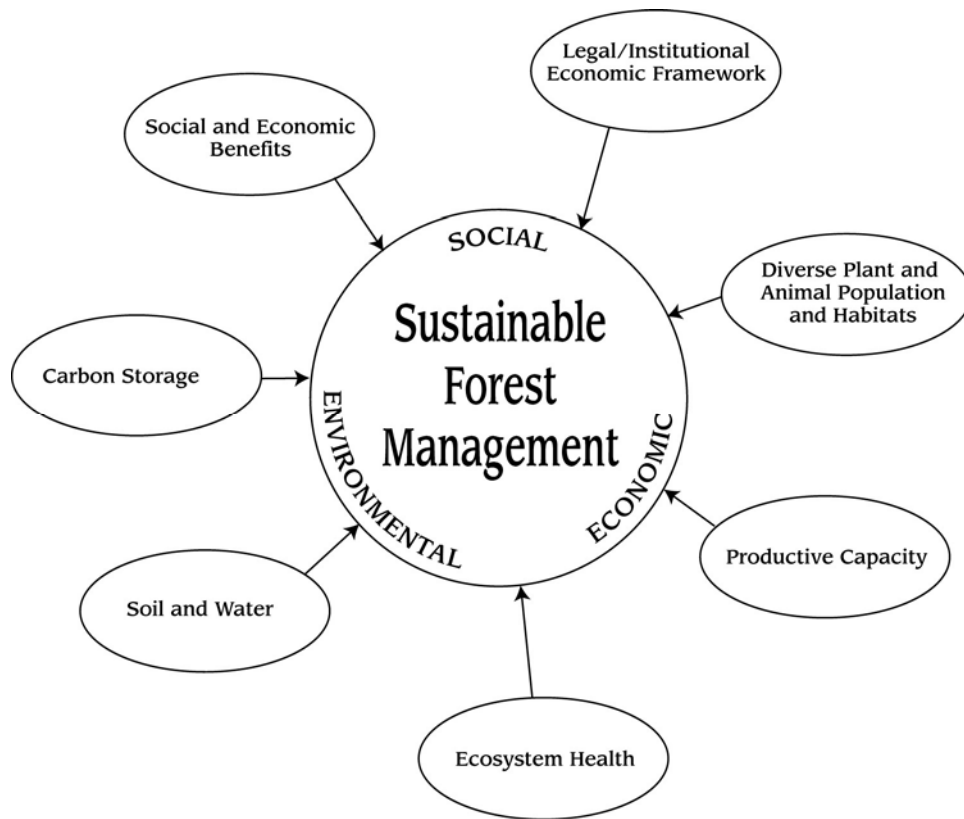


# Oregon Indicators of Sustainable Forest Management



Prepared by  
The Oregon Department of Forestry

Based on recommendations by  
The Oregon Board of Forestry  
Ad Hoc Sustainable Forest Management Indicators Advisory Committee

Endorsed by  
The Oregon Board of Forestry  
January 3, 2007  
(with August 7, 2007 technical edits)

January 3, 2007

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## **Preface**

This document is a product of the Oregon Board of Forestry and is based on the collaborative efforts and recommendations of the 20-person ad hoc Sustainable Forest Management Indicator Advisory Committee to the Oregon Board of Forestry, appointed in March of 2005.

The Board's charge to the Advisory Committee was to:

1. Coordinate with technical experts to reach both strong policy and technical consensus on a set of recommended sustainable forest management indicators for use in measuring *Forestry Program for Oregon* implementation progress.
2. Solicit and summarize broad stakeholder input on both the usefulness of the selected indicators and the desired future outcomes for these indicators.
3. Provide advice to the Board of Forestry on desired future outcomes for the recommended indicators.
4. Provide advice to the State Forester on future Forest Assessment Project priorities.

The committee included a broad range of perspectives on Oregon forest resource issues. Oregon Department of Forestry personnel provided staff support to the committee and also provided separate recommendations to the Board for initial desired trend statements for the indicators.

More information on the Oregon Indicators of Sustainable Forest Management Development Project and the advisory committee's work can be found on the Oregon Board of Forestry website: [www.oregonforestry.org](http://www.oregonforestry.org) (follow the links to Sustainable Forestry Indicators).

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## **Acknowledgements**

The Oregon Board of Forestry and Oregon Department of Forestry wishes to thank the following individuals and organizations for their contributions to this document:

### **Oregon Board of Forestry Ad Hoc Sustainable Forest Management Indicator Advisory Committee Members**

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Chris Jarmer, Northwest Regional Forest Practices Committee/Oregon Forest Industries Council  
Kemper McMaster, USDOJ Fish and Wildlife Service  
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Hal Salwasser, OSU College of Forestry  
John Shelk, Ochoco Lumber Company  
Gary Springer, Committee for Family Forestlands  
Karen Steer, Sustainable Northwest  
Rex Storm, Associated Oregon Loggers  
Karen Tarnow/Bob Baumgartner, Oregon Department of Environmental Quality  
Bob Van Dyk, Pacific University  
Sara Vickerman, Defenders of Wildlife  
Representative Brad Witt, House District 31

### **Oregon Department of Forestry Staff Support**

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Strategy D:	Jim Paul, Keith Mills, Liz Dent
Strategy E:	Andrew Yost
Strategy F:	Jim Cathcart, Dave Overhulser, Jim Wolf
Strategy G:	Jim Cathcart
Administrative and Facilitation Support:	Cathy Clem, Jeri Chase, and Chris Roach

Plus, thanks to the numerous technical and policy experts who have also assisted the committee during the indicator development process.

## Introduction

Sustainability has emerged worldwide as a unifying concept in forest management. “Sustainable forest management” is defined in the *2003 Forestry Program for Oregon* as meaning forest resources across the landscape are used, developed, and protected at a rate and in a manner that enables people to meet their current environmental, economic, and social needs, and also provides that future generations can meet their own needs. However, sustainability is an abstract value, like justice. As stand-alone concepts, we cannot reduce values like sustainability and justice to mere numbers. Also, what is or should be sustained changes in response to environmental, economic, and social changes over time.

The seven strategies of the *Forestry Program for Oregon* form a framework around which forest sustainability issues can be organized and discussed and identify the outcomes the Board of Forestry wants to achieve from a statewide perspective. The *Forestry Program for Oregon* recommends that Oregonians achieve consensus on a set of indicators as useful tools to measure progress towards the goal of sustainably managed forest resources. Once adopted and in place, indicators can provide the Oregon Board of Forestry, other policy-makers, and the public with information describing the environmental, economic and social conditions of Oregon’s public and private forests and provide a cost-effective way to consistently collect important data needed to monitor changes in these conditions over time.

Oregon indicators of sustainable forest management are intended to address all Oregon public and private forestlands and belong to all Oregonians, regardless of their values and perspectives, and not just the Board of Forestry. Oregon indicators may also provide valuable linkages to other sustainability conversations and forest resource assessments at community, regional, national and international scales.

Well designed sustainable forest management indicators can:

- Convey critical and complex information more simply to build public confidence and facilitate better communication and cooperation among all parties interested in forest resources;
- Inform social understanding of forests and the forces that influence them;
- Provide a framework around which natural resource inventory, assessment, planning, and management can be better coordinated;
- Provide citizens interested in forests with a tool to encourage society to better address and communicate what it needs from forests; and
- Help to repair a fragmented administrative landscape by providing a common language for measurement and discussion.

The indicators should be viewed as being similar to measuring sticks. They provide a tool to make Oregon forest environmental, economic, and social conditions and trends measurable and understandable. They can tell us what current conditions and trends *are*. The next step is to define what sustainable forest management means to Oregonians by reaching political consensus on what the desired conditions and/or trends for this suite of indicators *should be*. Determining how to collect data and report data for each indicator is a technical task.

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Determining what to measure and what the desired range of conditions or trends are political tasks informed by science. These political discussions must consider how best to integrate the environmental, economic, and social benefits of Oregon's forests over time.

This document describes 19 indicators of sustainable forest management and associated data sources that state, federal, tribal, local government, and private partners in Oregon can use in ongoing monitoring, policy development, and communications efforts. To be useful, the committee believes the draft indicators should be evaluated against the following criteria:

Relevant-- Indicators should be clearly related and relevant to *Forestry Program for Oregon* strategies and high priority components. Indicators should be relevant for all stakeholders in the system, including the least powerful.

Understandable—Indicators should be clear in content, easily understandable, with units that make sense, expressed in imaginable, not eye-glazing, numbers. The indicators should pass the common sense test applied by the general public.

Measurable—Indicators should be measurable on a consistent, reliable basis, using well-defined data that can be compiled without long delays.

Practical and Feasible—The value of the information provided by an indicator should exceed the cost to gather it. Technical expertise should be available to collect and process data for the indicators.

Sufficient to the purpose—Indicators should not contain too much information to comprehend, nor too little information to give an adequate picture of the situation.

Sensitive to change—Changes in the forest, whether from human actions or natural changes, should elicit a response in an indicator in time to act on it.

Scale appropriate—Indicators should be measurable at an appropriate scale and not over- or under-aggregated.

Scientific merit—The indicators should be supported by peer-reviewed studies or well-reasoned hypotheses.

Compatible—With the exception of locally important indicators, indicators should “roll up” into State, regional, and national efforts to define criteria and indicators of forest sustainability.

On that last point, compatibility, it is important to note that the proposed indicators are intended to complement, and not replace or diminish, other important performance measures, such as the Oregon Progress Board Benchmarks and Department of Forestry performance measures. Oregon Benchmarks examine all sectors of Oregon's environment, economy, and society while the indicators focus only on Oregon's forests. And while the indicators evaluate the cumulative results of all Oregon public and private forest management, Department of Forestry performance measures are designed to consider only the outputs and outcomes of the agency's programs. Likewise, there is a tremendous need for forest-related monitoring, research, and assessments to support the indicators and to track other important issues. All of this work is important. The indicators should be viewed as the “vital signs” Oregon will use to track the environmental, economic, and social benefits and values we derive from Oregon's forests and our progress on the journey towards sustainability.

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Desired conditions and trends are the pathway for long-term sustainability planning and reference points for determining progress. They also help focus on key priorities. This approach is also an effective way to communicate intent to the general public. While the indicators and their metrics may remain fairly constant, desired conditions and trends for the indicators should be revisited and updated periodically as more information on the interplay between the indicators becomes available and as societal values evolve. The set of initial desired trend statements in this report are recommended as a starting point for Oregonians to discuss and further refine. As indicator data become available, the interplay between indicators becomes more evident, and as social preferences evolve, it will be appropriate to periodically revisit and update the trend statements. There is no predetermined formula for calculating sustainable forest management. Oregonians together must define what mix of indicator outcomes will define sustainable forest management for us.

## Summary of Oregon Indicators<sup>1</sup> of Sustainable Forest Management, Metrics<sup>2</sup>, and Initial Desired Trends<sup>3</sup>

**Note:** The proposed indicators vary in their readiness for immediate implementation. Some take advantage of existing data collection efforts and some will be new initiatives where further development is needed. Among the new initiatives, some indicators can be implemented with existing resources while others will require new funding or a reallocation of existing resources. A few indicators will require new field data collection based on randomized sampling. In every case this field data collection will be valuable for other purposes in addition to informing the proposed indicator. More information is available in the detailed description for each indicator. To highlight these differences, the following symbols are used in this summary:

\$\$ -- A significant new or expanded level of funding may be needed to fully implement the indicator on a statewide basis.

☼ -- Indicators that are new data collection concepts. More development may be needed before implementation.

% -- Metrics that may use field sampling to collect data.

### ***Forestry Program for Oregon Strategy A: Promote a sound legal system, effective and adequately funded government, leading-edge research, and sound economic policies.***

- **A.a. Ability to measure and report on all other Oregon sustainable forest management indicators ☼**

#### Metrics:

- For each indicator, a description of the data coverage, data frequency, data currency, data source, data reliability, and references
- A matrix that rates data coverage, currency, frequency, and reliability for each indicator against predetermined evaluation criteria

*Desired trend: Data for all Oregon indicators are increasingly current, complete, and reliable.*

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<sup>1</sup> Indicators are parameters that measure specific quantitative and qualitative attributes and help monitor trends in the sustainability of forest management over time. No priority or order is implied in the listing and labeling of the draft indicators.

<sup>2</sup> Metrics are units of data for each indicator (includes data source, format, scale, timing).

<sup>3</sup> Desired trends are socially preferred changes in, or status of, indicator data over time to contribute to the overall goal of sustainable forest management.



- **A.b. Development and maintenance of sustainable forest management knowledge** (Related *Forestry Program for Oregon* Actions: A.3., A.8., A.9.)

Metrics:

- Student participation in K-12 forest education programs with a field component
- Number of Oregon public university and community college resident faculty engaged in forest resource instruction and forestry extension (FTE)
- Expenditures on forest resource research
- Number of Oregon members of natural resource professional societies
- Number of Oregon family forest landowners obtaining Master Woodland Manager status or similar advanced management training

*Desired trend: Oregon student and family forest landowner participation in forest education programs is increasing and forest resource research funding, higher education forest resource instruction, natural resource professional society membership, and forestry extension staffing are maintained or increasing.*

- **A.c. Compliance with forestry regulations** (Related *Forestry Program for Oregon* Actions: A.1., A.2., A.4., A.5, A.7)

Metrics:

- Number of Oregon Forest Practices Act notifications of operations received from private forestlands by type of activity
- Percent of inspected private commercial forest operations that are in compliance with the Forest Practices Act by rule category, such as reforestation %
- Percent of private forestland directly encumbered by Forest Practices Act best management practices compliance
- Summary of federal forest plan project implementation monitoring results %

*Desired trend: High levels of compliance with management plan standards and guidelines on Oregon federal forestlands. High levels of voluntary compliance with Oregon Forest Practices Act requirements for reforestation and other activities on private lands. Clear public policy expectations for private forest landowners' contributions to the protection and maintenance of public forest resource values.*

***Forestry Program for Oregon Strategy B: Ensure that Oregon's forests provide diverse social and economic outputs and benefits valued by the public in a fair, balanced, and efficient manner.***

- **B.a. Forest-related revenues supporting state and local government public services** (Related *Forestry Program for Oregon* Actions: A.9., B.3., B.5., B.7., B.8., B.12.)

Metrics:

- Payments related to National Forests including Secure Rural Schools and Community Self-Determination Act payments and National Forests timber harvest payments
- Payments related to BLM forests including Secure Rural Schools and Community Self-Determination Act payments, payments from O&C grant lands timber harvest payments, and forest related payments in-lieu of taxes
- Board of Forestry payments to counties and local taxing districts
- Common School Fund payments
- County Forest revenues
- Forest land and mill property taxes and fire protection levies
- Harvest tax
- Weight-mile tax
- Corporate income and excise tax

*Desired trend: Forest-related revenues are a significant and predictable funding source for Oregon state and local government public services dependent on those revenues.*

- **B.b. Forest-related employment and wages** (Related *Forestry Program for Oregon* Actions: B.1., B.2., B.5., B.6., B.7., B.8., B.12.)

Metrics:

- Forest-related employment in rural and urban areas and in forest-based communities
- Forest-related wages and salaries in rural and urban areas and in forest-based communities

*Desired trend: Forest-related Oregon employment and compensation are stable or increasing.*

- **B.c. Forest ecosystem services contributions to society** (Related *Forestry Program for Oregon* Actions: B.5., B.7., B.9., B.10.) ☀

Metrics:

- Recreation use value
- Passive use value
- Carbon sequestration value

*Desired trend: Oregon forest ecosystem services produced are stable or increasing and are sustainable.*

- **B.d. Forest products sector vitality** (Related *Forestry Program for Oregon* Actions: B.1., B.2., B.4., B.5., B.6., B.8., G.6., G.7.)

Metrics:

- Sales value of wood products and forest industry equipment from Oregon manufacturers
- Cost of production compared to other areas
- Production capacity, condition, technology, and investment
- Capital expenditures in wood product and paper manufacturing
- Net foreign and domestic exports of Oregon wood products

*Desired trend: Production and values of Oregon wood and paper products and forest industry equipment are stable or increasing.*

**Forestry Program for Oregon Strategy C: Maintain and enhance the productive capacity of Oregon's forests to improve the economic well-being of Oregon's communities.**

- **C.a. Area of non-federal forestland and development trends** (Related *Forestry Program for Oregon* Actions: B.4., C.1., C.2., C.4., D.7, D.8.)

Metrics:

- Area of nonfederal wildland forest
- Parcelization of private forestland

*Target<sup>4</sup>: Area of Oregon non-federal wildland forest in 2010 is 97.4 percent of 1974 levels (Oregon Progress Board target for identical Oregon Benchmark 82).*

- **C.b. Timber harvest trends compared to planned and projected harvest levels and the potential to grow timber** (Related *Forestry Program for Oregon* Actions: C. 3., C.5)

*Target and desired trend: Oregon timber harvest levels are 90 to 110 percent of planned and projected levels (Oregon Progress Board target for Oregon Benchmark 83) and the potential to grow timber is stable or increasing.*

**Forestry Program for Oregon Strategy D: Protect, maintain, and enhance the soil and water resources of Oregon's forests.**

- **D.a. Water quality of forest streams** (Related *Forestry Program for Oregon* Actions: D.1., D.2., D.3., D.4., D.5., D.7.) \$\$

Metrics:

- Physical/chemical properties (temperature, dissolved oxygen, turbidity, pH, phosphorus, nitrogen, nitrate, ammonium nitrate, total solids) %
- Biological properties (bacteria, macro invertebrates, biological oxygen demand) %

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<sup>4</sup> Targets are specific socially preferred outcomes or results for the indicators. At this time, targets have only been established for Indicators C.a., and C.b.

*Desired trend: Water quality index values in forested Oregon watersheds are stable or improving.*

- **D.b. Biological integrity of forest streams** (Related *Forestry Program for Oregon* Actions: D.1., D.2., D.3., D.5., D.6., D.7., E.6.) \$\$

Metrics:

- For macro invertebrates (mostly aquatic insects) and vertebrates (fish and aquatic amphibians): Species richness, percent alien species, percent cool water individuals, percent anadromous individuals, percent coldwater species, number of tolerant individuals, number of native coldwater species and individuals, number of size classes ‰

*Desired trend: Index of biotic integrity values in forested Oregon watersheds are stable or improving.*

- **D.c. Forest road risks to soil and water resources** (Related *Forestry Program for Oregon* Actions: D.1., D.2., D.3., D.4., D.5., D.6.) \$\$ ☀

Metrics:

- Percent of road system disconnected from the stream network ‰
- Percent of stream crossings on fish streams providing passage ‰
- Land area in non-forest condition due to roads (road subgrade plus cutslope) ‰

*Desired trend: Increasing proportion of sampled Oregon forest roads are determined to pose a low risk to soil and water resources.*

## **Forestry Program for Oregon Strategy E: Contribute to the conservation of diverse native plant and animal populations and their habitats in Oregon's forests.**

- **E.a. Composition, diversity, and structure of forest vegetation** (Related *Forestry Program for Oregon* Actions: E.1., E.2., E.3., E.4., E.5., E.6.) \$\$

Metrics:

- Vegetation species diversity: richness, evenness ‰
- Vegetation structure, percent cover ‰
- Vegetation change detection: plot #'s, area, percent cover ‰

*Desired trend: Following establishment of a statewide plant and animal conservation policy, the composition, diversity, and structure of Oregon forest vegetation are within, or growing towards, desired future condition ranges.*

- **E.b. Extent of area by forest cover type in protected area categories** (Related *Forestry Program for Oregon* Actions: E.1., E.2., E.3., E.4., E.5., E.6.)

Metrics:

- Amount of area for each forest cover type
- Ownership/protection category

*Desired trend: Following establishment of a statewide plant and animal conservation policy, allocations of Oregon forest cover types to protected area categories are consistent with desired future conditions.*

- **E.c. Forest plant and animal species at risk** (Related *Forestry Program for Oregon* Actions: E.1., E.2., E.3., E.4., E.5., E.6.)

Metrics:

- Number of species in each federal ESA status ranking
- Number of forest species in Oregon Natural Heritage Program Information Center Lists 1 and 2
- Historic and current distribution of forest species

*Desired trend: Decreasing number of Oregon native forest plant and animal species at risk (extinction, extirpation, endangered, threatened, or potentially endangered or threatened).*

***Forestry Program for Oregon Strategy F: Protect, maintain, and enhance the health of Oregon's forest ecosystems, watersheds, and airsheds within a context of natural disturbance and active management.***

- **F.a. Tree mortality from insects, diseases, and other damaging agents** (Related *Forestry Program for Oregon* Actions: F.1., F.2., F.6.)

Metrics:

- Tree mortality (cubic feet)
- Current tree mortality from insects and diseases (acres)

*Desired trend: Stable or decreasing long-term levels of Oregon forest tree mortality.*

- **F.b. Invasive species trends on forestlands** (Related *Forestry Program for Oregon* Action: F.3.)

