Eastern Region; published campground guides	State, region	Periodic	Recommend survey of States and compilation of data from other sources every 5 years.
Outdoor recreational participants and activity days by activity	USDA FS Southern Research Station, National Survey on Recreation and the Environment; USDI F&WS, Fishing, Hunting, and Wildlife-Associated Recreation	State, region	5 year	Does not directly measure recreation in forested areas. Need to decide which outdoor recreation activities to track.
14. Public and private investments in forest health, management, research, and wood processing				
Federal funding in forest health and management	USDA FS NA	State, region	Annual	

¹⁵ Roundwood is defined as logs, bolts, or round sections cut from growing stock and nongrowing stock sources.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
State forestry program funding	NASF State Forestry Statistics; USDA FS NA	State, region	Periodic	No established reporting cycle—varies from 2 to 5 years.
Capital expenditures ¹⁶ by wood product manufacturers (by industry ¹⁷)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.
Forestry research funding at universities	USDA Cooperative State Research, Education, and Extension Service	State, region	Annual	
USDA Forest Service Research funding	USDA FS Research and Development	Region	Annual	
15. Forest ownership and land use (including acres of specially designated land)				
Forest land ownership (acres)	USDA FS FIA, National Woodland Owner Survey; NASF State Forestry Statistics	State, region	5 year	FIA data are collected on an annual rolling cycle, reporting averages every 5 years. Plus/minus 10% error at the State level. NASF data are collected periodically from State forestry agencies.
Reserved forest land ¹⁸ (acres)	USDA FS FIA	State, region	5 year	The reporting cycle is staggered across States. ¹⁹ Does not adequately measure private conservation forest lands.

¹⁶ Total capital expenditures include new and used expenditures for permanent additions and major alterations to manufacturing establishments and for machinery and equipment used for replacement and additions to plant capacity if they were of the type for which depreciation accounts were ordinarily maintained.

¹⁷ North American Industry Classification System categories: wood products manufacturing, paper products manufacturing, and wood furniture manufacturing

¹⁸ FIA reserved forest lands include those withdrawn from timber utilization by law or administrative regulation.

¹⁹ FIA data are collected on a rolling cycle, with data collected on all plots within a State in 5–7 years.

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
Specially designated public forest land: Federal, State, some county (acres by IUCN category ²⁰)	CBI/WWF Protected Areas Database and UCLA Managed Area Database, via USDA FS FIA	State, region	Periodic	No established reporting cycle. The Forest Service is working with these databases at the national level to measure forest land protected. May require an accuracy check for the data in our region.
Specially designated State land: forests, parks, natural areas, old growth forest, others (acres by category)	Survey of States (NAASF)	State, region	Periodic	No established reporting cycle. Recommend survey of States every 5 years.
Private land with public conservation easements: Forest Legacy areas (acres), State government easement programs (acres)	USDA FS Forest Legacy Program; Survey of States (NAASF)	State, region	Annual, periodic	Forest Legacy data reported annually. No established reporting cycle for State government easement programs. Recommend survey of States every 5 years.
Forest land in State current use/tax reduction programs	Survey of States (NAASF)	State, region	Periodic	No established reporting cycle. Recommend survey of States every 5 years.
Urban forest (acres)	USDA FS	State, region	Annual	
16. Employment and wages in forest-related sectors				
Wood product manufacturing employees (by industry ²¹ and as a proportion of total manufacturing employment)	U.S. DOC Census Bureau, Economic Census and County Business Patterns	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector only collected as part of the County Business Patterns data. Potential for missing data due to disclosures policy.
State forestry employees	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle; varies from 2 to 5 years.

²⁰ International Union for the Conservation of Nature (IUCN) categorizes protected areas according to six management categories (e.g., strict nature reserve/wilderness area, managed resource protected area). The United Nations Environmental Program, World Conservation Monitoring Center has a Protected Areas Program in collaboration with IUCN, which manages a worldwide protected areas database following the IUCN categories. The UCLA managed areas database was the primary source for the U.S. data in this international database.