Metrics:

- Biotic stressors: exotic insects and diseases, invasive plants, and animals (acres affected)
- The number or percent of invasive pests on Oregon's 100 most dangerous list excluded or contained in native and urban forests

*Desired trend: No invasive species on Oregon's 100 most dangerous list are uncontained in the state's forests, and a stable or decreasing forest acreage is affected by invasive species.*

- **F.c. Forest fuel conditions and trends related to wildfire risks** (Related *Forestry Program for Oregon* Actions: F.1., F.2., F.4., F.5., F.6.) \$\$

Metrics:

- Percent of forestland in condition class 1, or fire regime IV or V.
- Percent of forestlands that produce a surface fire type (no passive or active crown fire) at 90<sup>th</sup> percentile weather and wind for region.
- Acres of forestland in fire regime I, II, or III that are treated to either maintain at, or reduced to, condition class I
- Acres of forestland treated to either maintain at, or reduced to, a surface fire type at 90<sup>th</sup> percentile weather and wind for region

*Desired trend: Increasing rates of effective forest fuel treatments to improve resiliency to wildfire and an increasing area of Oregon forestland resilient to wildfire.*

### **Forestry Program for Oregon Strategy G: Enhance carbon storage in Oregon's forests and forest products.**

- **G.a. Carbon stocks on forestlands and in forest products** (Related *Forestry Program for Oregon* Actions: G.1., G.2., G.4., G.5., G.6., G.7.) ☼

Metrics:

- Status of forest carbon stocks in various carbon pools, including forest products. (Expressed as mass/area)
- Status of changes in forest carbon stocks where forests and forest products acting as a source or as a sink. (Expressed as mass/area/unit of time)

*Desired trend: Rates of storage of carbon in Oregon forests and Oregon forest products are stable or increasing.*

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## **Oregon Indicators of Sustainable Forest Management**

Note: For several indicators, examples of possible report formats are posted at [www.oregonforestry.org](http://www.oregonforestry.org). Follow the links to “Sustainable Forestry Indicators.”

***Forestry Program for Oregon Strategy A: Promote a sound legal system, effective and adequately funded government, leading-edge research, and sound economic policies.***

**A.a. Ability to measure and report on all other Oregon sustainable forest management indicators**

*This indicator will produce a narrative and tabular report on the capability to collect the data and information needed to inform all other Oregon sustainable forest management indicators.*

**Desired trend:** Data for all Oregon indicators are increasingly current, complete, and reliable.

**Relevance:** This indicator assesses the availability and reliability of information needed to measure or describe the indicators associated with *Forestry Program for Oregon Strategies A through G*. Public discussion and decisions related to natural resource sustainability issues should be based on comprehensive, current, and sound data. Forests are more likely to be managed on a sustainable basis if relevant forest information is up-to-date and easily available to decision-makers, forest managers, and the general public. Without adequate data, trends cannot be detected nor impacts estimated. Better knowledge will lead to better decisions at all levels of forest management. Successful implementation of the strategy and indicator framework requires the continued availability of information to report on the indicators. Information regarding the availability, frequency, coverage, and reliability of indicator data provides analysts with critical information for evaluating and prioritizing sustainability needs.

**Overall Data Availability:** For some indicators, data is already being collected, analyzed, and reported at meaningful scales and timeframes. Other indicators have only been partially implemented in the past or are entirely new. By working closely with the designated parties responsible for data collection and reporting for each indicator, adequate data should be available to inform this indicator. The sustainable forest management indicators will be supported by the Department of Forestry's Forest Assessment Project which has the goal of addressing the information needs of ODF programs, assisting with broader state initiatives supported by the Governor or other agencies, and integrating ODF assessment work with that of other state and federal agencies. The PNW Research Station technical staff has also organized around supplying data for the indicators.

**Background:** This indicator provides information for *Forestry Program for Oregon Strategy A*, particularly Action A.3. The *Forestry Program for Oregon Strategy A through G* indicators are designed to provide Oregonians and others with information on the state's progress toward sustainable forest management. They are intended to provide information in response to the public's



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environmental, economic, and social concerns regarding forests. With the exception of the 2000 *Oregon's First Approximation Report for Forest Sustainability*, this comprehensive information has not been available in one document. It is hoped that citizen and government use of sustainable forest management indicators will improve the quality of the public debate and highlight the need for the organized collection of current, reliable data. Indicators have generally been accepted as an appropriate framework for evaluating the status, condition, trends, and prospects for the state's forests organized around the seven *Forestry Program for Oregon* strategies. The first requirement of such an evaluation is the availability of a basic set of data for the indicators. The second requirement is that the data be current and reliable.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 7-- Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management: 2003 Indicator 60 (2010 Indicator 57): Availability of up-to-date data, statistics, and other information important to measuring or describing indicators

associated with criteria 1 through 7 and 2003 Indicator 61 (2010 Indicator 58): Scope, frequency, and statistical reliability of forest inventories, assessments, monitoring, and other relevant information.

*Northeastern Area:* Existence, type, and frequency of forest-related planning, assessment, and policy review.

**Metric Descriptions**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
For each indicator, a description of the data coverage, data frequency, data currency, data source, data reliability, and references	Department of Forestry, with assistance as needed from the Institute for Natural Resources	State	Five Years	ODF	Strong partnerships needed with other state and federal agencies who serve as individual indicator data sources.
A matrix that rates data coverage, currency, frequency, and reliability for each	Department of Forestry, with assistance as needed from the Institute for	State	Five Years	ODF	Strong partnerships needed with other state and federal agencies who serve as individual indicator data sources.

indicator against predetermined evaluation criteria.	Natural Resources				
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**Description:** Starting with the 1997-1999 biennium, ODF staff have been working to produce information on the cumulative effects of forest practices on Oregon’s soil, air, water, fish, and wildlife resources. The “Oregon Forests Assessment Project” is an ongoing assessment of the sustainability of Oregon’s forests. Through the Forest Assessment Project Study Plan, ODF is developing a systematic framework of data, and models to analyze a broad range of forest-related issues and provide data for the indicators. These analyses are critical in planning for the future, and at the same time they help political leaders and policy-makers address many current policy questions. Figure 1 illustrates the steps in the forest assessment process.

Data for the indicators may range from full current coverage to one-time studies, to anecdotal information. By looking at a cross section of the information in four broad categories – coverage, currency, frequency, and reliability, a brief overview of the situation for each indicator can be evaluated. Although information is available for most of the indicators, few indicators have a full range of data that is current, statewide in scope, and collected frequently. A system is needed for maintaining current information across this broad suite of indicators in an organized manner. Program infrastructures that support these indicators need to be in place and funded to collect and report the needed information.

A chart summarizing coverage, currency, frequency, and reliability for all indicators will be provided along with more detailed summary for each indicator including published and unpublished references.

**Quality Assurance:** Primary sources for each indicator in Strategies A through G will be consulted to provide assurance that the information reported for this indicator is accurate. The Forest Assessment Project will also assess data quality.

**Repeatability:** Information for this indicator should be consistently available from the data sources for the other Strategy A though G indicators.

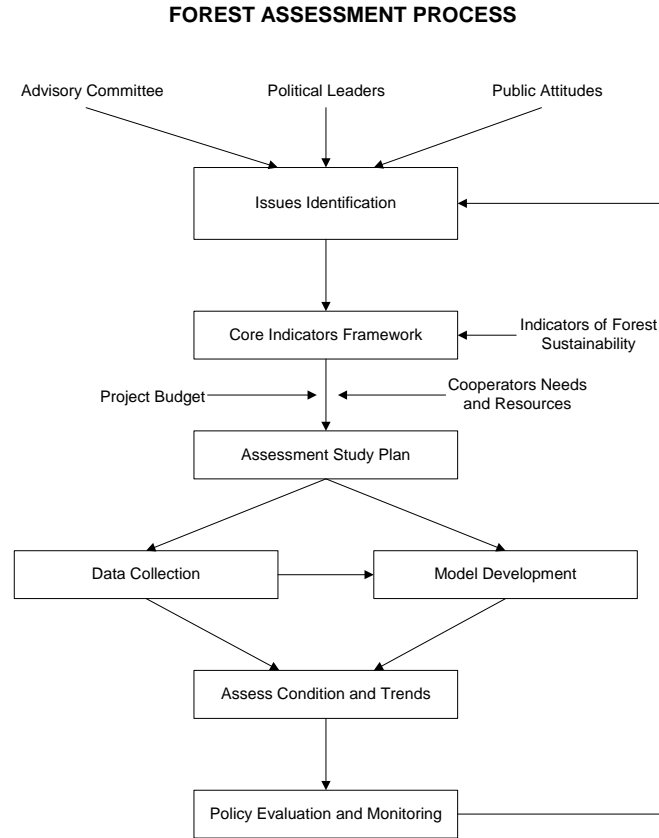


Figure 1.

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## **A.b. Development and maintenance of sustainable forest management knowledge**

*This indicator will produce a tabular report on trends in public and professional education and research related to sustainable forest resource management.*

**Desired trend:** Oregon student and family forest landowner participation in forest education programs is increasing and forest resource research funding, higher education forest resource instruction, natural resource professional society membership, and forestry extension staffing are maintained or increasing.

**Relevance:** The management practices that determine forest sustainability depend largely upon an informed citizenry and human skill and ingenuity. It is important to improve public understanding of forest ecosystems and the complex issues regarding our forest resource management. If citizens are well informed, they in all likelihood will have expectations that are consistent with the sustainability of forest resources and will take actions individually and collectively that are compatible with principles of sustainability. For example, one method for accomplishing this goal is to provide multiple opportunities for experiential learning in forests, complemented by hands on classroom activities, throughout a young person's academic career. These experiences enable and encourage students to become active participants in their local communities and help interested young people pursue academic and professional careers in the sciences and natural resources.

A wide range of disciplines and skills is necessary to implement sustainable forest management actions, including not only the traditional scientific disciplines of forestry, botany, wildlife biology, and ecology, but also the social sciences of economics, geography, and civics and government. Human resources in the form of high quality, adequately trained and equipped scientists, land managers, forest workers, and government program administrators provides a essential link in ensuring sustainable forest management objectives are achieved.

**Overall Data Availability:** Data for the indicator metrics should be available from listed sources, but not always on an annual basis. Data on K-12 educational experiences is periodically assembled by the Oregon Forest Resources Institute (OFRI) and the Environmental Education Association of Oregon. Additional information may need to be solicited from individual education programs. Since there is no other central clearinghouse for tracking all K-12 forest education opportunities, the indicator may underreport forest education accomplishments. OSU Forestry Extension manages the Master Woodland Manager Program and tracks participation by family forest landowners in this and similar advanced management courses.

**Background:** This indicator provides information for *Forestry Program for Oregon Strategy A*, Actions A.3. and A.9. The indicator also provides information related to *Forestry Program for Oregon Vision Statement 6* and *Value Statement 9*.

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It is the Board of Forestry's vision that citizens understand, accept, and support sustainable forestry and make informed decisions. Broad segments of the general public are often unaware of or misinformed about the use, management, and protection of forests. There is substantial virtue in communicating the important role that forests play in the lives of the general public. By so doing, the seemingly disinterested public may gain a heightened awareness of forests and subsequently treat them with respect and encourage investment in their sustainable management. Unfortunately, much of the forestry community's focus is on immediate and highly visible political issues involving forests, with only minimal attention directed to the general public's need for a more basic understanding of forests and forest sustainability (Best and Wayburn 2001).

Since the breadth of knowledge about forest resources is enormous, as is the range of potential audiences seeking information about forests, exactly how to convey information about resource sustainability and to whom such information should be conveyed are significant challenges for educational programs. Educational initiatives involving forest resource sustainability are undertaken by an incredibly diverse set of public and private organizations. Nearly every federal agency has some responsibility to inform the public or segments thereof about conditions that affect forests. State governments have statutory requirements and programs that often mirror federal laws and programs in both the breadth of subject material addressed and the number of agencies engaged in conveying such material. A most notable educational and extension partnership involves State governments, local governments, and land grant universities. Private organizations are also brimming with educational programs many of which address forest sustainability. The National Wildlife Federation and the Audubon Society are but two examples of private organizations with strong environmental education initiatives.

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

The approaches to continuing education range from correspondence courses to formal doctoral programs and short-term workshops. Universities are major sources of continuing education, although employers and some private organizations provide such opportunities as well. Occupational registration and certification programs focused on forest resource professionals and timber harvesters commonly require the maintenance of professional skills applied to forest and related natural resources.

Underpinning all forest management knowledge is ongoing fundamental and operational research. A long term commitment to improving knowledge through well-designed research is important for ensuring forests are managed sustainably.

**Related State, National, or International Indicators:**

*Montreal Process*: Criterion 7-- Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management:  
 2003 Indicator 53 (2010 Indicator 50): Extent to which institutional framework supports including the capacity to provide for public involvement activities and public education, awareness, and extension programs, and make available forest related information  
 2003 Indicator 55 (2010 Indicator 52): Extent to Which the Institutional Framework Supports the Conservation and Sustainable Management of Forests, Including the Capacity to Develop and Maintain Human Resource Skills Across Relevant Disciplines

**Metric Descriptions**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reprting Responsibility	Limitations/Considerations
Student participation in K-12 forest education programs with a field component <ul style="list-style-type: none"> <li>• Program title, organization/sponsor</li> <li>• Geographic availability</li> <li>• Target grade level</li> <li>• Type of education experience</li> <li>• Content focus</li> <li>• Approximate annual student days</li> <li>• Process used for assurance that education curriculum is consistent with current science</li> </ul>	Oregon Forest Resources Institute	Statewide	Five years	OFRI	Oregon Forest Resources Institute data may underreport programs and number of participants.
Number of Oregon public university and	Oregon University	Statewide	Two years	ODF	

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community college resident faculty engaged in forest resource instruction and forestry extension (FTE)	System and Department of Community Colleges and Workforce Development  OSU College of Forestry				
Expenditures on forest resource research	OSU College of Forestry PNW Research Station	State of Oregon research and federal research in Forest Service Region 6, which includes Oregon	Annual	OSU, PNW	
Number of Oregon members of natural resource professional societies Subcategories: <ul style="list-style-type: none"> <li>• Society of American Foresters</li> <li>• American Fisheries Society</li> <li>• Ecological Society of America</li> <li>• Wildlife Society</li> <li>• Association of Consulting Foresters of America</li> <li>• Associated Oregon Loggers Certified Professional Loggers</li> </ul>	Society of American Foresters, American Fisheries Society, Ecological Society of America, Wildlife Society, Association of Consulting Foresters of America, Associated Oregon Loggers	Statewide	Annual	ODF	

Number of Oregon family forest landowners obtaining Master Woodland Manager status or similar advanced management training	OSU Forestry Extension	Statewide	Annual	ODF	

**Description:** This indicator will use five metrics to evaluate the development and maintenance of general and technical knowledge that facilitates sustainable forest management. The metrics will focus on the areas of:

- K-12 outdoor forest resource education experiences.
- Public university and community college forest resource faculty and forestry extension specialist staffing.
- Expenditure on forest resource research
- Professional natural resource affiliations.
- Family forest landowners receiving advanced management training, such as through the Master Woodland Managers Program.

K-12 forest education may occur both in the field and in the classroom and there are excellent classroom based forestry curricula available to Oregon teachers, such as Project Learning Tree. Forests themselves can also provide an exciting setting for teaching students on other basic education concepts such as biology, chemistry, mathematics, and written and oral communications. This metric focuses on K-12 forest education experiences that occur in forests because of the importance of Oregonians actually seeing, feeling, hearing, smelling, and even tasting what is in our forests to truly understand and appreciate them. The Oregon Forest Resources Institute (OFRI) database of known outdoor forest education programs will form the information base for the K-12 metric. OFRI tracks this information primarily for its own strategic planning efforts. Other programs likely exist that are not tracked by OFRI. They will be encouraged to come forward and add their information to the database. Once these reports become available, this indicator can used to evaluate and improve the adequacy of K-12 forest education efforts.

The objectives of the Master Woodland Manager training is to train family forest landowners to improve the management on their properties through the development of a management plan and to have them contact and motivate non-active woodland owners. The curriculum is based on what information and skills the volunteers need for improved management on their own properties and help motivate other woodland owners.



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**Quality Assurance:** Listed data sources will be responsible for providing accurate data in a consistent manner. Data quality will be largely dependent on the organizations submitting information. ODF will work with OFRI to develop a standardized reporting format for K-12 forest resource education programs that should permit direct comparisons between reporting programs.

**Repeatability:** Data for the diverse set of indicator metrics should be regularly reported, but not always on an annual basis. Consistent reporting will allow for meaningful trend information to be available.

**References:**

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## **A.c. Compliance with forestry regulations**

*This indicator will produce a report on project implementation compliance on federal forestlands with approved management plan standards and guidelines. It will also produce reports on voluntary compliance with the Oregon Forest Practices Act by private forest landowners and operators, and the effects of Forest Practices Act compliance on private landowners' ability to manage their forest resources.*

**Desired trend:** High levels of compliance with management plan standards and guidelines on Oregon federal forestlands. High levels of voluntary compliance with Oregon Forest Practices Act requirements for reforestation and other activities on private lands. Clear public policy expectations for private forest landowners' contributions to the protection and maintenance of public forest resource values.

**Relevance:** Oregon's public and private forestlands are among our greatest state assets and significantly contribute to the Oregon's quality of life. Together, private and federal landowners (primarily the USDA Forest Service and USDI Bureau of Land Management) manage over 94 percent of Oregon forestlands.

Private property rights and the role private forest landowners are asked to play in providing the environmental, economic, and social benefits desired by the public are important issues to Oregonians. The Oregon Forest Practices Act is a regulatory program that attempts to both promote continued active management private forestlands and ensure public values derived from these lands are protected. Finding the balance between these two objectives has been a challenge for Oregonians throughout the 34-year history of the Act. But it is important to note that after so many years, the Forest Practices Act is still in place, continues to evolve, and enjoys high levels of landowner support and voluntary compliance. It is important to track Forest Practices Act compliance and the effects that compliance is having on the ability for private landowner to continue to actively and profitably manage their forests. The public and private landowners are particularly interested in tracking landowner compliance with the Forest Practices Act requirements for reforestation after commercial harvest operations.

The Northwest Forest Plan (NWFP) describes a management strategy for nearly 25 million acres of federally managed land in Washington, Oregon, and northern California. The management strategy in the Record of Decision for the NWFP consists of detailed standards and guidelines and specific land use allocations, which provide a comprehensive set of ecosystem management frameworks for three interrelated strategies: aquatic, terrestrial, and socioeconomic. The framework from the NWFP amended the individual Forest plans in the range of the Northern Spotted Owl. Other Forest Service and BLM forestlands in Eastern Oregon are not addressed by the Northwest Forest Plan but operate under standards and guidelines of their individual management plans. As

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future national forest and BLM district plans are adopted, they will begin to update and replace the existing standards and guidelines on Oregon federal forestlands.

Effective federal project implementation monitoring and evaluation against established standards and guidelines fosters improved management and more informed planning decisions. It helps identify the need to adjust desired conditions, goals, objectives, standards and guidelines as conditions change. Monitoring and evaluation helps the federal land management agencies and the public determine how management plans are being implemented, whether plan implementation is achieving desired outcomes, and whether assumptions made in the planning process are valid.

**Overall Data Availability:** Data for this indicator regarding Forest Practices Act compliance are available through the Department of Forestry's Private Forests Program monitoring. Notification information is derived from the actual count of notifications received. Compliance information is based on the records of operation inspections maintained by ODF stewardship foresters. The level of compliance inspections varies as a result of changing budgets and other high priority workloads. Information on the extent to which forest practice rules restrict private property management is an assessment project that will be periodically conducted by the Private Forests and Forest Resources Planning Programs.

Data regarding federal project implementation monitoring will be compiled and reported by the Pacific Northwest Interagency Regional Monitoring Program, as well as individual national forests and BLM districts. As federal forest management plans are updated, project implementation monitoring will continue but will likely evolve as the new plans will be developed under recently adopted planning rules (Forest Service) and reflect a more modern set of resource concerns and more modest budgets.

**Background:** This indicator provides information relevant to *Forestry Program for Oregon* Actions A.1., A.2, A.5., A.7., C.3, D.2., and D.8.

Forests make a vital contribution to Oregon by providing jobs, products, tax base and other social and economic benefits, by helping to maintain forest tree species, soil, air and water resources and by providing a habitat for wildlife and aquatic life. With respect to private forestlands, Oregon's legal framework, specifically the Oregon Forest Practices Act (ORS 527.610 to 770, 527.990 (1) and 527.992), is designed to encourage economically efficient forest practices that ensure the continuous growing and harvesting of forest tree species and the maintenance of forestland for such purposes as the leading use on privately owned land, consistent with sound management of soil, air, water, fish and wildlife resources and scenic resources within certain visually sensitive corridors and to ensure the continuous benefits of those resources for future generations of Oregonians. The extent to which protection of special environmental, cultural, social, and/or scientific resources and values is required by the Act is the result of public processes leading to legislation and/or administrative rule-making. Commercial operations on private forestland are subject to many laws and

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regulations which deal primarily with consequences of such operations rather than the manner in which operations are conducted. The Oregon Forest Practices Act is unique in that it is intended to prevent resource damage before it occurs through well-designed, science-based best management practices, operator and landowner education, and, when necessary, effective enforcement.

Private property rights and the role of private forest landowners in providing public natural resource benefits is an important issue that is evolving through legislation, ballot measures, and litigation. The degree to which Forest Practices Act requirements limit private landowner's ability to actively manage their forest resources for their full economic potential is part of this issue.

The purpose of project implementation monitoring on federal forestlands is to determine and document if the NWFP and other individual national forest and BLM district management plans and their respective standards and guidelines are being consistently followed. Projects include activities such as timber sales, other silvicultural activities, prescribed fires, road management, recreation, grazing, and mining, watershed restoration, and watershed assessments. The measure of success or expectation is not specified in numbers or percentages in the Record of Decision. Rather, monitoring provides the public and agency officials with feedback about how well, both locally and regionally, particular activities comply with meeting standards and guidelines designed to achieve the strategies. The monitoring is iterative and adaptive to help determine compliance, whether deficiencies were found in implementing them, and if corrective actions are needed. The results generally lead to immediate adjustments in management actions by the local field unit if noncompliance is found. Implementation monitoring also documents actual management practices as they are conducted by field units, thus providing an important link between line officers and management plan implementation direction. (Baker, Palmer, and Tolle, 2005)

**Related State, National, or International Indicators:**

*Montreal Process*: Criterion 7-- Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management:  
2003 Indicator 51 (2010 Indicator 48): Extent to which legal framework encourages best practice codes for forest management.  
2003 Indicator 52 (2010 Indicator 49): Extent to which the legal framework provides for the management of forests to conserve special environmental, cultural, social, and/or scientific values.

**Metric Descriptions**

<b>Metric</b>	<b>Data Source</b>	<b>Reporting Scale</b>	<b>Reporting Cycle</b>	<b>Reporting Responsibility</b>	<b>Limitations/Considerations</b>
Number of Oregon Forest Practices Act notifications of operations received from private forestlands by type of activity	ODF Private Forests Program	Statewide	Annual	ODF	Notifications are a count of landowner/operator intentions. Not all operations are completed as notified.
Percent of inspected private commercial forest operations that are in compliance with the Forest Practices Act by rule category, such as reforestation	ODF Private Forests Program	Statewide	Annual	ODF	This metric is also Department of Forestry performance measure. Inspection levels are determined by budgeted resources and other workloads.
Percent of private forestland directly encumbered by Forest Practices Act best management practices compliance	ODF Private Forests and Forest Resources Planning Programs	Statewide	Five years	ODF	Difficult to clearly separate rule encumbrances from landowner management intentions. Often, landowner and operator actions exceed the requirements of the Act.
Summary of federal forest plan project implementation monitoring results	The Pacific Northwest Interagency Regional Monitoring Program; annual provincial	USDA Forest Service and BLM forestlands in Oregon	Annual reports with ten year summary reports	Regional Ecosystem Office	The results of compliance monitoring cannot be extrapolated to the entire population of projects and activities implemented under management plans. The results, however, do provide

	<p>implementation monitoring reports; annual regional implementation monitoring reports, and the NWFP compliance monitoring database.</p>				<p>insight into possible problems and trends where a sample size of at least 10 projects or activities has been monitored. Where a sample size of fewer than 10 of a specific project type was monitored the results stand only as case studies.</p>
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**Description:** Notifications must be submitted to the Department of Forestry prior to conducting a commercial forest operation. Notifications provide information about the location of the operation and planned activities. Compliance determinations are based on the percentage of operations inspected that are in compliance. Not all operations are inspected and different regulations apply depending on the type of activities conducted and the presence or absence of protected resources. Based on notification information, highest priorities for inspection are those operations with the greatest potential for damage to protected resources. Operation inspections are limited by budget and other workloads assigned to department stewardship foresters. A systematic compliance audit conducted in 2002 support a conclusion that stewardship foresters have done a good job of identifying Forest Practice Act non-compliance when it occurs. Information on the extent to which private landowner activities are affected by Forest Practices Act compliance is a more complicated question requiring significant data collection and analysis. But such information will be valuable to ongoing political and legal discussion about the effectiveness, efficiency, and equity of Oregon Forest Practices Act administration. A protocol for such a study will need to be developed. Funding for such work could come from the Private Forests Monitoring Program and the Forest Resources Planning Program’s Forest Assessment Project.

Northwest Forest Plan project implementation monitoring is expected to answer the following questions:

- What was the level of compliance with the standards and guidelines contained in the Northwest Forest Plan Record of Decision for the activities monitored?
- Which standards and guidelines had less compliance?
- What were the common reasons given for noncompliance?

Implementation monitoring is conducted using Provincial Advisory Committees’ members reviewing project documents and visiting the project in the field. Project compliance is determined by the Provincial Advisory Committees’ members attending the reviews and

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is based on documentation, and at times, actual measurements in the field. The results are designed to follow closely the Record of Decision format by describing compliance associated with (1) land use allocations, (2) the aquatic conservation strategy, (3) survey and manage species, and (4) biological opinions. In the past, the monitoring approach has been to identify a set of NWFP projects or activities each year and then to evaluate their compliance with NWFP standards and guidelines. The project types to be monitored in a given year are identified by consulting with the monitoring program managers and reviewing input from provincial advisory committees. Each year, a list of projects and activities is compiled by the region. A random stratified sample was drawn from this list to identify those projects or activities to be monitored that year. (Baker, Palmer, and Tolle, 2005) These methods may change as new national forest and BLM district management plans are adopted that supersede the NWFP.

**Quality Assurance:** Notification information is collected and tabulated in the Department of Forestry's Forest Activity Computerized Tracking System. The quality of notification information is the responsibility of the operator, landowner, or timber owner submitting it. Non-compliance determinations by stewardship foresters are reviewed by their supervisors and reviewed and compiled by program operations staff. Quality assurance for studies of Forest Practices Act encumbrance of private forest lands will be described in the study protocol.

Northwest Forest Plan project implementation monitoring data collected at the provincial scale are sent to the regional team. All data are double checked for accuracy of data entry. The data are then evaluated and used by the team in preparing a draft annual report. After review and update, this report is finalized and published. These methods may change as new national forest and BLM district management plans are adopted that supersede the NWFP.

**Repeatability:** All three Forest Practices Act metrics should be repeatable but direct comparisons of compliance rates and encumbrance studies may be affected by changes in regulations and changes in resources available for operation inspections.

Significant improvements to Northwest Forest Plan project implementation compliance monitoring have already been achieved, including:

- Developing an implementation monitoring database;
- Developing a web page;
- Publishing reports and summaries annually;
- Establishing a standardized report format;
- Selecting projects to be monitored early;
- Requiring projects to be implemented before review;
- Conducting an annual workshop for provincial team leaders before field reviews; and

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- Establishing participation by senior subject matter specialists and regional team members in reviews.

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***Forestry Program for Oregon Strategy B: Ensure that Oregon's forests provide diverse social and economic outputs and benefits valued by the public in a fair, balanced, and efficient manner.***

**B.a. Forest-related revenues supporting state and local government public services**

*This indicator will produce tabular and graphical information on historical and current trends in selected forest-related revenues to state and local governments in Oregon. These revenues support public services such as education, public safety, environmental protection, and forestry research.*

**Desired trend:** Forest-related revenues are a significant and predictable funding source for Oregon state and local government public services dependent on those revenues.

**Relevance:** Revenue adequate to operate high quality schools, other public services by counties and other local governments, and state government public services is very important to Oregonians. Trends in forest-related revenues supporting state and local government public services is proposed as an indicator because of the important roles these revenues play in maintaining and enhancing the quality of schools and other government programs. Data for this indicator will be used to annually report private forestland and industry property taxes, forestland harvest taxes, forest-related corporate state income taxes, forest-related weight-mile truck taxes, and revenues from Oregon's state, BLM and National Forests. Currently, forest-related revenues to state and local government share wealth created from Oregon's forests except for federal payments, which are now transfer payments from the federal treasury to Oregon's counties and schools. Supporting documentation will be available to provide more detail on specific revenue sources, trends in revenue generation, and legal and political considerations that might affect revenue generation. Some revenues derived from recreation, water, and other forest resources are included in this indicator as they are included in revenues from state and federal forests; others will be included as they become more significant and better documented. Information will be reportable in tabular and graphical formats.

**Overall Data Availability:** Information about forest returns to state and local government is often needed by policy makers and analysts, but is not consistently nor accurately collected by anyone. ODF's Forest Resources Planning Program is currently collecting some of the data needed for this indicator and will begin including it into ODF's annual reports. Property tax programs and federal sources of revenue to local governments have evolved over time, which creates difficulties in collecting and interpreting tax revenue data. Consistent data are available from 1994-2004 for some of the information and for 2000-2004 or other periods for other

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information. This information will be available into the foreseeable future. Data are currently available statewide, but could likely be disaggregated to the county level if necessary. Considerable effort would be required to disaggregate currently available data into smaller geographic areas and to collect information about revenues derived from recreation, water and other forest resources. Information about forest-related state personal income taxes needs to be developed. Ideally, forest-related state personal income tax revenues should be included as a metric for this indicator. That is not currently possible because industry and occupation are not specified on Oregon income tax forms. Industry is also not specified on federal income tax forms, though general occupation is. It would be difficult for Oregon Department of Revenue to accurately attribute income tax to a specific source of income. For example, should spouses of forest industry workers filing joint returns be included? How should reported income be treated for people with more than one job, where only one is related to the forest industry? Differentiating between income taxes attributable from wages and salaries, transfer payments, and interest and dividends, etc. would not be possible. At this time any data collected on forest-related state personal income tax revenues would not be credible.

In the future it may be possible to report on the distribution of these revenues among state and local government public services.

**Background:** This indicator provides essential information about *Forestry Program for Oregon Strategy B* and Actions B.3., B.5., and B.12. Forests provide revenue for state and local governments in Oregon. The revenue is largely derived from payments from income taxes, timber harvesting on public land, harvest taxes on private forest land, property taxes on privately-owned forest land and production facilities, and federal payments in-lieu of taxes or federal appropriations to offset the fiscal impacts of declining timber harvests on federal lands to county and other local governments. A summation of these payments can provide an estimate of selected forest revenues directly provided to the state and local governments of Oregon from forestlands.

Local government dependence on these revenues for funding varies, but counties with much forestland could generally expect considerable revenue from property taxes and from timber harvest payments from county, state, and federal forests. With decreasing federal forest harvests since the 1980s, counties were forced to alter their budgets and find other means for supporting county programs. The Spotted Owl Safety Net Payments (1994-2000) and now the Secure Rural Schools and Community Self-Determination Act (2001-2006) provided stable federal forest funding for Oregon counties since 1994, unlinking federal payments from timber harvests and using a method of set payments. The amount of forest revenue for state and local governments has stabilized considerably in the past decade since federal revenue, which represents a majority of forest revenue, is no longer based on timber harvests on forestland. These laws were passed to give Oregon counties time to find alternative sources of revenue to supplement declining federal harvest-related revenue—the likelihood of finding alternatives providing that magnitude of revenue are highly unlikely. Several hundred million dollars are provided to Oregon counties annually by the USFS and BLM, accounting for a large portion of forest-related revenue. However, given other federal budget priorities, there is uncertainty over whether this level of funding will be maintained beyond 2006.

**Related State, National, or International Indicators:**

*Canadian Council of Forest Ministers:* Criterion 5: social and economics benefits: Indicator 5.2.1, Distribution of financial benefits from the timber products industry.

*Montreal Process:* Criterion 6—Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies: 2010 Indicator 40: Distribution of revenues derived from forest management.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Payments related to National Forests including Secure Rural Schools and Community Self-Determination Act payments and National Forest timber harvest payments	USFS	Statewide/ County	Annually	USFS, ODF	<i>Secure Rural Schools and Community Self-Determination Act</i> susceptible to change or not being renewed
Payments related to BLM forests including Secure Rural Schools and Community Self-Determination Act payments, O&C grant lands timber harvest payments, and forest related payments in-lieu of taxes	BLM	Statewide/ County	Annually	BLM, ODF	Extremely difficult to understand funding mechanism; <i>Secure Rural Schools and Community Self-Determination Act</i> susceptible to change or not being renewed
Board of Forestry payments to counties & local taxing districts	ODF	Statewide/ County	Annually	ODF	Revenues to counties and local taxing districts directly increase budgets; revenues to schools offset state payment which result in an increase in state revenues
Common School Fund payments	ODF	Statewide/ County	Annually	ODF	Returns to schools come from earnings from the common school fund, not from ODF

					payments
County Forest Revenues	Counties	Statewide/ County	Annually	ODF	Does not include forest revenues from municipal, OSU College of Forestry, ODOT, Oregon Parks, and Native American forests, which are often included with county forests as “Other Public”
Forest land and mill property taxes and fire protection levies	ODR	Statewide/ County	Annually	ODF, ODR	Currently undetermined is how consistent the data collected will be; it may be necessary to make estimates using tax rates and property values
Harvest tax	ODR	Statewide	Annually	ODR	Tax returns can vary depending upon timber harvest levels and tax rates; tax rates are determined by the legislature each biennium
Weight-mile tax	ODR	Statewide	Annually	ODR	Currently reliable data is available from 1999-2004; data from 1994-1997 could be developed by ODR, but it would take considerable data editing to ensure data reliability
Corporate income and excise tax	ODR	Statewide	Annually	ODR	Corporate tax returns are volatile because of pollution tax credits, changes in tax laws, and other factors; data is only available from 2000 forward.

**Description:** Oregon’s forest tax structure and laws governing returns to local governments from Oregon’s federal forests change periodically. This makes it difficult to display revenues supporting state and local government services in a consistent format. For example the privilege tax on timber harvesting on most private lands was phased out by 2003; starting in 2004, only some small woodland owners would pay a privilege/severance type of forest tax related to timber harvesting. All other private, nontribal forestland owners fall under the forestland property tax category. Currently, the following eight types of forest-related revenue sources are included in the indicator. Work will continue to develop additional metrics to more fully describe forest-related revenues supporting state and local government public services.

- Corporate income and excise taxes paid by forest industry businesses
- Weight-mile taxes paid by log and chip trucks

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- Real and personal property taxes paid by private timber industries
- Fire protection levies paid by private forest land owners
- Revenue from USFS, BLM, State, and County forests. Currently this includes funding from the *Secure Rural Schools and Community Self-Determination Act*
- Forest related payments in lieu of taxes paid on lands owned by the BLM
- Common School Fund timber receipts
- Forest Products Harvest Tax and privilege/severance taxes

Revenue from income and excise taxes, weight-mile taxes, harvest taxes and revenues distributed to the Common School Fund do not directly fund local governments and taxing districts in Oregon. However, they indirectly bolster local economies and education by contributing to state revenue from forestland, much of which is shared with schools or spent locally. For example, at the state-level, the Forest Products Harvest Tax funds important services such as enforcement of the Oregon Forest Practice Rules. Earnings from the Common School Fund are distributed to local school districts, and forest-related income tax payments allow Oregon to distribute more funds to local school districts.

**Quality Assurance:** Forest revenue data is error checked by the USFS, BLM, ODF, ODR and Oregon's counties. Revenue levels will be run through error checking programs to be developed ODF. All elements of ODF's annual reports are peer reviewed by agency and private analysts.

**Repeatability:** Trend analyses can be reported every year, with increasing certainty over time unless enabling legislation changes.

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- Oregon Property Taxes website: [http://www.oregon.gov/DOR/TIMBER/2003\\_fpht.shtml](http://www.oregon.gov/DOR/TIMBER/2003_fpht.shtml) accessed 6/10/05

## **B.b. Forest-related employment and wages**

*This indicator will produce tabular, map, and graphical information on historical and current trends of some selected sectors in forest-related employment and wages in rural, urban, and forest-based areas.*

**Desired trend:** Forest-related Oregon employment and compensation are stable or increasing.

**Relevance:** Maintaining and enhancing rural economies is very important to Oregonians. Many communities in rural Oregon have fallen behind the state's more populated areas in economic-well being. In addition to ameliorating current high unemployment and poverty levels, domestic violence, and other social problems in rural areas, healthy rural economies benefit urban areas because of the economic interdependence between the two. It is also often difficult for remote rural communities to adjust to economic change. Trends in forest-related employment and wages is proposed as an indicator because of the direct relationship between having family-wage jobs and economic well-being, the availability of the data, and the importance of forest industries to rural communities. Data for this indicator will be used to report the employment and earnings for important sectors of Oregon's forest industries for both rural and urban areas, for forest-based communities and for individual counties of the State. Supporting documentation will be available to provide more detail on individual industries and by geographic areas.

For the purpose of this indicator, "forest-based communities" means communities that exceed the state average in their reliance on the forest products industry for their economic base.

**Overall Data Availability:** GIS technology is now available to separate Oregon forest sector employment information into rural and urban areas and by forest-based communities, while still meeting data confidentiality requirements. Previously it was not feasible to use Oregon Employment Department data to track employment trends in rural and urban areas and for forest-based communities separately. The Employment Department aggregated the data by county, and information about individual firms is protected from disclosure by confidentiality laws. Additional information about log truck drivers, proprietors, construction workers, and other forest sector employees classified by the Employment Department into other industries was collected for 2005 by the Oregon Department of Forestry and can continue to be collected in the future. The geographic distribution of Oregon's timber dependent communities is available from several published sources. Additional efforts will need to be made if employment and earnings information from recreation, nontimber forest products, and other nontimber forest-related industries are to be included in this indicator.

**Background:** This indicator provides essential information for *Forestry Program for Oregon* Strategy B and Actions B.1., B.2., B.5., B.7., B.11., and B.12. Employment and earnings have for decades been used as an indicator or benchmark of economic conditions. Citizens and policy makers continue to place emphasis on their forests providing social and economic benefits, and employment and earnings continue to be included in most sets of economic indicators. Rural Oregon counties continue to lag behind urban Oregon in

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employment, earnings, and personal income, but the picture is clouded by data including both rural and urban areas in the same counties. New data sets and GIS technology will also allow breakouts of unemployment rates into rural and urban categories. The Bureau of Labor Statistics, the IMPLAN Group, and others can provide additional background information about employment and earnings trends in Oregon and local areas. This indicator will provide up-to-date and easy to collect information about economic conditions and trends in rural and forest-based areas of Oregon. It will also be relatively easy to project the impacts of economic changes, such as economic impacts resulting economic development projects, on employment and earnings in rural areas, including forest-based communities.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 6—Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies: 2003 Indicator 44: Employment in the forest sector and the forest sector employment as a proportion of total employment; 2003 Indicator 45: Average wage rates; 2003 Indicator 46: Viability and adaptability to changing economic conditions of forest dependent communities; 2010 Indicator 36: Employment in the forest sector; and 2010 Indicator 37: Average wage rates, annual average income and annual injury rates in major forest employment categories.

*Oregon Benchmarks: Business Vitality*—1: Percent of Oregon jobs outside the I-5 corridor and Deschutes County; 4: Net job growth rural/urban

*Oregon Benchmarks: Income*—12: Average annual payroll per covered worker; 15: Oregon unemployment rate

*Canadian Council of Forest Ministers*—Criterion 5, social and economics benefits: Indicator 5.2.2, Distribution of financial benefits from the timber products industry; Indicator 5.3.5: Employment; Indicator 5.3.6: Average income in major employment categories

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Forest-related employment in rural and urban areas and in forest-dependent communities	OED, ODF	Statewide & E/W by rural/urban and for forest-based communities	Annually	OED, ODF	Challenges with including forest-related employment currently classified into other sectors; difficult to include recreation and other nontimber employment; data confidentiality must be maintained; will not include all forest-related employment
Forest-related wages and salaries in rural and urban areas and in forest-dependent communities	OED, ODF	Statewide & E/W by rural/urban and for forest-based	Annually	OED, ODF	Challenges with including forest-related wages currently classified into other sectors; difficult to include recreation and other nontimber employment; data confidentiality must be maintained; will not include all



		communities			forest-related employment
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**Description:** Data to be used for this indicator will come from Oregon covered payroll information, submitted to the unemployment compensation program by firms doing business in Oregon. Oregon Covered Employment and Wages provides the most complete summary of Oregon employment and wage information published by the State of Oregon. All businesses covered by Employment Department law report employment and wage information that is tabulated by North American Industry Classification System (NAICS) codes and geographically—statewide and by county. GIS maps will be used to divide the employment and wage information into rural and urban areas, into forest- and not forest-dependent communities and into different geographic areas. Sectors of the economy to initially be included in the indicator will include NAICS categories:

- 113: Forestry and logging
- 321: Wood products, and
- 322: Paper

Additional information about small company proprietors and log truck drivers and other forest product employees classified by the Employment Department into other industries was collected for 2004 by the Oregon Department of Forestry and can continue to be collected in the future. Some information about employment and wages is available for forest industries other than wood products. For example, NAICS 113 includes gathering of forest products, so it includes some employment data about gathering of mushrooms, moss, truffles, bear grass, evergreens, and other nontimber forest products. More information about recreation, nontimber forest products, and other forest-related industries can be included in this indicator as data becomes available. Data on public sector employment in forestry related activities will not be included.