²¹ North American Industry Classification System categories: wood products manufacturing, paper products manufacturing, and wood furniture manufacturing

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
USDA Forest Service employees	USDA FS HRM	Region	Annual	
Wood product manufacturing production worker wages or wages per hour (by industry ²²)	U.S. DOC Census Bureau, Economic Census	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector not included in the Economic Census. Potential for missing data due to disclosures policy.
Wood product manufacturing annual payroll (by industry ²² and as a proportion of total manufacturing payroll)	U.S. DOC Census Bureau, Economic Census and County Business Patterns	State, region	5 year	Newer data not directly comparable to previous data. Starting in 2002, logging sector only collected as part of the County Business Patterns data. Potential for missing data due to disclosures policy.
State forestry employee salaries	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle; varies from 2 to 5 years.
17. Existence, type, and monitoring of forest management standards/guidelines				
Categories of forest management standards/guidelines (natural resource values or problem areas)	Survey of States (NAASF); Minnesota Agricultural Experiment Station	State, region	Periodic	Research-based reporting. No set reporting cycle.
Program type (e.g., voluntary, regulatory)	Survey of States (NAASF); NASF State Forestry Statistics; Minnesota Agricultural Experiment Station	State, region	Periodic	Research-based reporting. No set reporting cycle.
Monitoring (by type of monitoring; e.g., implementation, effectiveness)	Survey of States (NAASF); Minnesota Agricultural Experiment Station Future potential: regional BMP monitoring protocol (USDA FS; U.S. EPA)	State, region	Periodic	Research-based reporting. No set reporting cycle. Regional BMP monitoring protocol is still in development.

²² North American Industry Classification System categories: wood products manufacturing, paper products manufacturing, and wood furniture manufacturing

Metric	Data Source	Reporting Scale	Reporting Cycle	Limitations/Considerations
18. Existence, type, and frequency of forest-related planning, assessment, and policy review				
Frequency and extent of State forest resource planning and assessment	Survey of States (NAASF/NFRPA)	State, region	5 year	No established reporting cycle. Recommend survey of States every 5 years.
Existence of laws and policies requiring State forest-related planning/assessment	Survey of States (NAASF/NFRPA)	State, region	5 year	No established reporting cycle. Recommend survey of States every 5 years.
Existence of active State forestry advisory committees	NASF State Forestry Statistics	State, region	Periodic	No established reporting cycle—varies from every 2 to 5 years.
Forest planning on non-industrial private forest land (acres)	USDA FS PMAS	State, region	Annual	
Forest planning on national forest land (status, acres)	USDA FS Eastern Region	State, region	Annual	

Acronym Glossary

AF&PA	American Forest & Paper Association	USDA FS	U.S. Department of Agriculture, Forest Service
BMP	Best Management Practice	FHM	Forest Health Monitoring Program
CBI/WWF	Conservation Biology Institute/World Wildlife Fund	FIA	Forest Inventory and Analysis Program
GIS	Geographic Information System	HRM	Human Resources Management
MRLC	Multi-Resolution Land Characteristics Consortium	NA	Northeastern Area, State and Private Forestry
NAASF	Northeastern Area Association of State Foresters	PMAS	Performance Measurement Accountability System
NASF	National Association of State Foresters	TPO	Timber Product Output Database
NASPD	National Association of State Park Directors	USDA NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
NFRPA	Northeastern Forest Resource Planners Association	USDI	U.S. Department of the Interior
NOAA	National Oceanic and Atmospheric Administration	BLM	Bureau of Land Management
RPA	Renewable Resources Planning Act Assessment	F&WS	Fish and Wildlife Service
UCLA	University of California, Los Angeles	U.S. DOC	U.S. Department of Commerce
USDA ARS	U.S. Department of Agriculture, Agricultural Research Service	U.S. EPA	U.S. Environmental Protection Agency
		BASINS	Better Assessment Science Integrating point and Nonpoint Sources
		USGS	U.S. Department of the Interior, U.S. Geological Survey