This indicator is designed to provide a measure of rural and forest-dependent employment and wages relative to those in urban areas, but when tracked over time they can also provide an index of change over time. The data will be comprehensive for all covered direct forest industry employment and will have high levels of precision and accuracy, but will not include some indirect employment and will not include employment in sectors like recreation that do not have direct ties to NAICS codes. The data can tie to classifications of forest-based communities determined by other analyses. The data can also be used to produce other useful social and economic analyses. For example, wage distributions and school enrollment changes related to changes in industrial base and employment and incomes for rural and forest-related communities. The data can be used to localize economic-related Oregon Progress Board Benchmarks:

- Employment in Rural Oregon
- Net Job Growth

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- Pay per worker
- Income disparity
- Workers at 150 percent or more of poverty
- Unemployment

**Quality Assurance:** Oregon Covered Employment and wages information data is collected, reviewed, and error checked by the Oregon Employment Department and by federal analysts.

**Repeatability:** Data is collected four times a year with the same survey protocols and with over 95 percent of eligible companies participating. In addition to excellent repeatability and being extremely accurate and precise, changes in employment and incomes in rural and urban areas will be readily identifiable. Initial lists of timber-dependent communities will be at least five years old to allow the tracking of changes in the number and location of these communities as well as in changes of employment and wages.

**References:**

- Canadian Council of Forest Ministers. 2005. Draft CCFM Criterion 5: Economic and social benefits current and potential indicators.
- Birch, K (coord). 2000. First Approximation Report for Sustainable Forest Management in Oregon: [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#First\\_Approximation\\_Report\\_](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#First_Approximation_Report_)
- Conway, F. 1994. Oregon's Timber-Dependent Communities: Where Are They and How Are They Faring? BMNRI Natural Resource News.
- Donoughue E. and Haynes R. 2002. Assessing the Viability and Adaptability of Oregon Communities. USFS General Technical Report PNW-GTR-549.
- Oregon Employment Department. 2004. Oregon Covered Employment and Wages, <http://www.qualityinfo.org/olmisj/PubReader?itemid=00000040>
- Seidel, K. 1993. Demographic and Economic Characteristics of Oregon's Timber Dependent Communities. Oregon State University Extension Service Oregon Profiles.
- Oregon Progress Board Benchmarks: <http://egov.oregon.gov/DAS/OPB/obm.shtml>

## **B.c. Forest ecosystem services contributions to society**

*This indicator will produce tabular information on trends in monetary measures of contributions to society and Oregon's quality-of-life from three different ecosystem services: recreation, passive use values, and carbon sequestration values.*

**Desired trend:** Oregon forest ecosystem services produced are stable or increasing and are sustainable.

**Relevance:** Maintaining and enhancing forest's non-commodity contributions to state and local economies, communities, and to Oregon's quality-of-life are very important to Oregonians. These values, such as clean water, habitat for fisheries, and scenery are often taken for granted because they are not generally traded in markets. As such, they have no 'price' and are therefore seemingly provided for "free". However, the goods and services that ecosystems provide are very familiar to us and would cost millions, if not billions, of dollars to replace. In addition to provision of immediate and long-term goods and services to Oregonians, clean water, high-quality fish and wildlife habitat and other ecosystem services add to the perception of a high quality-of-life in Oregon that can help attract desirable industries and highly skilled workers to the state. Fortunately, the field of environmental valuation in economics has well-developed tools for measuring the value of these resources in monetary units that are comparable to market prices.

**Overall Data Availability:** Monetary estimates for the value of a subset of non-commodity ecosystem services are available from published scientific research. Until recently the environmental costs and benefits of forestry had not been integrated into a comprehensive framework linking them with monetary contributions from commodity outputs. Over the last decade much progress has been made which provides monetary estimates of environmental services provided by forests. Much work remains to be completed before there can be a seamless integration of all forest ecosystem services and goods and services traditionally bought and sold in markets into a comprehensive assessment and monitoring program, according to Haynes and Horne (1997) ". . . recent advances in the field of economic valuation make it possible to include in a resource valuation many outputs and conditions that were once considered unquantifiable."

**Background:** This indicator provides essential information for *Forestry Program for Oregon* Strategy B and Actions B. 1., B.2., B.5., B.7., B.11., and B.12. Although ecosystem services are key elements in determining the social and economic well-being of Oregonians, their contributions have only sporadically been integrated into forest assessment, planning, and monitoring efforts. Employment, and earnings and other traditional measures of economic well-being have for decades been used as an indicator or benchmark of economic conditions. As a result, noncommodity benefits, particularly those only partially understood, may often be unaccounted for. This indicator begins the process to integrate some of Oregon's forests nonmarket contributions into the Oregon Board of Forestry's Forest Assessment and Indicators of Forest Sustainability.

**Related State, National, or International Indicators:**

*Canadian Council of Forest Ministers:* Criterion 5, social and economics benefits; Indicator 5.1.8, Value of unmarketed forest-based services.

*Montreal Process:* Criterion 6 -- Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies: 2003 Indicator 43: Non-consumptive use forest values and 2010 Indicator 27: Revenue from forest based environmental services.

*Oregon's First Approximation Report:* Criterion 6 -- Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies; Indicator 43, Non-consumptive use forest values, including social/cultural, recreational and biological values.

*2003 California Forest and Range Assessment:* Chapter 6, socio-economic well-being: commodity and non-commodity production and use trends.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Recreation Use Value	OSU, ODF	Statewide & for E. & W. Oregon	Every five years	OSU, ODF	Challenges include developing credible protocols for monetary measures of recreation use values
Passive Use Value	OSU, ODF	Statewide & for E. & W. Oregon	Every five years	OSU, ODF	Challenges include developing credible protocols for monetary measures of passive use values. Includes biodiversity/habitat values
Carbon Sequestration Value	OSU, ODF	Statewide & for E. & W. Oregon	Every five years	OSU, ODF	Challenges include developing credible protocols for monetary measures of carbon sequestration values

**Description:** This indicator will provide a monetary measure of the non-commodity contributions to society and Oregon’s quality-of-life. The basic value categories in this indicator include:

- Recreation use value (comprised of several forest-related recreation activities) will be calculated as dollars per person per activity day multiplied by the number of activity days;
- Passive use values (comprised of bequest, existence and aesthetic values) and will be calculated as dollars per person or dollars per household multiplied by Oregon’s population or number of households converted to dollars per acre; then dollars per acre

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would be multiplied by the number of acres of forest land (or forest cover type/stand size and/or other relevant forest condition class); passive use include biodiversity/habitat values;

- Carbon sequestration value calculated as dollars per ton sequestered per acre multiplied by the number of forested acres;

The monetary estimates will be taken from published scientific research. In cases where a range of values are available, some link based on expert judgment to land quality/land type (e.g., multi-resource vs. reserves) will be established to differentiate levels of value accruing from different land management themes.

Additional value categories that are identified/requested by the committee and external reviewers will be evaluated on a case-by-case basis according to the availability and credibility of existing data.

Timeline:

This work is projected to take 100 hours to complete over a four month period.

Basic steps in developing this indicator will include:

- Obtaining empirical monetary estimates for each value category
- Obtaining recreation use estimates
- Obtaining acreages of forest land by forest type, stand structure, stand size and other relevant forest condition classes
- Linking value categories to forest types (by management theme) to generate a range of feasible empirical monetary estimates for the value categories

**Quality Assurance:** Data will be collected, reviewed, and error checked by the Oregon State University College of Forestry and Oregon Department of Forestry analysts. Methodology, data compilation procedures, and publications will be peer reviewed. The quality of this new indicator concept will improve over time at the science/art of quantifying environmental services matures.

**Repeatability:** Monetary estimates of value and population estimates will be taken from published scientific research every five years. Analysis of the components of change will be completed to insure that reported changes come from changes in demographics or values rather than from changes in sampling and analysis procedures.

**References:**

- Canadian Council of Forest Ministers. 2005. Draft CCFM Criterion 5: Economic and social benefits current and potential indicators.

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- Birch, K (coord). 2000. First Approximation Report for Sustainable Forest Management in Oregon: [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#First\\_Approximation\\_Report\\_](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#First_Approximation_Report_)
- Haynes, R.W. and Horne, A. 1997. Economic Assessment of the Basin. In T.M. Quigley and S.J. Arbeldide (eds.), An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins.

## **B.d. Forest products sector vitality**

*This indicator will produce tabular and graphical information on historical and current trends in sales and competitiveness of Oregon's forest products sector.*

**Desired trend:** Production and values of Oregon wood and paper products and forest industry equipment are stable or increasing.

**Relevance:** Oregon's forest products industry continues to enhance and diversify Oregon's economy and provides economic values to both rural and urban communities. With low interest rates and high demand for housing in the U.S., we have seen resurgence in Oregon's forest products industry. Today, despite reduced harvests from historical levels on federal lands, Oregon still remains the leader in lumber production in the United States. Currently, Oregon's forest sector, including indirect economic effects, provides 9 percent of Oregon's jobs, 10 percent of the State's labor income, and 11 percent the State's economic output. A large share of these economic benefits occurs in more rural areas of the State, areas with high unemployment rates and other economic problems. In addition to ameliorating economic and social problems in rural areas, healthy rural economies benefit urban areas because of the economic interdependence between the two. It is therefore important to understand the health and sustainability of Oregon's forest products sector and its prospects for continuing to produce the economic values that Oregonians have come to expect from their forests. Long-term trends in sales and investments in forest industry infrastructure indicate the health of the industry and its ability to continue to successfully compete in the global market place.

**Overall Data Availability:** Information about sales from, condition of, and investment in Oregon's primary forest products sector is available from several sources, but is not consistently nor accurately compiled by anyone into a single document. Over the years, ODF and the PNW Research Station have periodically published surveys of the primary wood-processing industries in Oregon; ODF is currently cooperating with the University of Montana's Bureau of Business and Economic Research and PNW to update these surveys. Private companies and the U.S. Census Bureau and the U.S. Bureau of Economic Analysis also publish information that may be used to better understand forest industry sales and infrastructure condition and trends. Currently the information being collected is adequate to begin developing this indicator, but over the long-term, this indicator could be much more useful if industry surveys and other information were better tailored to provide information specific to this indicator. Another problem is that using information from accounting firms, consultants, and other proprietary sources would require continually purchasing information from them. Currency of the data will be a concern. For example, the most recent published capital expenditure information from the U.S. Census Bureau is two years old and reflects conditions when timber harvest levels were at historical lows. It may be that capital expenditures have increased with robust housing markets and increasing timber harvests.

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Data for annual timber harvest levels comes from the *Oregon Timber Harvest Report*, which is published annually by ODF. This report consists of information about wood processing and timber harvest in Oregon, which has been gathered since 1849. ODF currently has the infrastructure and plans to continue producing the *Oregon Timber Harvest Report* annually. Harvest data for this purpose is converted into cubic feet from board feet using a year-specific conversion ratio compiled for the *Harvest Report*. Data for the *Oregon Timber Harvest Report* comes from the USFS, BLM, ODR, Counties, Native American Tribes, the Oregon State University College of Forestry, and ODF. Harvest information is then aggregated by county, owner, and eastern and western Oregon and published on the ODF Forest Resources Planning Program's web site.

**Background:** This indicator provides essential information about *Forestry Program for Oregon* Strategy B and Actions B.1, B.2, B.5, B.6, and B.12. The lumber and wood products industry comprises a large portion of Oregon's economic base and is crucial to the social and economic health of both urban areas and rural communities. A relatively low population, large lumber and wood products industry, and strong demand for Oregon's high-quality products has fostered substantial out-of-state timber product exports. Timber-related sectors can be divided into two manufacturing sectors. The first sector includes industries that manufacture solid wood products, including secondary products such as millwork or wood furniture; the second sector includes pulp and paper manufacturing. The basic manufacturing sectors purchase logs from logging contractors and other firms provide a wide range of services to wood and paper product manufacturers and to grow and protect Oregon's timber supply. Backward economic linkages continue to ripple through Oregon's economy as companies provide forestry-related business with services and supplies, and families of workers, proprietors, and investors spend their incomes. Sales of the primary sectors of Oregon's forest industry can indicate the trend in overall industry robustness in an easily understandable way. Investment in wood processing plants indicates resources dedicated to maintaining the productivity of these industries in a globally competitive environment.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 6 -- Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies: 2003 Indicator 29: Value and volume of wood and wood products production, including value-added through downstream processing; 2003 Indicator 32: Value of wood and non-wood commodity production as a percentage of Gross Domestic Product (GDP); 2003 Indicator 38: Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation, and tourism; 2003 Indicator 39, Level of expenditure on research and development, and education; 2003 Indicator 40: Extension and use of new and improved technology; 2003 Indicator 41: Rates of return on investment; 2010 Indicator 31: Value of exports and imports of non-wood products; 2010 Indicator 32: Exports as a share of wood and wood products production and imports as a share of wood and wood products consumption; and 2010 Indicator 34: Value of capital investment and annual expenditure in forest management, wood and non-wood product industries, forest-based environmental services, recreation and tourism.



*Canadian Council of Forest Ministers:* Criterion 5 -- social and economics benefits: Indicator 5.1.3, Production, consumption, imports, and exports of timber products; Indicator 5.3.4, Productivity index. Criterion 6, society's responsibility: Indicator 6.5.3, Investment in forest research, timber products industry research and development, and education. *USDA Forest Service, Northeastern Area:* Criterion 6, maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies: Indicator 12, Wood and wood products production, consumption, and trade; Indicator 14, Investments in forest health, management, research, and wood processing; Indicator 16, Employment and wages in forest-related sectors  
*Ontario's Forests:* Criterion 5 -- providing for a continuous and predictable flow of economic and social benefits from the forest: Indicator 5.2, Monitoring and supporting forest sector employment, investment and competitiveness; Indicator 5.3, Monitoring and supporting enhanced forest sector contributions to the economy.

**Metric Descriptions:**

<b>Metric</b>	<b>Data Source</b>	<b>Reporting Scale</b>	<b>Reporting Cycle</b>	<b>Reporting Responsibility</b>	<b>Limitations/Considerations</b>
Sales value of wood products and forest industry equipment from Oregon manufacturers	Oregon Mill Studies	Statewide	Every five years	PNW, ODF, U. of Montana	Some information currently available; other information not available until 2007 mill study
Cost of production compared to other areas	Resource Information Systems, Inc.	Statewide	Annually or every five years	Resource Information Systems, Inc., ODF	Data needs to be purchased from RISI
Production capacity, condition, technology, and investment	Oregon Mill Studies	Statewide	Every five years	PNW, ODF, U. of Montana	Some information currently available; other information not available until 2007 mill study
Capital expenditures in wood product and paper manufacturing	U.S. Census Bureau	Statewide	Annually	U.S. Census Bureau, ODF	Annual capital expenditures include both new investment and depreciation replacement
Net foreign and domestic exports of Oregon wood products	ODF, PNW, U.S. Bureau of Economic Analysis	Statewide	Annually	ODF, PNW	Little information exists about domestic exports of Oregon wood products. Several calculations will necessary to develop information for this metric. This metric must also consider logs and wood products

					imported into the state for manufacturing or sales.
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**Description:** Long-term trends in sales and investment are interrelated and indicate the ability of Oregon’s forest products industry to continue providing economic, environmental and social benefits to Oregonians. Increased investment could improve product values and/or industry productivity leading to increased rates of return for forest management and less pressure to develop forestlands to other uses as well as increased incentive to maintain and improve forest health. Increased product sales would increase cash flow and improve rates of return, thereby encouraging investment in forest management and industry infrastructure. This indicator provides direct insight into the physical sustainability and competitiveness of Oregon’s forest products industry. Sales value from primary and secondary wood products and pulp and paper producers would be collected every five years with the Oregon mill studies. Cost of production information would be purchased annually from Resource Information Systems, Inc. and compared with the costs of producing similar products in other regions. Resource Information Systems, Inc. is globally recognized as the source for independent economic analysis for the international forest products industry. Investment is measured with two metrics:

- Annually tabulate gross investment in equipment and structures for the lumber and wood products industry and for the paper and allied products industry, and
- Inventory industry production capacity, technologies used in production, and investment in specific technologies for both depreciation replacement and new investment; this information would be collected every five years with the Oregon mill studies.

The U.S. Census Bureau Annual Capital Expenditures Survey (ACES) is part of a comprehensive program designed to provide detailed and timely information on capital investment in new and used structures and equipment by nonfarm businesses. Beginning with the 1999 ACES, capital expenditures data are published for 130 industries comprised primarily of three-digit and selected four-digit industries from the North American Industry Classification System (NAICS): 1997. Prior to the 1999 ACES, capital expenditures data were published for 97 industries comprised of two-digit and selected three-digit industries from the Standard Industrial Classification system. Annual capital expenditures include both new investment and depreciation replacement.

PNW and ODF estimate Oregon’s timber product exports by using information about Oregon’s population, U.S. per capita timber product consumption, and product shipment data. Annual estimates of Oregon’s population are available online from the Bureau of Economic Analysis and other sources. Census data is not collected every year; therefore, the annual population count is an updated estimate of Oregon’s population supplied by the U.S. Bureau of Economic Analysis and from information from the Oregon Office of Economic Analysis. Per capita consumption data is available at the national level, but not at the state-level. Therefore, PNW and ODF developed methodology to estimate Oregon-specific per capita wood products consumption. U.S. per-capita timber product

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consumption is adjusted to better reflect consumption in Oregon by using lumber shipment data from the Western Wood Products Association to ODF through cooperative agreements and from other information. Oregon timber product consumption data will be provided and updated jointly by PNW and ODF. Timber products that are not consumed in Oregon are assumed to be exported overseas or to other states.

All data is aggregated and makes no comparison between public/private or eastern/western Oregon. Timber harvest, timber product consumption, and export information will be refined over the next several years, but is expected to result in relatively small adjustments to the database.

**Quality Assurance:** Data from the Oregon mill studies will be error checked by the University of Montana's Bureau of Business and Economic Research, PNW and ODF. The U.S. Census Bureau is responsible for the accuracy of information in the "Annual Capital Expenditures" report.

**Repeatability:** Trend analyses on capital expenditures in wood product and paper manufacturing in Oregon can be reported every year. Sales, investment, and information about condition and trends of Oregon wood products industry's infrastructure are published in the Oregon mill study every five years. Mill study information is readily available on the web soon after it is collected; a peer reviewed formal report is published within two years of data collection.

#### References:

- Annual Survey of Manufacturers, Geographic Area Statistics: 2003. 2005. <http://www.census.gov/mcd/asm-as3.html>, accessed 11-1-05.
- Morgan, T. and others. 2004. California's Forest Products Industry: A Descriptive Analysis. Gen. Tech. Rep. PNW-GTR-615. Portland, OR: USDA Forest Service.
- Hovee, E.D. 2005. Oregon Forest Sector Contributions and Potential. Oregon Forest Resources Institute.
- Howard, J. 2003. U.S. Timber Production, Trade, Consumption, and Price Statistics: <http://permanent.access.gpo.gov/lps5730/1965-2002/fplrp615.pdf>
- *Oregon Annual Timber Harvest Reports:* <<http://egov.oregon.gov/DAS/OPB/obm.shtml>> <[http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#Annual\\_Timber\\_Harvest\\_Report](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#Annual_Timber_Harvest_Report)>
- Oregon Office of Economic Analysis Population Forecasts and other information: [http://www.oregon.gov/DAS/OEA/demographic.shtml#Short\\_term\\_State\\_Forecast](http://www.oregon.gov/DAS/OEA/demographic.shtml#Short_term_State_Forecast)
- Region Economic Accounts: Annual State Personal Income (choose population graph and relevant years) <<http://www.bea.doc.gov/bea/regional/spi/>>
- Ward, Franklin and Lettman, G. 2000. Oregon's Forest Products Industry: 1998. Oregon Department of Forestry.

## ***Forestry Program for Oregon Strategy C: Maintain and enhance the productive capacity of Oregon's forests to improve the economic well-being of Oregon's communities.***

### **C.a. Area of non-federal forestland and development trends**

*This indicator will produce tabular and graphical information on historical and current trends in the extent of Oregon's nonfederal forest land base, particularly large contiguous tracts of forestland with few developments, and projections of future development of forestland to other uses.*

**Target:** Area of Oregon non-federal wildland forest in 2010 is 97.4 percent of 1974 levels (Oregon Progress Board target for identical Oregon Benchmark 82).

**Relevance:** Maintaining and enhancing the productive capacity of Oregon's forests to produce the ecological, social, and economic values Oregonians expect from their forests requires limiting the development of forestland to other uses. Showing trends in land use change to and from forestland is proposed as an indicator because of the importance of maintaining Oregon's forestland base for producing fish and wildlife habitat, timber, and other traditional forest values on a sustainable basis. Data for this indicator will be used to report historical and current trends in land use and indications of potential development of forestland to other uses. Supporting documentation is available to provide more detail on land use change by geographic area, ownership, and historical information on land use change back to 1973. Other land use information that is currently available includes the number of dwellings being added to forestland that is not being converted to other uses, projections for future forest land development, and the effects of land use change on forest management, forest values, and fire conditions.

Data for this indicator, combined with data from Indicator E.a. (Composition, diversity, and structure of forest vegetation), will contribute to analyses of the broader topic of forest fragmentation and the potential effects of fragmentation on forest resources.

**Overall Data Availability:** Data to update this report are available every five years from reports produced jointly by the Oregon Department of Forestry Forest Resources Planning Program and the Pacific Northwest Research Station's Forest Inventory and Analysis Program. The most current data is available in two reports published by ODF: *Forest Farms and People, Land Use Change on Non-Federal Land in Western Oregon 1973-2000* and *Forest Farms and People, Land Use Change on Non-Federal Land in Eastern Oregon 1975-2001*. Data used for this indicator are the same data used to create and update Oregon Progress Board Benchmark 82: The percent of non-federal land in 1974 still preserved for forest use. Indicator C.a. currently includes land use data from 1973-2000, but information about land available for timber management is available back to the 1950s. Land use information will be updated to 2005 in 2006 and an updated statewide report about land use and land use change in Oregon will be published in

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2007. Data coverage is complete for all nonfederal lands in Oregon. Information is not currently available, but is being developed, for use as an indicator of projected future development of the State's forestland.

**Background:** Ensuring retention and improvement of the forest landbase is essential to providing the diverse ecological, social, and economic outputs and benefits necessary to achieve the Oregon Board of Forestry's mission and visions, and to implement the strategy and actions integral to the *Forestry Program for Oregon*. Specifically, this indicator provides essential information for *Forestry Program for Oregon* Actions A.1, A.6, B.4, C.1, D.7, and G.1. Similar information was used to evaluate the sustainability of Oregon's forest landbase in the 2000 *First Approximation Report for Sustainable Forest Management in Oregon*, in the *Oregon State of the Environment Report 2000*, and in Oregon Progress Board Benchmark #82.

Economic and population growth, and consequently land development, remain strong near Oregon's urban areas. In some locations, land ownership change and development is occurring so rapidly that looking at historical information about land use change is becoming less useful for evaluating the success of the *Forestry Program for Oregon's* actions and strategies and other state and federal policies and programs. Therefore, it is essential to create a leading indicator for land use change, one that indicates locations and rates of probable future development of Oregon's forest land to other uses. A metric has been developed which will keep track of parcelization of private forestland in Oregon. Parcelization of private land is often a precursor to development of forest and agricultural land to urban and rural residential uses.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 2—Maintenance of the productive capacity of forest ecosystems: 2003 and 2010 Indicator 10: Area of forest land and net area of forest land available for wood production.

*Northeastern Area*—Area of timberland.

*Heinz Center*—Forest area and ownership.

*Heinz Center*—Forest pattern and fragmentation.

*Oregon Benchmarks: Environment--82:* Percent of Oregon's non-federal forest land in 1974 still preserved for forest use.

*Oregon State of the Environment Report:* Conversion of forest land to more developed uses, landscape pattern of patches.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Area of nonfederal wildland forest	ODF, PNW-FIA	Statewide & County	Five years	ODF	Information is plot-based, which creates difficulties when used with map-based information for fire condition and other analyses. This is a following indicator; ownership and land use change is occurring fast enough in some areas to limit this indicator's usefulness for monitoring, assessment, and policy-making purposes.
Parcelization of private forestland	ODF, PNW-FIA	Statewide & Regionally	Five years	ODF	This is a leading metric that is still under development. With current resources, it will take up to five-years to gather enough information to use this indicator to determine likely development patterns in Oregon's private forests.

**Description:** This indicator shows changes in the area of nonfederal wildland forest over time and will indicate where and to what extent development is likely to occur. *Wildland forest* is forestland not used in conjunction with residential, farm, and other nonforest uses. Generally, it consists of large contiguous tracts of at least one square mile of forestland with fewer than five developments per square mile generally scattered across the area. Data used for the indicator comes from aerial photographs taken from 1973-2005. A sample of 37,000 points on non-Federal land in Oregon is interpreted for dominant land use and other characteristics. By comparing this information at selected time intervals, changes in development patterns and land uses are determined. ODF currently has the infrastructure and plans to continue producing the reports on land use change on nonfederal lands in Oregon every five years. ODF and FIA continue to work together on land use change studies and will produce a new statewide report in 2007 and will include this information in the Oregon Board of Forestry's *2010 Assessment of Oregon's Forests*. The data will allow analyses of any effects on land use resulting from the implementation of 2004 Ballot Measure 37. In the future, the data will also be separated into various private ownership categories such as corporate, family, investment organization, and non-profit. Statewide information about parcelization of private forestlands will be tied to a subset of the photo interpreted plots.

Because of their remote locations and the laws and policies affecting them, Oregon's federal forestlands—about 57 percent of the State's total—are not threatened with development. However, potential conversion of private lands that make up 38 percent of

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Oregon's forest land base has been an enduring policy concern. State and other nonfederal public land is often closer to private land that might potentially be developed for other uses and may be affected by changes in land use on nearby private lands. Therefore, land use change information is collected on nonfederal public land. Parcelization of public forestland is unlikely to occur. For that reason, forest parcelization data will be collected and analyzed only on private forestland.

**Quality Assurance:** A quality assurance/quality control procedure implemented by FIA insures that the information used for the indicators will be of the highest quality. In addition, the data is error checked by ODF. Reports are then peer reviewed by agency, academic, and private analysts.

**Repeatability:** Data will be collected and analysis of land use trends will be reported every five years. The data will continue to be collected on the same sample of 37,000 points. Data definitions and the area represented by each point will remain the same.

**References:**

- Birch, K (coord). 2000 First Approximation Report for Sustainable Forest Management in Oregon: [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#First\\_Approximation\\_Report\\_](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#First_Approximation_Report_)
- Lettman, G (coord). 2002. *Forest Farms and People, Land Use Change on Non-Federal Land in Western Oregon 1973-2000* [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/docs/ForestFarmsPeople.pdf](http://oregon.gov/ODF/STATE_FORESTS/FRP/docs/ForestFarmsPeople.pdf)
- Lettman, G (coord). 2004. *Forest Farms and People, Land Use Change on Non-Federal Land in Eastern Oregon 1975-2001* [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/docs/EORDZ.pdf](http://oregon.gov/ODF/STATE_FORESTS/FRP/docs/EORDZ.pdf)
- Oregon Progress Board Benchmarks: <http://egov.oregon.gov/DAS/OPB/obm.shtml>
- Risser, and others. 2005. *Oregon State of the Environment Report*. <http://egov.oregon.gov/DAS/OPB/soer2000index.shtml>

## **C.b. Timber harvest trends compared to planned and projected harvest levels and the potential to grow timber**

*This indicator will produce tabular and graphical reports on trends in timber growth, planned and projected timber harvests, and actual timber harvests.*

**Target and desired trend:** Oregon timber harvest levels are 90 to 110 percent of planned and projected levels (Oregon Progress Board target for Oregon Benchmark 83) and the potential to grow timber is stable or increasing.

**Relevance:** Maintaining timber harvest levels while also meeting other environmental economic, and social needs is very important to Oregonians. Comparing trends in projected and actual timber harvest levels for private and public lands is proposed as an indicator because of the importance of maintaining a viable primary forest processing industry to state and local economies. Data for this indicator will be used to report historical and current actual timber harvest levels, projected timber harvest levels, and the potential—except for Congressionally designated Wilderness Areas and National Parks—of Oregon’s forests to grow timber. Supporting documentation is available to provide more detail on actual harvests by geographic area, ownership, and back in time to 1849. For this indicator, “planned and projected harvest levels” means the volume of timber that forests can continuously produce, given the intensity of management resulting from public forests’ management plans and under current and forecasted economic conditions for private landowners. The potential to grow timber is generated from computer models which maximize timber harvests in Oregon’s within economic constraints, except for those forests within Congressionally designated Wilderness Areas and National Parks.

**Overall Data Availability:** Data to update this report are available annually from the Oregon Department of Forestry Forest Resources Planning Program’s annual *Oregon Timber Harvest Report*, from analyses completed periodically by the Oregon Department of Forestry and the Oregon State University College of Forestry, and from public agencies managing forestland in Oregon. Data used for this indicator is the same data used to create and update Oregon Progress Board Benchmarks 83A and 83B. Indicator C.b. currently includes timber harvest data from 1962-2004, but information in different timber utilization standards and ownership aggregations is available back to 1849. Data coverage is complete for the entire state. Data for private forestlands is generated through projections and data for public forestlands is derived from approved management plans. Published studies will be used as the basis for determining potential timber growth.

**Background:** This indicator provides essential information for *Forestry Program for Oregon Strategy C* and Actions C.1., C.3., C.5., and C.6. Similar information was used to evaluate Oregon’s timber harvests in the 2000 *First Approximation Report for Sustainable Forest Management in Oregon*, in the *Oregon State of the Environment Report 2000*, and in Oregon Progress Board Benchmarks 83A and 83B, updated annually. Evaluation of timber harvest only in terms of growth and mortality can be misleading and confusing for



the general public. Comparing actual harvests to those levels projected under current laws, regulations, and policies is the most direct and least complicated way making these comparisons. For comparison purposes, information will be included about the potential for growing wood in Oregon’s forests without most regulatory constraints.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 2—Maintenance of the productive capacity of forest ecosystems: 2003 Indicator 13: Annual removal of wood products compared to the volume determined to be sustainable; 2010 Indicator: Total growing stock and annual increment of both merchantable and nonmerchantable tree species in forests available for wood production; and 2010 Indicator 13: Annual harvest of wood products by volume and as a percentage of net growth or sustained yield.

*Heinz Center:* Timber harvest, timber growth and harvest.

*Oregon Benchmarks: Environment--83A:* Actual timber harvest as a percent of potential harvest levels under current plans & policies, public lands; *83B:* Actual timber harvest as a percent of potential harvest levels under current plans & policies, private lands.

*Oregon State of the Environment Report:* Timber harvest relative to sustainable levels (reference: estimated sustainable levels in plans and management intentions).

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Annual timber harvest volume, compared to the volume expected under current plans and the potential to grow wood, public lands	ODF, BLM, USFS	Statewide	Annually	ODF	Planned and projected harvest volumes can change with changes in economics, laws, regulations, policies, and agency plans. Timber utilization standards change over time.
Annual timber harvest volume, compared to the volume expected under current and forecasted economic conditions and the potential to grow wood, private lands	ODF, BLM, USFS	Statewide	Annually	ODF	Planned and projected harvest volumes can change with changes in economics, laws, regulations, policies, and agency plans. Timber utilization standards change over time.

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**Description:** This indicator compares potential timber harvest levels, projected harvest levels under current laws and policies, and actual harvest levels. Projections for potential timber harvest levels come from computer projections completed by ODF. Information about wood processing and timber harvest in Oregon has been gathered since 1849 and is published annually by ODF in the *Oregon Timber Harvest Report*. Timber supply studies have been jointly completed by the Oregon State University College of Forestry and ODF since 1976. ODF currently has the infrastructure and plans to continue producing the *Oregon Timber Harvest Report* annually. ODF and the College of Forestry continue to work together on timber supply studies and will produce new timber supply projections for a *2010 Assessment of Oregon's Forests*. Information about projected harvest levels comes from timber supply projections of harvests for private owners and from agency plans and information from agency analysts for public owners.

Information for this indicator is from public agency sources. Data for the *Oregon Timber Harvest Report* comes from the USFS, BLM, ODR, Counties, Native American Tribes, the Oregon State University College of Forestry, and ODF. Harvest information is then aggregated by county, owner, and eastern and western Oregon and published on the ODF Forest Resource Planning Program's web site. Projected harvest levels for private land are determined by using computer models which use previous timber harvest levels, site productivity for timber growth, current timber inventory, and current and projected management practices as inputs

This indicator compares harvests by ownership group, public and private. Public harvests include those from forests managed by USFS, BLM, ODF, ODOT, the Oregon State University College of Forestry, state parks, county and municipalities, and other public ownerships. Private owners include industrial and family forest owners. Tribal forest harvests are projected separately as private landowners but grouped with public lands because land management objectives are similar to those of public lands.

Data will be reported in cubic feet.

**Quality Assurance:** Harvest data is error checked by the USFS, BLM, ODF, and ODR. Harvest levels by county and ownership are run through error checking programs by ODF. Annual timber harvest reports are then peer reviewed by agency and private analysts.

**Repeatability:** Trend analyses can be reported every year, with a need to recognize changes in timber utilization standards and agency definitions of "projected harvest levels."

**References:**

- Birch, K (coord). 2000 First Approximation Report for Sustainable Forest Management in Oregon: [http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#First\\_Approximation\\_Report\\_](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#First_Approximation_Report_)
- Oregon Annual Timber Harvest Reports: <http://egov.oregon.gov/DAS/OPB/obm.shtml>  
[http://oregon.gov/ODF/STATE\\_FORESTS/FRP/RP\\_Home.shtml#Annual\\_Timber\\_Harvest\\_Report](http://oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#Annual_Timber_Harvest_Report)

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- Oregon Progress Board Benchmarks: <http://egov.oregon.gov/DAS/OPB/obm.shtml>
- Risser, and others. 2005. *Oregon State of the Environment Report*. <http://egov.oregon.gov/DAS/OPB/soer2000index.shtml>

## ***Forestry Program for Oregon Strategy D: Protect, maintain, and enhance the soil and water resources of Oregon's forests.***

### **D.a. Water quality of forest streams**

*This indicator will help Oregonians assess the quality of water in forest streams. This indicator will provide tabular, graphical, and map information that integrates complex analytical water quality data and generates a single number expressing the degree of impairment of a given water body.*

**Desired trend:** Water quality index values in forested Oregon watersheds are stable or improving.

**Relevance:** Maintaining water quality for aquatic life and human uses is very important to Oregonians. Trends in water quality conditions are proposed as an indicator because of the relative sensitivity to management, the availability of data, and the importance of water quality to native fish and other beneficial uses. Data for this indicator will be used to report the status of specific forest stream reaches and miles of forest streams or the percent of forest stream miles with a poor, fair, or good water quality index. Supporting documentation will be available to provide more detail on individual water quality factors leading to these ratings. Information will be reportable in tabular, graphical, and map formats.

**Overall Data Availability:** While some data to calculate water quality index are available from coastal streams and ambient sites statewide, it will largely be a new monitoring endeavor to obtain data that is consistent with proposed statewide environmental indicators for the Oregon Plan for Salmon and Watersheds. The determination of the extent of forest stream river miles with good, fair or poor water quality index scores requires data collected through probabilistic sampling designs. Such data has been collected for 1<sup>st</sup> through 3<sup>rd</sup> order streams only in the Lower Columbia ESU, Coastal Coho ESU, Southern Oregon Northern California Coho ESU, Western Cascades Ecoregion and the John Day river basin. Due to both state and federal budget reductions none of the probabilistic sampling programs that collected that data are still ongoing. Probabilistic data coverage for forested streams throughout Oregon is currently incomplete and additional resources within the Department of Environmental Quality would be needed to achieve such coverage and continue monitoring for trending purposes. Therefore, additional funding from EPA or other sources will be needed for full implementation of this indicator.

Annual reports are prepared evaluating the most recent ten year's data for the statewide ambient river monitoring sites. There are 135 ambient river monitoring sites on major streams statewide, 69 of these sites are on streams that are dominated by forestry land use.

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Many of these sites have been monitored since the 1980 with some since 1960. Data from the ambient monitoring network is excellent for trending but only for those sites and stream segments monitored.

**Background:** This indicator provides essential information for *Forestry Program for Oregon* Strategy D and Actions D.1., D.2., D.3., D.4., and D.5. Water quality indices were first seriously proposed and demonstrated beginning in the 1970s. Evaluation of water quality only in terms of raw data can be misleading and confusing for the general public. As a result, it may be difficult for a person interested in water quality to interpret the data to gain an overall understanding of water quality conditions. This may result in faulty conclusions regarding water quality status and management practices. Thus it is difficult to effectively communicate the results from water quality improvement programs when the raw data is confusing. As a solution, a water quality index integrates complex analytical data and generates a single number expressing the degree of impairment of a given water body. This improves communication with the public and increases public awareness of water quality conditions. While Water Quality Index (WQI) is good for estimating general or overall water quality, it may not be adequately sensitive to an individual stressor such as temperature or sediment. When overall water quality may be rated good by the WQI, an individual WQ indicator could be at an undesirable level. Data used to populate the WQI can be analyzed separately to address individual parameters of special interest.

WQI provides an index relative to the needs of aquatic biota. For drinking water, the forestry issue is whether source water for municipalities can be reasonably treated to a drinking water standard. WQI does not evaluate all possible human health hazards. Many public water systems have established monitoring programs that could be used for additional information on drinking water.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 4—Conservation and Maintenance of Soil and Water Resources: Indicator 18: Area and percent of forest land with significant soil erosion; 2003 Indicator 23: Percent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability; 2003 Indicator 24: Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change; and 2010 Indicator 21: Area and percent of water bodies, or stream length, in forest areas with significant change in physical, chemical or biological properties from reference conditions.

*Heinz Center:* Nitrogen movement, chemical contamination.

*Northeastern Area:* Water quality in forested areas.

*Oregon Benchmarks: Environment--79:* Percent of monitored stream sites with (a) increasing and (b) decreasing water quality trends and (c) good to excellent condition.

*Environmental Indicators for the Oregon Plan for Salmon and Watersheds:* Water Quality Index.

*Oregon State of the Environment Report:* Proportion of monitored stream sites with good to excellent water quality according to the Oregon Water Quality Index.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Physical/chemical properties (temperature, dissolved oxygen, turbidity, pH, phosphorus, nitrate, ammonium, total solids)	DEQ	3 <sup>rd</sup> field hydrologic unit classification (HUC)	Annual Trend analyses can be reported every year, with increasing certainty over time.	OWEB	Current data available is not probabilistic.
Biological properties (bacteria, biological oxygen demand)	DEQ	3 <sup>rd</sup> field HUC	Annual Trend analyses can be reported every year, with increasing certainty over time.	OWEB	Current data available is not probabilistic.

**Description:** The Water Quality Index was developed for the purpose of providing a simple, concise and valid method for expressing the significance of regularly generated laboratory data, and was designed to aid in the assessment of water quality for general recreational uses. Due to resource availability and in order to maintain a manageable, yet representative index, the WQI will have certain limitations. The WQI index cannot determine the quality of water for all uses. Some uses conflict with others. For instance, water quality considerations for agricultural uses are different from considerations for recreational uses. WQI cannot provide complete information on water quality. An index provides only a summary of the data. Also, WQI cannot evaluate all health hazards. The WQI can be used to show water quality variation both spatially and temporally. The index allows users to easily interpret data and relate

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overall water quality variation to variations in specific categories of impairment. WQI can identify water quality trends and problem areas. These can be screened out and evaluated in greater detail by direct observation of pertinent data, thus increasing efficiency. Used in this manner, the WQI provides a basis to evaluate effectiveness of water quality improvement programs and assist in establishing priorities for management purposes.

The listed parameters are compared with values established by the Oregon Department of Environmental Quality (DEQ) from reference conditions or standards. Multiple parameters are combined into one index. WQI analyzes a defined set of water quality parameters and produces a score describing general water quality. The Department of Environmental Quality Laboratory has maintained a large network of ambient water quality monitoring sites. Monitoring sites are representative of Oregon streams, including pristine waters and highly impacted waters.

These data are analyzed to determine which parameters limit general water quality during various seasons. Each site with sufficient data is analyzed for the presence of significantly increasing or decreasing trends. The Seasonal-Kendall test (WQHydro) is used for trend analysis to ensure that the significant trends that exist are not due to normal seasonal variation. Significant trends are reported at the 80 percent or greater confidence level. Seasonal averages were calculated for the summer season (June - September) and USFWS season (fall, winter, spring: October - May). The minimum of these seasonal averages is used for ranking purposes and for GIS display. The minimum seasonal average takes into account seasonal variability between different river systems.

WQI is calculated in two steps. The raw analytical results for each parameter, having different units of measurement, are transformed into unitless subindex values. These values range from 10 (worst case) to 100 (ideal) depending on that parameter's contribution to water quality impairment. These sub indices are combined to give a single water quality index value ranging from 10 to 100. The unweighted harmonic square mean formula used to combine sub indices allows the most impacted parameter to impart the greatest influence on the water quality index. This method acknowledges that different water quality parameters will pose differing significance to overall water quality at different times and locations. The formula is sensitive to changing conditions and to significant impacts on water quality.

An Environmental Monitoring and Assessment Program (EMAP) (random probabilistic) sampling design is proposed with a five year rotating panel. A similar design has been implemented in the state for various projects, including EMAP and Oregon Plan monitoring by EPA, DEQ, and ODFW. Fifty sites per 3rd-field HUC would be sampled as well as 50 additional reference sites. This equals 300 sites for five provinces or 800 sites for 15 basins. The five-year rotating panel approach involves visiting a subset of sites each year until the desired sample size is attained after five years. It will be necessary to return to a subset of sites every year, as well as a subset of sites several times a year, in order to characterize some WQI components adequately.

This approach presents three advantages:

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- Sample size increases after the first five years, because we would start a new set of 300 (five provinces) or 800 (15 basins) sites.
- We can report a preliminary statewide picture every year with increasing precision over time.
- After the first five years, we can report on the 3rd-field HUC and every year after that begin reporting on trends.

The sampling frame currently available is the 1:100,000-stream layer. A 1:24,000 stream layer will provide a superior sampling frame if it is available when this project is implemented.

The indicators are designed to provide a measure of condition, but when tracked over time they can also provide an index of change over time. To answer the question *Is there a difference between years?*, we will use a step-trend (box-and-whisker plot) analysis. To answer the question *Is the trend improving, degrading, or staying the same?*, we will use a monotonic (regression) analysis.

**Quality Assurance:** Data can be collected using spatially balanced random sampling. In general, as sample size increases and variability decreases, the precision in estimating conditions increases. Expected precision with 50 sites per HUC is expected to be 12 to 15 percent.

**References:**

- Dent, L., Salwasser, H., Achterman, G. 2005. Environmental Indicators for the Oregon Plan for Salmon and Watersheds. Institute for Natural Resources.
- <http://www.deq.state.or.us/lab/wqm/wqimain.htm>



## **D.b. Biological integrity of forest streams**

*This indicator will provide information in tabular, graphical, and map formats that integrates complex biological data into a single number that, together with reference condition information, indicates the degree of biological alteration or quality of a given water body.*

**Desired trend:** Index of biotic integrity values in forested Oregon watersheds are stable or improving.

**Relevance:** Maintaining high quality aquatic biological assemblages is very important to Oregonians, and protecting those biota forms the basis for water quality standards. Although indirect or surrogate indicators are important, only biological indicators can directly assess biological condition. The status and trends in entire biological assemblages, as indicated by indices of biotic integrity, are proposed as indicators because of their sensitivity to management, the availability of data, and their importance. Data for these indicators will be used to report the miles of forest streams or the percent of forest stream miles with a poor, fair, or good biotic integrity index. Supporting information on component metrics will be available to provide more detail on the biological factors leading to these ratings.

**Overall Data Availability:** Considerable data are available from randomly selected sites on 1<sup>st</sup> and 3<sup>rd</sup> order streams in the western Cascades, Coast Range, and the Blue Mountains (DEQ, Environmental Monitoring and Assessment Program, and Oregon Plan monitoring since 1994) but this is largely a new monitoring endeavor consistent with proposed statewide environmental indicators for the Oregon Plan for Salmon and Watersheds. Many more sites have been sampled in the past 20 years. Data coverage for forested streams throughout Oregon is currently incomplete for some areas of the state and for larger streams. Therefore, additional funding from EPA or other sources will be needed for full implementation of this indicator.

**Background:** This indicator provides essential information for *Forestry Program for Oregon Strategy D* and Actions D.1., D.2., D.3., D.4., and D.5. The index of biotic integrity (IBI) was proposed and demonstrated in the 1980s throughout the U.S. as a communication tool for scientists, managers, and the public. Evaluation of raw biological data, consisting of counts of dozens of species, can be misleading and confusing for scientists, let alone the general public. As a result, it is difficult for interested persons to interpret raw data and gain an overall understanding of biotic conditions. This may result in faulty conclusions regarding biological status and management practices. Thus it is difficult to effectively communicate results from protection and restoration programs when the raw data are confusing. Also large tables of data from a handful of sites are difficult to interpret and to use for documenting relative status and trends. Such data must be synthesized into a single number for each site visit to facilitate comparisons. This is precisely what IBI does; it integrates complex biological data into a single number that, together with reference condition information, indicates the degree of biological alteration or quality of a given water body. This improves communication with the public and increases public awareness of biological conditions.

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Multiple IBIs and other models have been developed in Oregon for both macroinvertebrates (mostly aquatic insects) and vertebrates (fish and aquatic amphibians). Such indices have been used in Oregon to demonstrate current status and spatial patterns, as well as in predictive models to represent historical conditions and future scenarios. It will be desirable to evaluate those IBIs in a data workshop and select a single version for vertebrates and another for invertebrates. But such an evaluation need not precede increased data collection.

**Related State, National, and International Indicators and IBI Applications:**

*Montreal Process:* Criterion 4—Conservation and Maintenance of Soil and Water Resources: 2003 Indicator 23: Percent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability; and 2010 Indicator 21: Area and percent of water bodies, or stream length, in forest areas with significant change in physical, chemical or biological properties from reference conditions.

*European Union, Water Framework Directive:* Status of fish assemblages in the European Union.

*USEPA, EMAP:* Status of aquatic vertebrate and macroinvertebrate assemblages in the streams and rivers of the mid-Atlantic and western conterminous states.

*USEPA, Office of Water:* Status and trends in aquatic vertebrate and macroinvertebrate assemblages in the streams and rivers of the USA states.

*Oregon Benchmarks: Environment--79:* Percent of streams with (a) increasing and (b) decreasing water quality trends and (c) good to excellent condition.

*Environmental Indicators for the Oregon Plan for Salmon and Watersheds:* Index of Biotic Integrity.

*Oregon State of the Environment Report:* Trends in the health of stream communities using an index comparing invertebrate populations to those expected in healthy aquatic habitats; the percentage of wild, native fish populations, including salmon, that are classified as healthy.

*California DFG:* Status and trends of aquatic macroinvertebrate assemblages in California streams.

*Iowa DNR--* Status and trends of aquatic vertebrate and macroinvertebrate assemblages in Iowa streams and rivers.

*Kentucky DEP:* Status and trends of aquatic vertebrate and macroinvertebrate assemblages in Kentucky streams.

*Maryland DNR:* Status and trends of aquatic vertebrate assemblages in Maryland streams.

*Ohio EPA:* Status and trends of aquatic vertebrate and macroinvertebrate assemblages in Ohio streams and rivers.

*Texas DWP:* Status and trends of aquatic vertebrate and macroinvertebrate assemblages in Texas streams.

*Vermont DEC:* Status and trends of aquatic vertebrate assemblages in Vermont streams.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
For macro invertebrates (mostly aquatic insects) and vertebrates (fish and aquatic amphibians): Species richness, Percent alien species, Percent cool water individuals, Percent anadromous individuals, Percent coldwater species, Number of tolerant individuals, Number of native coldwater species & individuals, Number of size classes	OWEB, DEQ, EPA OSU	3 <sup>rd</sup> field hydrologic unit classification(HUC)	Five years	OWEB, DEQ	Challenges with seasonal variability not being captured

**Description:** The IBI was developed to provide a simple, concise and valid method for expressing status and trends in biological assemblages, developing biological criteria, and directly assessing biological conditions. An IBI score and its component metric scores are rarely diagnostic, that is they rarely indicate the physical, chemical, or biotic stressor resulting in a low score. IBI scores are useful for showing spatial and temporal variation and for relating biological variation to stressor and disturbance variations. In that sense, IBIs are excellent tools for screening problem areas and major stressors, which can be evaluated in greater detail by direct observation

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of pertinent data, thus increasing efficiency. Used in this manner, the IBI provides a basis for evaluating the effectiveness of stream improvement programs, landscape rehabilitation, and for establishing management priorities.

The listed metric scores are added together in a single step to form one index score indicating biological condition and ranging from 0 (worst case) to 100 (ideal).

An Environmental Monitoring and Assessment Program (EMAP) (random probabilistic) sampling design is proposed with a five-year rotating panel to evaluate IBI on basin as well as ecoregion scales. A similar design has been implemented in the state for various projects, including EMAP and Oregon Plan monitoring by EPA, DEQ, and ODF&W. Fifty sites per 3rd-field HUC would be sampled as well as 50 additional reference sites. This equals 800 sites for 15 basins. The five-year rotating panel approach involves visiting a subset of sites each year until the desired sample size is attained after five years. It will be necessary to return to a subset of sites every year, as well as a subset of sites twice a year, in order to assess measurement variability and evaluate temporal trends more accurately.

This approach presents three advantages:

- Sample size increases again after the first five years, because we would start a new set of 800 (15 basins) sites.
- We can report a preliminary statewide picture every year with increasing precision over time.
- After the first five years, we can report on the 3rd-field HUC and every year after that begin fairly precise reporting on trends.

The sampling frame currently available is the 1:100,000-stream layer.

IBIs measure status, but when tracked over time they also measure temporal trends. To answer the question *Is there a difference between years?*, we will use both box-and-whisker plots and cumulative frequency distributions. To answer the question *Is the trend improving, degrading, or staying the same?*, we will use a monotonic (regression) analysis.

**Quality Assurance:** Data can be collected using spatially balanced random sampling or Before-After-Control-Intervention designs. In general, as sample size increases and variability decreases, the precision in estimating conditions increases. Expected precision with 50 sites per 3<sup>rd</sup> field HUC is expected to be 12 to 15 percent. Revisit variance allows estimation of measurement error or variability, which is normally quite low.

#### References:

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## **D.c. Forest road risks to soil and water resources**

*This indicator will provide the results in tabular form of assessments of three forest road condition factors. The primary purpose of the assessment information will be to assist landowners in identifying the road elements that pose the greatest risk to soil and water resources. This indicator will be a byproduct of that survey work.*

**Desired trend:** Increasing proportion of sampled Oregon forest roads are determined to pose a low risk to soil and water resources.

**Relevance:** Roads provide many forest management benefits. They provide access for property owners, public recreation, fire suppression, vegetation and wildlife management, and product transportation. However, roads are a landscape altering feature, and can have negative effects on both water and soil resources. There is a great deal of research on roads, and based on this research roads can have the following adverse effects on soil and water:

- Direct alteration of streams, lakes or wetlands
- Blockages in the stream channel to fish migration, movement of gravel and large wood, or causing washout or diversion of stream crossing fills.
- Landslides
- Surface erosion
- Stream flow alteration

Other effects of roads and road use can include disturbance of wildlife and their habitats and the spread of invasive plants, pests or diseases. These other effects are outside the scope of this indicator.

**Overall Data Availability:** There is a great deal of research on the effects of roads, but little information on current road conditions. There is ODF monitoring data and reports on road drainage from 1995, and on turbidity between 2000 and 2002. Reliable data on roads must be collected on the ground, as road effects on resources depend on location, construction, and repair and maintenance practices. Currently, complete and available data on forest road based the rapid road survey protocol proposed by this indicator is limited to State-managed forestlands within three watersheds (Miami, Upper Nehalem, and Wilson). Similar monitoring was planned as part of the Oregon Plan for Salmon and Watersheds -- Road Hazard Identification and Risk Reduction project, but has yet to be implemented. With this indicator in place and with support from forest landowners and the Department of Environmental Quality, there may be an opportunity to obtain resources through a federal Clean Water Act Section 319 grant, Northwest Power Planning Council grant, or Oregon Watershed Enhancement Board grant to implement the rapid road survey protocol on all roaded Oregon forestlands.

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**Background:** This indicator addresses *Forestry Program for Oregon* Actions D.2, D.4, D.5, and D.6. The Oregon Forest Practices Act prescribes best management practices that must be employed during forest road construction and maintenance associated with commercial forest operations on non-federal lands. Federal land management agencies are recognized as designated management agencies for water quality standard compliance on federal lands. In addition, one of the goals of the Oregon Plan for Salmon and Watersheds is to further reduce the effects of roads on streams and aquatic habitat. To this end, many private landowners and State Forests have been implementing the Road Hazard Identification and Risk Reduction Project since 1997. Thousands of miles of roads have been inspected and repaired as part of this project (Oregon Plan Report, 2005). However, there is no consistent monitoring of how road conditions improved after these repairs.

Road density is a parameter suitable for remote sensing that has been evaluated on some National Forests. This is not a reliable indicator unless all roads are in similar condition, location, and built with the same practices. There is no good comprehensive data for these road parameters at this time. The BLM has a GIS layer (Ground Transportation Roads and Trails) that could be used to find road density in both riparian and steep hill slope areas but this would require significant GIS analysis plus, the road data is inconsistent and lacking among different land ownerships. In order to make the layer useful, a ground survey would be necessary to both validate missing roads, and calibrate for the quality of roads. As part of the Oregon Plan there is a proposed effort to monitor roads consistently across forest ownerships, but this has yet to be implemented.

Current available information indicates that the conditions of roads vary by land manager, by landscape, and by relative position of roads in watersheds.

First and foremost, improving the quality and the amount of road data, based on systematic on-the-ground surveys will provide assessment information that can help forest landowners manage their road systems better. A secondary benefit of such a survey process would be information that could inform an indicator of the overall effects of forest roads on Oregon's soil and water resources.

**Related State, National or International Indicators:**

*Montreal Process:* Criterion 4 -- Conservation and maintenance of soil and water resources: 2003 Indicator 18: Area and percent of forestland with significant erosion (rill, sheet, gully, mass wasting, and roadside), 2010 Indicator 18: Proportion of forest management activities (e.g. site preparation, harvesting) that meet best management practices or other relevant legislation to protect soil resources and 2010 Indicator 21: Area and percent of water bodies, or stream length, in forest areas with significant change in physical, chemical or biological properties from reference conditions.



**Metric Descriptions**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
<ul style="list-style-type: none"> <li>• Percent of road system connected to the stream network</li> <li>• Percent of stream crossings on fish streams providing passage</li> <li>• Land area in non-forest condition due to roads (road subgrade plus cutslope)</li> </ul>	Grant-funded contract administered by ODF in cooperation with other organizations	<ul style="list-style-type: none"> <li>• Dependent on the extent of the surveys. Possible scales include: forest ownership type, watershed scale, georegion scale, statewide scale.</li> <li>• Size of sample based on statistical evaluation, funding, and landowner commitment.</li> <li>• Random samples across as many types of forest ownerships as possible.</li> </ul>	Ten years (suggested)	To be determined. Preferable to have data collection, analysis, and reporting done by a third-party, across all ownerships.	<ul style="list-style-type: none"> <li>• Requires significant funding either through Clean Water Act Section 319 grants or other sources.</li> <li>• Requires significant buy-in and support from the various forest landowners statewide.</li> </ul>

**Description:** The objective of the rapid road survey protocol is to efficiently and effectively evaluate road risks to soil and water resources. The survey is designed to consistently evaluate current conditions and also near-term future road conditions as they are likely to be affected by major storms. This survey can identify the road elements that pose the greatest risk to soil and water resources. The survey can be used to quantify fish passage restrictions, washout risk, hydrologic connection to streams, and forestlands that are in non forest condition, among others. This indicator will focus on three of those elements. The metrics can be used to compare the relative effects of roads in one watershed versus another and project potential changes in these conditions, for better or worse, over time with maintenance and repair (or the lack thereof).

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The sampling protocol for this indicator needs further development. A data collection system is needed that can be consistently updated. A stratified random sample by landowner class and geographic area is recommended. Resources are currently not available to implement this indicator. A challenge to full indicator implementation will be the potentially high cost associated with having an adequate sample to provide useful information. Sample and stratification protocols have implications for cost and data quality. It is estimated a sampling cycle to collect data for the indicator metrics and other road condition factors would cost \$150,000 to \$250,000 (approximately \$100 per mile of road sampled) and would take about a year to complete using contracted services.

**Quality Assurance and Repeatability:** This survey has been completed for three watersheds. With training and field quality assurance, accuracy is in the 75 to 90 percent range.

**References:**

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## ***Forestry Program for Oregon Strategy E: Contribute to the conservation of diverse native plant and animal populations and their habitats in Oregon's forests.***

### **E.a. Composition, diversity, and structure of forest vegetation**

*This indicator will provide tabular and graphical information about forest vegetation. A forest vegetation map is also desirable, but such a map will be a product of future assessment work and not a product of this indicator.*

**Desired trend:** Following establishment of a statewide plant and animal conservation policy, the composition, diversity, and structure of Oregon forest vegetation are within, or growing towards, desired future condition ranges.

**Relevance:** The composition, diversity, and structure of vascular plants are important factors in assessing biological diversity of forested ecosystems. Vegetation is the source of primary production and a primary determinant of habitat for many species. Changes in these factors due to non-native species are a particular concern at multiple spatial scales. The composition and structure of plants can serve as indicators of changes to ecosystems and as indicators of the status of other organisms and ecosystem processes that are difficult to measure directly. Without these data, our ability to assess and evaluate changes in species composition, range shifts of native species as a result of climate change, or the spread of noxious and exotic plant species is greatly compromised.

This indicator focuses on the diversity and composition of vegetation comprising Oregon's forests. The information is rich in species level information and will be used to answer questions such as:

- What are the plant species found in a sample of Oregon's forests?
- How does the diversity and composition of plant species vary across Oregon's forested landscape?
- What is the relationship between plant diversity, canopy cover, and forest community?
- What percentage of forest sampling sites contains invasive species?

Data for this indicator, combined with data from Indicator C.a. (Area of non-federal forestland and development trends), will contribute to analyses of the broader topic of forest fragmentation and the potential effects of fragmentation on forest resources.

**Overall Data Availability:** Data are currently not being collected for this indicator. One inventory of historic data is available from the USDA Forest Service, Forest Inventory and Analysis (FIA) Program for all forested lands in the U.S. This data can be reported at state and regional scales and covers all public and private forestland including administratively reserved areas, Wilderness, National Parks, and defense installations. The FIA Program, which works with the states to collect data, is converting to a continuous annual

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inventory. The new program includes the measurement of a fixed proportion of the plots (referred to as a panel) in each state, each year, known as annual inventory. Legislative mandates requires measurement of 10 percent of the plots in each state each year, to be achieved through a federal-state partnership. Individual states may choose to increase the sample intensity by installing additional plots, at their own expense, in order to increase precision.

**Background:** This indicator provides essential information for all Strategy E actions but primarily for Actions E.1, E.4, E.5, and E.6. Key Action E.1 calls for a statewide assessment to evaluate the conditions and trends of native plant and animal populations. This vegetation indicator is the only monitoring information available for forest plant species at a statewide scale. Peer-reviewed research has been published (Gray and Azuma 2005) for this indicator and involves analysis of repeatability and implementation that is important for evaluating the accuracy of conditions and trends.

A forest vegetation indicator has been under development for several years, with ongoing concerns about expense and logistical difficulties of carrying out a rigorous survey of vascular plant species. There is no comparable information available, so if implemented in Oregon, it would be the first statistically sound, quality assured, multi-scale assessment of native and exotic plant diversity in the forests of the state. Several government agencies in the western U.S. are currently implementing the indicator on an increased density of inventory plots for special assessments.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 1 – Conservation of biological diversity: 2003 Indicator 1: Extent of area by forest type relative to total forest area; 2003 Indicator 2: Extent of area by forest type and by age class or successional stage; 2003 Indicator 3: Extent of area by forest type in protected area categories as defined by IUCN or other classification systems; 2003 Indicator 4: Extent of areas by forest type in protected areas defined by age class or successional stage; 2003 Indicator 5 (2010 Indicator 3): Fragmentation of forest types; and 2010 Indicator 1: Area and percent of forest by forest ecosystem type, successional stage, age class, and forest ownership or tenure.

*Heinz Center:* Forest types; At risk native species; Area covered by non-native plants; Forest types with significantly reduced area.

*British Columbia:* Indicator 1—Ecosystem Diversity

*Northeastern Area:* 1.4—Status of forest/woodland communities and species of concern.

*Mt. Hood National Forest:* Long-term community dynamics; landscape diversity; species richness; special habitats

*Oregon Benchmarks: Environment--88:* Percent of monitored terrestrial species not at risk

*Oregon Benchmarks: Environment--89:* Percent of land in Oregon that is a natural habitat

*Oregon State of the Environment Report:* Amount of commercial forest types in different structural stages compared to amounts in healthy forest systems; Change in area of native vegetation types

**Metric Descriptions**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Vegetation species diversity: richness, evenness	USFS FIA	State	Five years	FIA PNW	Species misidentification, phenology, plot size, sampling time.
Vegetation structure, percent cover	USFS FIA	State	Five years	FIA PNW	Observer consistency, plot size
Vegetation change detection: plot #'s, area, percent cover	USFS FIA	State	Five years	FIA PNW	Accuracy and precision, sample size

**Description:** This vegetation indicator is created from species-level data and a set of variables collected on Phase 3 (forest health) FIA plots. Note that Phase 3 plots are a subset of Phase 2 plots. There is one Phase 3 plot for every 16 Phase 2 plots. However, Phase 3 vegetation data is currently not being collected in Oregon. (Note: Forest cover type mapping for Indicator E.b. is conducted with Phase 2 plots in combination with Forest Service continuous vegetation survey data.) The information from this indicator is designed to assess the type, abundance, and spatial arrangement of all trees, shrubs, herbs, grasses, and ferns occurring on FIA Phase 3 plots. Information about the abundance and arrangement of species (structure) allows plot classification into community types. Iterative measurements (monitoring) provides information for detecting and quantifying change.

- *Diversity.* The vegetation data can be analyzed to report on relative diversity, structure, and changes on permanently monitored plots. Classification of plots can be used to stratify results of other forest health indicators. *Diversity* measures include alpha diversity which is the number of species within a sampling unit or individual plot; *gamma diversity* is the total number of species documented on all plots within a reporting region; and *beta diversity* is a measure of species heterogeneity across a region, is considered the number of distinct communities, and is calculated as the ratio of gamma diversity to alpha diversity.
- *Structure.* Structure can be summarized for each forest type group as mean cover of life form in each vertical layer. Abundance and spatial arrangement of plant species on a plot also provides the information so that the vegetation can be classified according to locally developed community types.
- *Change detection.* The nested sampling design allows us to assess changes in frequency. Several factors can bias results when using percent cover alone. By using frequency, analysts can more reliably assess distribution and changes in distribution over time than by using differences in cover alone.

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Frequency and structure data can be used in conjunction with physiographic and stand variables (slope, aspect, elevation, soil, stand age) to model and map community types describing existing vegetation and potential climax communities. These analyses can address additional questions such as:

- Do plot-level site conditions correlate with resistance and resilience to disturbance?
- How do canopy changes relate to understory vegetation dynamics?
- How are patterns in species distributions and composition related to atmospheric and other environmental pollutants?
- What are the fuel profiles generated from down woody debris and vegetation structure variables by community type?

**Quality Assurance:** The present quality assurance program includes training for data collectors, documentation of methods, checks of data quality, peer review of analysis products, and continuous feedback to ensure system improvement. All field data collectors, regardless of whether they are Federal, State, or contractors, receive standardized training and pass a certification test before collecting data. Field crews enter measurements into portable data recorders in the field thus enabling real-time error checking as data are entered. Quality assurance data and analyses are included in available publications.

**Repeatability.** Agreement of species level identification, by same sample unit and using Sorensen's index of similarity, between two botanists was 70.6 percent for subplot-level analysis and 66.6 percent for quadrat-level analysis (Gray and Azuma 2005). Species-level identification ranged from 67 percent for field identification to 80 percent for both botanists following use of an herbarium. Comparison of species richness found by each botanist, counting all plant records produced a correlation coefficient of 0.87 for estimates on quadrats and a coefficient of 0.94 on subplot records. Correlations between botanists were high for non-native species ( $r = 0.9$ ) or as the numbers of non-native species ( $r = 0.98$ ). Misidentifications of plant species, as might expected, occurs primarily for species that are difficult to distinguish especially when all plant parts are not available (e.g. fruits or flowers).

**References:**

- <http://www.fia.fs.us>
- USDA FIA Fact Sheets: Sampling and Plot Design, Phase 2 and Phase 3: Ground Measurements, Vegetation Indicator
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## **E.b. Extent of area by forest cover type in protected area categories**

*This indicator will provide tabular, graphic, and map information on forestland in different forest cover types and protected area categories.*

**Desired trend:** Following establishment of a statewide plant and animal conservation policy, allocations of Oregon forest cover types to protected area categories are consistent with desired future conditions.

**Relevance:** All of Oregon's forestlands receive some level of resource protection starting with federal air, water, and species-conservation laws and our own state laws governing land use, water, fish and wildlife, and forest practices. Some private lands are owned and managed with the specific objective of protecting natural resource values. This indicator will provide the basis for documenting landscape-level changes in the area of forest cover types allocated to each protection-level category as a basis for discussing whether allocations are appropriate in the context of providing other environmental, economic, and social benefits.

Example questions this indicator can help provide answers to are:

- How much land area of the Douglas-fir forest cover type is allocated to wood production, nature emphasis, and multi-resource designations?
- How are the various forest cover types in each protection category distributed across Oregon's forested landscape?

**Overall Data Availability:** Data for this indicator are available from state and federal land management agencies. The most recent information layer for protected area categories is available from Oregon Department of Forestry, Forest Resources Planning Program. Forest cover type categorization will be conducted through the USDA Forest Service PNW Research Laboratory.

This indicator was a component of the *First Approximation Report for Sustainable Forest Management in Oregon* (FAR) and utilized digital data from state and federal management agencies including USDI Bureau of Land Management, State of Oregon GIS Service Center, and The Interior Columbia Basin Ecosystem Management Project. The information layer for protected area categories was assembled by ODF's Forest Resource Planning Program and was comprised of the first iteration for the Forest Ecosystem Management Assessment Team classification in 1993. An updated version (V.2) of the protected areas layer is more accurate in terms of spatial locations, area estimates, and changes between Late Successional Reserves and Adaptive Management Areas. The FAR forest cover type information layer was based on ODFW's Gap Analysis layer. Work is currently underway through the USDA Forest Service to create a forest cover type and size class layer based on Gradient Nearest Neighbor (GNN) modeling using a set of predictor variables derived from, sampling data, a digital elevation model, and LandSAT remote sensing imagery. Completion for this layer is

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expected by 2010. The FAR Indicator #4 added size class or successional stage to Indicator #3 and data for tree diameters (size class) was contributed by the Oregon Forest Industry Council. Size class information will also be produced with GNN for integration with protected categories and forest cover type.

**Background:** Information for this indicator is relevant to *Forestry Program for Oregon* Actions E.1, E.2, and E.5. This indicator will be critical to the coarse-scale, statewide assessment for the status and trends of, and conservation policy for, plant and animal populations on all ownership classes called for with action items E.1 and E.2, respectively. Forestlands managed in various levels of protection from human impact have the potential to supply diverse habitats for many animal and plant species. Many plant and animal species require a narrow set of habitat factors that are specific to a particular forest cover type (defined by the dominant tree species) or combination of vegetation/prey species. Therefore, a comprehensive set of forest cover types included in the state's many protected area categories may be important for species conservation. Monitoring changes in the amount of area in each category will be a primary information component for achieving the objective of sustaining native plant and animal communities under *Forestry Program for Oregon* Action item E.5.

The World Conservation Union identified seven "Protected Area Management Categories" (Gland et al. 1994) to communicate information about the amount of land area in each protection-level. These following seven categories were used in Oregon's *First Approximation Report* and include:

**Scientific Reserves-** experimental forests, areas of critical environmental concerns, The Nature Conservancy lands, research natural areas.

**Wilderness Areas, National Parks, National Monuments** -areas that are specially designated by Congress or the President.

**Habitat/Species Management Area-**wildlife reserves, late successional reserves, key watersheds.

**Protected for Conservation and Recreation**—National Scenic Areas, National Recreation Areas, Special Interest Areas  
**Adaptive Management Areas**

Other ownership categories also provide various levels of "protection." All non-federal forest lands within the state of Oregon fall within standards of the Forest Practices Act and federal forest lands must meet standards of protection established in the Northwest Forest Plan. In addition the ownership GIS layer contains administratively withdrawn and congressionally reserved categories. Also considered will be Nature Conservancy lands and other private ownerships with a natural resource protection objective. The various levels of forest protection represent a spectrum of management practices from least to most intense and have been aggregated into three broad categories: reserve (or nature emphasis), multi-resource, and wood production (Wells et al. 2003).



**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 1 -- Conservation of biological diversity: 2003 Indicator 3: Extent of area by forest type in protected area categories as defined by the World Conservation Union or other classification system; 2003 Indicator 4: Extent of areas by forest type in protected areas defined by age class or successional stage; 2003 Indicator 5: Fragmentation of forest types; and 2010 Indicator 2: Area and percent of forest in protected areas by forest ecosystem type, and by age class or successional stage.

*Oregon Benchmarks: Environment--83:* Percent of Oregon’s non-federal forest land in 1974 still preserved for forest use.

*Oregon Benchmarks: Environment--89:* Percent of land in Oregon that is a natural habitat

*Heinz Center:* Forest types; Forest types with significantly reduced area; Forest age; Forest management categories

*British Columbia:* Indicator 1-2—What are the types and ages of B.C.’s forest ecosystems? How have B.C.’s forests changed over the last century?

*Northeastern Area:* 1.4—Area of forest land relative to total land and area of reserved forest land; extent of area by forest type and by size class, age class, and successional stage.

*Oregon State of the Environment Report:* Percentage of at-risk species that are protected in dedicated conservation areas.

*Mt. Hood National Forest:* Landscape diversity; landscape pattern; special habitats.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Amount of area for each forest cover type	USDA Forest Service	State	~ Ten years	FIA PNW	Coarse scale, modeling assumptions, cumulative errors
Ownership/protection category	ODF	State	Two to five years	ODF	Boundary and classification accuracy

**Description:** This indicator provides an integration of field sampling, remote sensing, and multivariate modeling to spatially represent the amount of forestland area, in each major forest cover type, that is allocated to the various categories of resource protection. GIS will be used to combine digital data sets (forest cover type, ownership-protection category) for this indicator. The forest cover type layer will be based on GNN modeling and be available in grid/raster format. GNN modeling applies direct gradient analysis and nearest-neighbor imputation to ascribe detailed ground attributes of vegetation to each pixel in a digital landscape map (Ohmann and Gregory 2002). This method integrates vegetation measurements from regional grids of field plots, mapped environmental data, and LandsAT Thematic Mapper imagery. The protection area category base layer is a vector GIS coverage that contains land ownership and land allocation boundaries that are classed according to their ownership-protection category. GIS overlays of these layers will produce the amount of area in each forest cover type category.

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**Quality Assurance:** Protected Area Categories were identified by Oregon Department of Forestry staff using BLM, Forest Service, private ownership, and state digital data sources. The accuracy of boundary locations can range anywhere from approximately 20 to 200 meters. Quality Assurance of spatial data must consider two distinct issues: 1) the spatial (i.e. location) accuracy of the boundaries that define each land unit across the state and, 2) the classification (i.e. the protection category) given to each of these land units defined by these boundaries. The boundaries used to define each land unit came from the best available digital data at a state-wide scale. It should be noted that the digital lines are not surveyed and as such do not have “legal” authority as do, for example, surveyed city tax lot data. However, for purposes of a general state-wide assessment these lines are within national map accuracy standards. The classification (i.e. the protection level) given to each land ownership/allocation category was done in cooperation with staff from the Oregon Department of Forestry, the Oregon Forest Industries Council, and Oregon State University. There is always uncertainty and disagreement as to which particular land ownership/allocation to assign some areas. However, most of the disagreement involves very small parcels of land when compared to the forested area of the entire state.

**Repeatability:** The multivariate GNN analysis and GIS overlays to produce information for this indicator can be repeated as future vegetation sampling, remote sensing information, and ownership updates become available. However, since GNN is dependent upon vegetation sampling, the error within and among temporal samples will be transferred to the GNN modeling process. Remote sensing information is dependent upon a functioning LandsAT 5 satellite or a comparable alternative imagery source.

**References:**

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## **E.c. Forest plant and animal species at risk**

*This indicator will provide tabular and map information on the status of plant and animal species that are recognized by federal and state resource management agencies as at risk because of rarity or because other factors demonstrably make them very vulnerable to extinction.*

**Desired trend:** Decreasing number of Oregon native forest plant and animal species at risk (extinction, extirpation, endangered, threatened, or potentially endangered or threatened).

**Relevance:** Species extinction is a natural process. However, plant and animal species are disappearing world-wide at an accelerated pace. Often there is a strong correlation between increasing numbers of species at risk and macroeconomic growth. This indicator will provide Oregonians with information by which to measure the state's progress at both preventing and reversing an increase in the number of forest species at risk through time.

Some questions this indicator can help answer include:

- How many and which forest species have gone extinct in the last 100 years in Oregon?
- How many forest species are considered at risk in Oregon?
- What is the set of forest plants, animals (including invertebrates) that are currently listed, or being considered as candidates for listing, under federal endangered species statutes?

The indicator will also provide useful information for forestlands on progress in implementing the Oregon Conservation Strategy, produced in 2005 by the Department of Fish and Wildlife.

**Overall Data Availability:** The U.S. Fish and Wildlife Service maintains, updates, and presents lists of endangered animals and plants by state and territory. The Oregon Natural Heritage Information Center (ONHIC) publishes information on rare, threatened or endangered species in Oregon. Both organizations provide public access to data via their individual web sites.

The primary means by which the US Fish and Wildlife Service (USFWS) disseminates information on rulemakings (listings, reclassifications, and delistings), is with the bimonthly *Endangered Species Bulletin*. The *Endangered Species Bulletin* also reports on recovery plans, regulatory changes, interagency consultations, changes in species status, research developments, new ecological threats, and a variety of other issues. The Service distributes the *Bulletin* free of charge to Federal, State and local agencies, and official contacts of the endangered species program.

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A key objective of ONHIC is to serve as a clearinghouse of distributional information regarding site-specific locations of rare, threatened, and endangered species. The Center encourages submission of species information, reports, and observations. The Center maintains a web site providing rare, threatened, or endangered plant and animal data available as zipped Excel Spreadsheet files. Distribution information is represented by county, ecoregion, and state. Ecoregion distribution information is based on the map developed by: Thorson et al. 2003. NatureServe Explorer (<http://www.natureserve.org/explorer>) was used to gather information for State and Province distribution listed in the Other States column.

ONHIC is the organization responsible for managing information related to rare and endangered invertebrates in Oregon. The U.S. Fish and Wildlife Service has granted the program limited authority to administer and manage a program for federally threatened and endangered invertebrate species, as provided under Section 6 of the US Federal Endangered Species Act. ONHIC has three objectives for the rare and endangered invertebrate program: 1) To gather as much information as possible on those invertebrates that are currently considered rare, threatened or endangered in order to enable managers to protect critical habitat or populations, 2) to promote inventory and taxonomic work on undescribed or poorly known species which may face significant threats, and 3) to assist in the USFWS recovery efforts for the certain invertebrates already protected under the Endangered Species Act.

**Background:** This indicator is relevant to all *Forestry Program for Oregon* Strategy E Actions. In 1987 the Oregon legislature passed an Endangered Species Act which gave the Oregon Department of Agriculture responsibility and jurisdiction over threatened and endangered plants and reaffirmed the Oregon Department of Fish and Wildlife's (ODFW) responsibility for gathering and managing information on threatened and endangered fish and wildlife species. Both agencies have cooperative agreements with the US Fish and Wildlife Service for the purpose of carrying out research and conservation programs for animal and plant species under the auspices of the federal Endangered Species Act. The Oregon Natural Heritage Program and its advisory council has been granted limited authority for invertebrates through a cooperative agreement with the U.S. Fish and Wildlife Service, via Section 6 of the Endangered Species Act. The Oregon Natural Heritage Information Center is part of the Information Program of the Institute for Natural Resources of Oregon State University. The Oregon Department of Fish and Wildlife has a formal contract with Oregon Natural Heritage Information Center to manage endangered wildlife species information. Although there is no formal contract, ONHIC also manages threatened and endangered plant information for the Oregon Department of Agriculture. ONHIC maintains comprehensive data bases for Oregon biodiversity concentrating on the rare and endangered plants, animals, and ecosystems. Site specific information is also available to ONHIC through a partnership between The Division of State Lands, The Nature Conservancy of Oregon and Oregon State University. ONHIC is currently supported primarily by federal natural resource agencies. Biologists working for these agencies, together with the state's herbaria and museums, provide most of the information that comprise ONHIC's databases. The Natural Heritage Advisory Council oversees the registration and dedication of ecologically significant natural areas and the creation of Oregon's Natural Heritage Plan.

ONHIC information is closely linked to the 2005 Oregon Conservation Strategy. The Strategy is an effort to use the best available science to create a broad vision and conceptual framework for long-term conservation of Oregon’s native fish and wildlife, as well as various invertebrates and native plants.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 1—Conservation of Biological Diversity: 2003 Indicator 7: The status (threatened, rare, vulnerable, endangered, or extinct) of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment; 2003 Indicator 8: Number of forest-dependent species that occupy a small portion of their former range; 2003 Indicator 9: Population levels of representative species from diverse habitats monitored across their range; and 2010 Indicator 5: Number and status of native forest associated species at risk, as determined by legislation or scientific assessment.

*Northeastern Area:* Indicator 4: Status of forest/woodland communities and species of concern (with focus on forest-associated species)

*Oregon Benchmarks:* *Environment--86:* Percent of monitored freshwater species not at risk: (state, fed listing): a. salmonids; b. other fish; c. other organisms (amphibians, mollusks); *88:* Percent of monitored terrestrial species not at risk: (state, fed listing): a. plants; b. vertebrates; c. invertebrates; *88 (old):* Protected species. Species populations that are protected in dedicated conservation areas: a. species found in streams or rivers; b. other; *89:* Percent of land in Oregon that is a natural habitat.

*Heinz Center:* At-Risk Native Species. What are the percentages of forest dwelling species in various levels of risk to extinction?

*Oregon State of the Environment Report:* Percentage of at-risk species that are protected in dedicated conservation areas.

*Environmental Indicators Oregon Plan for Salmon and Watersheds:* Number of native plant and animal species and distribution over time (departure from potential) and at-risk species (aquatic, estuarine, and terrestrial; plant and animal).

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Number of forest species in each federal ESA status ranking	USFWS	State/Nation	Two months	USFWS	Incomplete spatial and temporal inventory and monitoring
Number of forest species in Oregon Natural Heritage Program Information Center Lists 1 and 2	ONHIC	State	Three years	ONHIC	For some species more information is needed before status can be determined.
Historic and current	ONHIC	State	Periodic	ONHIC	Spatial accuracy, variety of sources and error,

distribution of forest species					quality assurance
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**Description:** For the purpose of this indicator, forest “species at risk” means those non-extinct plant and animal species that are:

1. Listed as threatened or endangered under federal endangered species statutes;
2. Candidates for potential listing as threatened or endangered under federal endangered species statutes; and/or
3. Assigned to Lists 1 and 2 by the Oregon Natural Heritage Information Center.

The US Fish and Wildlife Service lists a species as endangered if it is expected to become extinct throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered in the foreseeable future. “Species” is broadly defined and includes subspecies and distinct populations (for vertebrates). A species is listed as threatened or endangered if it faces the present or threatened destruction, modification, or curtailment of its habitat or range; over utilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting the species’ survival. A species can be considered for listing by two ways: through the petition process or the candidate assessment process.

ONHIC **List 1** contains taxa that are threatened with extinction or presumed to be extinct throughout their entire range. **List 2** contains taxa that are threatened with extirpation or presumed to be extirpated from the state of Oregon. These are often peripheral or disjunct species which are of concern when considering species diversity within Oregon's borders. They can be very significant when protecting the genetic diversity of a taxon. ONHIC regards extreme rarity as a significant threat and has included species which are very rare in Oregon on this list. The 2004 ONHIC reports contain approximately 280 animal species and 549 plant species on Lists 1 and 2.

The Oregon Conservation Strategy has identified “species of greatest conservation need.” The Strategy uses information on species distribution and abundance produced by ONHIC.

**Quality Assurance:** A strict legal process known as “rulemaking procedure” is followed in order to list a species through the federal candidate assessment process. Through “notices of review,” published in the *Federal Register*, biological information is obtained to complete the status reviews for species identified as “candidates” for listing. Species are prioritized for listing based on the degree or magnitude of threat followed by the immediacy of the threat and taxonomic distinctiveness. After a 60-day public comment period and within one year of a listing proposal, one of three possible courses of action is taken: 1) a final listing rule is published because

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the best available biological data supports it; 2) the proposal is withdrawn because the biological information on hand does not support the listing; or 3) the proposal is extended for 6 months because of disagreement within the scientific community.

ONHIC lists are compiled using the most current information available on the distribution and abundance of plants and animals native to Oregon. Although based on a large volume of information, it is by no means complete. Much is known about some species, very little about others. ONHIC welcomes additional information or recommendations regarding any of the taxa listed.

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***Forestry Program for Oregon Strategy F: Protect, maintain, and enhance the health of Oregon's forest ecosystems, watersheds, and airsheds within a context of natural disturbance and active management.***

**F a. Tree mortality from insects, diseases, and other damaging agents**

*This indicator will provide tabular and map information on tree mortality in Oregon forests.*

**Desired trend:** Stable or decreasing long-term levels of Oregon forest tree mortality.

**Relevance:** When major disturbance events occur in forests, both the public and policy makers want to know if tree mortality is exceeding historic levels and what if anything can be done about it. The first metric tracks tree mortality from all causes and data can be summarized by tree species. The second metric provides an overview of tree mortality from insects and diseases across the landscape on an annual basis. Data for the second metric has been collected for over five decades and provides historic picture of tree mortality in Oregon.

**Overall Data Availability:** Tree mortality volume estimates from natural causes for the 1990's are available from the USDA Forest Inventory and Analysis (FIA) Program. Volume measurements collected on earlier FIA measurement occasions may not be comparable to current data. The U.S. Forest Service and Oregon Department of Forestry have conducted annual aerial surveys mapping tree mortality from insect and disease infestations since 1949. Aerial survey estimates of tree mortality are currently available back to 1970. For both proposed metrics, extracting and summarizing historical data pertinent to this indicator will require significant time and effort by USFS and ODF personnel.

**Background:** Tree mortality data, both spatial distribution and cumulative volumes, are relevant to Actions F.1 and F.2 of the *Forestry Program for Oregon*. Tree mortality from pest outbreaks, weather events, and fire constitute important and interrelated disturbance factors affecting Oregon's forests. In many cases pest outbreaks can be viewed as positive processes that increase diversity across the landscape. However, when these disturbances negatively impact people's values or are unusually severe or widespread they are often referred to as unhealthy.

The acres affected by pests such as Swiss needle cast and insect defoliators, as detected by aerial surveys, are not included in metric two. These pests do cause significant growth loss, but in most cases do not result in mortality among dominant and co-dominant trees. Including defoliators like the western spruce budworm in this indicator would cause metric two to fluctuate by millions of acres while



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representing little real change in forest cover. To the extent defoliators and foliage diseases contribute to tree mortality, those impacts will be captured by the FIA ground plots evaluated in metric one.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 3 – Maintenance of forest ecosystem health and vitality: 2003 Indicator 15: Area and percent of forest affected by processes or agents beyond the range of historic variation and 2010 Indicator 15: Area and percent of forest affected by biotic processes and agents.

*Heinz Center:* Forest Disturbance: How many acres are affected each year by fire, insects, and tree disease?

*Northeastern Area:* 3.7 – Area and percent of forest land affected by potential damaging agents.

*Oregon State of the Environment Report:* Number of nuisance invasive species

**Metric Descriptions**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Tree mortality (cubic feet)	USDA Forest Service FIA	State	Five year	USDA Forest Service FIA	Changes in survey design make historical comparisons of data difficult.
Current tree mortality from insects and diseases (acres)	State via USDA Forest Service Forest Health Monitoring and Forest Health Protection	State	Annual	USDA Forest Service FHM and FHP	Aerial sketch map surveys are affected by observer consistency and accuracy as well as light conditions (visibility).

**Description:** Data on tree mortality from natural causes are collected by FIA and reported in thousand cubic feet for major softwood and hardwood species. The FIA plot data summarizes tree mortality from all biotic and abiotic causes and measurements provide volume estimates. In many cases the cause of tree mortality on FIA plots cannot be attributed to a specific agent. The Coop Annual Aerial Survey, flown by the State and USDA Forest Service Forest Health Monitoring and Forest Health Protection, detects clusters of recent dead and dying trees (five or more) based on fading crowns (color change). Aerial observers, using a digital sketch mapping system linked to a Global Positioning System unit, draw a polygon around the cluster of dying trees. These data are then processed using GIS technology to provide information on the location of the tree mortality as well as an estimate of the infested area. In most cases this tree mortality is attributed to insects and diseases affecting a particular tree species. This annual survey links tree mortality to a specific time, agent, and place (ownership). Maps of tree mortality developed from aerial survey data are excellent

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communication tools with the public and policy makers. Trends in tree mortality can be identified by comparing aerial survey data over many years.

**Quality Assurance:** The FIA provides rigorous training for field crews on data collection and field checks a number of plots each year for the accuracy of measurements. Aerial observers attend annual training sessions and do some ground checks of polygons after completion of the survey. The current national Forest Health Monitoring standard for aerial detection of tree mortality is that a 100 acre polygon of tree mortality ( $>1/4$  tree per acre) will not be missed 90 percent of the time.

**Repeatability:** Data on natural tree mortality volumes should be available from FIA on a five year reporting cycle. Changes in FIA survey design present difficulties in making comparisons with earlier measurements, but remeasurement of tree mortality on a small percentage of old plots will be available for comparison and detecting trends. Better estimates can be made once the annual inventory plots begin to be remeasured in 2012. The annual aerial survey has been flown in a generally consistent manner for more than five decades. Tree mortality data is currently available for aerial surveys going back to 1970. Both the FIA program and aerial survey are well supported and will continue to provide data in the future.

## **F b. Invasive species trends on forestlands**

*This indicator will produce tabular and graphical information on the spread of selected invasive species and on the success of Oregon in controlling new invasive species introductions.*

**Desired trend:** No invasive species on Oregon's 100 most dangerous list are uncontained in the state's forests, and a stable or decreasing forest acreage is affected by invasive species.

**Relevance:** Invasive species constitute a major threat to the integrity of native forest ecosystems. Oregon's mild climate coupled with increases in commerce and influxes of new people have facilitated the introduction and spread of invasive pests. Invasive species reduce the diversity found in native forests and adversely affect populations of native species through predation, competition, altered fire regimes, or destruction of habitat. Exotic pests can have significant economic impacts in the form of direct damage to crops and the loss of markets through quarantines. The public generally supports efforts by government to prevent the introduction and establishment of new pests. Based on the identification of a new pest and its perceived threat, natural resource agencies are often directed to take actions that would eradicate or contain the organism. Monitoring the status of pests on the Oregon Invasive Committee's list of the 100 most dangerous invaders can provide an early warning to policy makers on new species threatening native and urban forests.

**Overall Data Availability:** Data on non-tree vegetation, including invasive species are collected from ground plots by the USDA Forest Inventory and Analysis (FIA) Program. The annual cooperative aerial survey also provides data on a few invasive insect and diseases. In general, data on spatial distributions and impacts of invasive species in forest areas are quite limited. The Oregon Department of Agriculture can supply information on invasive organisms with ongoing eradication programs, invasive weeds, and potential new pests on Oregon's 100 most dangerous invaders list.

**Background:** The status of invasive species on Oregon's forestland relates to Actions F.2, F.3, and F.6 of the *Forestry Program for Oregon*. Invasive pests are commonly recognized as significant threats to forest health by the forest industry, environmental organizations, and the general public. The first metric for this indicator provides a picture of the spread of selected invasive species, those with data available, over Oregon's forestlands. However, the relevance of this indicator is limiting because it does not strongly address the real invasive species issue; impacts of the most damaging invasive species and keeping the worst new pests out of Oregon. The second metric recognizes that the impacts of invasive species go beyond measures of spread and relative abundance. Some invasive organisms, such as sudden oak death, currently have a very limited distribution in acres but the potential to destroy all of the tanoak forests in southern Oregon and dramatically affect economic activity through the establishment of quarantines. The most important part of a prevention strategy for new invasive pests is the success of government programs and cooperating land managers

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to exclude, eradicate, or contain introductions – and that is what the second metric is designed to address. These prevention programs require the participation and support of all natural resource agencies, landowners, and the public to be successful. Invasive species threats to Oregon’s aquatic resources – specifically those aquatic resources occurring within and a part of forest land areas – is outside the scope of this indicator but will indirectly addressed by Indicator D.b.

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 3 – Maintenance of forest ecosystem health and vitality: 2003 Indicator 15: Area and percent of forest affected by processes or agents beyond the range of historic variation and 2010 Indicator 15: Area and percent of forest affected by biotic processes and agents.

*Heinz Center:* Area Covered by Non-native Plants: What percentage of plant cover in forests is not native to the region?

*Heinz Center.* Forest Disturbance: How many acres are affected each year by fires, insects, and disease?

*Northeastern Area:* 3.7 – Area and percent of forestland affected by potential damaging agents.

*Oregon Benchmarks: Environment--90:* The number of most threatening invasive species not successfully excluded or contained since 2000.

*Oregon State of the Environment Report:* Number of nuisance invasive species

**Metric Descriptions:**

<b>Metric</b>	<b>Data Source</b>	<b>Reporting Scale</b>	<b>Reporting Cycle</b>	<b>Reporting Responsibility</b>	<b>Limitations/Considerations</b>
Biotic stressors: exotic insects and diseases, invasive plants, and animals (acres affected)	USDA Forest Service FIA Oregon Department of Agriculture, Forest Health Protection	State	Five year for FIA Annual for Forest Health Protection and Oregon Department of Agriculture	USDA Forest Service FIA Oregon Department of Agriculture, Forest Health Protection	Data are available on relatively few species.
The number or percent of invasive pests on Oregon’s 100 most dangerous list excluded or contained in native	Oregon Department of Agriculture, Oregon Invasive Species Council	State	Annual	Oregon Department of Agriculture	The list is updated annually.  It is difficult to predict which exotic species will become significant pests.

and urban forests.					
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**Description:** For the biotic stressors metric, data are available from FIA ground plots and the coop aerial survey. In general, the data on exotic plants from FIA plots are very recent and restricted to a few easily identifiable species. The current annual FIA survey inventories all understory plants >3 percent cover when tallied on the regular plots (P2). The forest health plots (P3) measure all plant species on several small areas of the plot. Locally important invasive plants may not be detected by FIA plots, especially if they have restricted habitats such as riparian areas. The occurrence of invasive insects and diseases such as balsam woolly adelgid and white pine blister rust are also recorded on the regular FIA plots. Aerial survey data are available for a number of introduced diseases and insects including, white pine blister rust, Port Orford root disease, sudden oak death, larch casebearer, spruce aphid, and balsam woolly adelgid. Aerial observers, using a digital sketch mapping system linked to a Global Positioning System unit, draw a polygon around clusters of infested trees. These data are then processed, using GIS technology, to provide the location of infestations as well as an estimate of the affected area. For some of the invasive insects and diseases monitored by aerial surveys, data are available going back several decades. Current data on significant invasive pests, such as white pine blister rust, can be deceptive since this virulent disease has killed most of its host in Oregon and is less frequently detected by aerial and ground surveys than it was several decades ago. Data on invasive species occurring on forestland but not affecting terrestrial vegetation maybe difficult to obtain.

No source has been identified that could provide statewide data on the spatial distribution and relative abundance of invasive plants on forestland. Once data becomes available, such a metric should be considered as an addition to this indicator.

The Oregon Invasive Species Council develops Oregon’s 100 most dangerous invaders list based on the consensus of state and federal scientists on what new invasive species pose the greatest threat to agricultural crops, forests, and aquatic ecosystems. This list is subjective and can be reviewed and changed on a yearly basis. The organisms appearing on this list include diseases, aquatic plants, land plants, aquatic invertebrates, land invertebrates, fish, birds, and mammals. Approximately 41 organisms on the list pose potential threats to forest ecosystems.

**Quality Assurance:** FIA provides rigorous training for field crews on data collection and field checks a number of plots each year for the accuracy of measurements. Aerial observers attend annual training sessions and do some ground checks of polygons after completion of the survey. The current national Forest Health Monitoring standard for aerial detection of tree mortality is that a 100 acre polygon of tree mortality (>1/4 tree per acre) will not be missed 90 percent of the time. The Forest Health Monitoring standard for defoliation detection is that 1200 contiguous acres will not be missed 90 percent of the time where more than 50 percent of the canopy exhibits 30 percent defoliation (30 percent defoliation is the point at which defoliation becomes visible from the air).

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**Repeatability:** Data on invasive pests from FIA plots are collected in a consistent manner and reported every five years. Aerial surveys have been flown in a similar manner for more than five decades. Data on tree mortality and defoliation from invasive insects and diseases are available for aerial surveys going back to 1970. Both the FIA program and aerial survey are well supported and can provide this type of data in the future.

## **F.c. Forest fuel conditions and trends related to wildfire risks**

*This indicator will provide information in both tabular and map form on forest fuel conditions and progress in managing forest fuel conditions.*

**Desired trend:** Increasing rates of effective forest fuel treatments to improve resiliency to wildfire and an increasing area of Oregon forestland resilient to wildfire.

**Relevance:** Wildfires are a natural part of Oregon's forests. In some forest ecosystems, management actions, including passive management, have led to unnatural build-ups of forest fuels which increase the risk of uncharacteristically intense wildfires. In other forest ecosystems, even historic (characteristic) fire intensities may be socially unacceptable. For example, stand replacement fires are part of the natural fire regime of some forest cover types, like lodgepole pine forests. However, human developments in or near a lodgepole pine forests will likely make stand replacement fires economically and socially undesirable. Both the public and policy makers want to know where and the how much of Oregon's forests are in a condition that is resilient to catastrophic wildfires and, over time, is the condition improving or worsening. They also want to know what is being done to effectively produce and/or maintain forest fuel conditions that are resilient to wildfires and see a map of where these treatments are occurring.

“Resilient” forest conditions means that when wildfires that do occur they will generally not burn at intensities greater than historic levels, thus avoiding uncharacteristic damage to forest ecosystems, watersheds, and airsheds. In some cases, “resilient” forest conditions may also mean that when wildfires that do occur they will not generally threaten economic and social values, regardless their relationship to historic intensity.

This indicator will provide information on both the scale of the forest fuel problem and the rate of fuel treatment. The indicator's metrics will track the amount of forestland that is resilient to wildfires and the amount of management activity occurring on forestlands to produce forest conditions resilient to wildfires.

**Overall Data Availability:** Fuel condition data are in the process of being developed by the LANDFIRE Mapping Project that will provide information in a consistent manner, statewide, across all ownerships. These data are planned to be updated every five years. Fuel treatment data will require some major work beyond existing data collection systems and will need to be coordinated with national efforts (since much of the data will come from federally funded projects). Currently, the Wildland Fire Leadership Council is evaluating new monitoring activities to improve their ability to track achievement of the primary objectives of the National Fire Plan and Healthy Forest initiative. The International Association of Wildland Fire held a conference titled *Fuels Management – How to Measure Success* in March 2006 in Portland.

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Fuel reduction projects, as well as other forest management activities, are currently reported in numerous databases by a variety of agencies. However, none of these provide reliable pre and post treatment fire behavior information; there is no consistency across agencies; and none are mapped consistently with common attributes. The National Fire Plan Operations and Reporting System (NFPORS) only includes federally funded projects and does not report data needed for the second metric; pre and post treatment conditions are not determined in a consistent manner; and there is no mapping component. ODF maintains several databases tracking commercial forest activities, federal cost share projects, smoke management activities, and Nation Fire Plan projects – again with limited or no pre and post treatment information, common attributes, or mapping component.

Fortunately, tools to help evaluate pre and post treatment fire resilience are being developed. Existing photo series can be enhanced, or software used to classify, at the project level, forestland into classifications suited to estimate both surface and crown fire characteristics. Also, guides and tools now exist through the Fire Regime Condition Class (FRCC) Guide to make consistent pre and post treatment assessments of FRCC at the project level. A statewide, spatial, interagency database, along with a field sampling process, will need to be developed to determine the amount and effectiveness of activities (treatments) on the landscape. A possible model is the web-based Natural Resource Projects Inventory used in California.

**Background:** Strategy F of the *Forestry Program for Oregon* addresses the need to “protect, maintain, and enhance the health of Oregon's forest ecosystems, watersheds, and air sheds within a context of natural disturbance and active management.” Key Action F.1 states that the “board will promote active fuels and vegetation management, along with aggressive wildfire suppression, as key tools to manage forest health on public and private forestlands.” Action F.2 states that the “board will promote forest landscape conditions that are resilient to natural disturbances, reducing the adverse environmental impacts and losses of forest resources to wildfire, insects, diseases and other agents in a cost-effective, environmentally, and socially acceptable manner.” Assessing the amount and effectiveness of these active fuels and vegetation management activities is important for evaluating progress, as well as for planning future vegetation maintenance strategies.

Fire Regime Condition Class is an interagency, standardized tool for determining the degree of departure from natural (reference) condition vegetation, fuels and disturbance regimes. FRCC is best suited for assessing fuel conditions that will produce uncharacteristic fire behavior that would adversely impact the natural ecological function of a forest landscape, primarily federal forestlands. FRCC is used in the 10-Year Comprehensive Strategy Implementation Plan (A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment), as well as the Healthy Forest Restoration Act, to identify where hazard fuel reduction projects should occur.



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Reducing the likelihood of large, high-intensity crown fires is a generally accepted means of maintaining fire resilient forests, (reducing the likelihood of costly fires that damage the environment and are socially unacceptable), especially on private lands and near communities. Crowning index is the wind speed necessary to sustain a crown fire -- the higher the wind speed, generally the lower the potential for crown fire. For example, fuel reduction treatments, if done right, result in a higher wind speed necessary to initiate a crown fire. A treatment might increase the wind speed from 15 to 20 mph (untreated) to 75 mph (treated).

**Related State, National, or International Indicators:**

*Montreal Process:* Criterion 3--Maintenance of forest ecosystem health and vitality: 2003 Indicator 15: Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals and 2010 Indicator 15: Area and percent of forest affected by abiotic agents.

*Heinz Center:* Fire frequency compared to pre-settlement (currently no data, due to lack of pre-settlement data).

*10-Year Comprehensive Strategic Implementation Plan, Goal 2:* Number of acres treated that are 1) in the Wildland Urban Interface or 2) in condition classes 2 or 3 in fire regimes 1, 2, or 3 outside the wildland urban interface, and are identified as high priority through collaboration consistent with the Implementation Plan, in total, and as a percent of all acres treated.

*Wildland Fire Leadership Council:* Draft monitoring proposal 1.8: Number of treated acres to moved to or maintained in the desired condition classes.

**Metric Descriptions:**

Metric	Data Source	Reporting Scale	Reporting Cycle	Reporting Responsibility	Limitations/Considerations
Percent of forestland in condition class 1, or fire regime IV or V.	LANDFIRE	State, region	Five year	ODF	Statewide, but may have limited value within the wildland urban interface and on private managed forests.
Percent of forestlands that produce a surface fire type (no passive or active crown fire) at 90 <sup>th</sup> percentile weather and wind for region.	LANDFIRE	State, region	Five year	ODF	Statewide
Acres of forestland in	NFPORS	State, region	Annual	USFS/BLM	Statewide, but may have

fire regime I, II, or III, that are treated to either maintain at, or reduced to, condition class 1.	USFS/BLM				limited value within the wildland urban interface and on private managed forests.
Acres of forestland treated to either maintain at, or reduced to, a surface fire type at 90 <sup>th</sup> percentile weather and wind for region.	ODF	State, region	Annual	ODF	Statewide
Note: Data and analysis tools needed to forecast FRCC and fire behavior given expected management parameters have been utilized on a limited localized basis and may be available for statewide application in the future.					

**Description:** The LANDFIRE Mapping Project will provide data needed for this indicator. Oregon is covered by three LANDFIRE regions, all scheduled to be completed in fall of 2006. The current plan is to remap the regions in Oregon every five years. These data will be valuable for watershed-scale planning and larger. Although the mapping resolution is 30 meters (approximately ¼ acre), accuracy will generally not be adequate for project level planning.

LANDFIRE will also produce the FRCC and the data elements needed to calculate the expected fire type (surface, passive or active crown) across the landscape. The 90<sup>th</sup> percentile weather and wind conditions will need to be determined for regions within Oregon by ODF using historic weather records. A fire potential mapping program called FLAMMAP will use the LANDFIRE data and fixed weather parameters to generate a map expected fire type. Percent surface fire type can be determined from the FLAMMAP output.

Note: Processes are available to determine fire type using existing FIA tree list data, but processing this data on a statewide basis would be very difficult.

Treatment data for federal lands are being reported through NFPORS. The Wildfire Leadership Council’s review of performance measures - will hopefully recommend including pre and post treatment indicators for fire behavior and a spatial component (although it’s too early to tell).

For non-federal forestlands, a multi-program database with mapping (spatial) capabilities will be needed, to track acres of all active management activities on forest landscapes. To estimate effectiveness of these activities, a small portion of these operations will need

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to be sampled every five years using a photo series to determine expected pre and post fire conditions for each forest activity (pre-commercial thinning, clear-cut harvest, partial-cut harvest, slash burning, etc) by forest vegetation type. The 90<sup>th</sup> percentile weather and wind conditions will need to be determined for regions within Oregon by ODF using historic weather records. These effectiveness factors would then be applied to all the data already gathered by ODF by the various programs to determine acres effectively treated to create a fire resilient condition.

Finally, an efficient process for sharing data between NFPORS and ODF's system will need to be developed. The Natural Resource Projects Inventory used in California allows both private and agency entities to report accomplishments online. In addition, there is a means of "dumping" large amounts of agency data into the system.

**Quality Assurance:** The LANDFIRE Mapping Project is national in scope, and uses regional workshops and peer review to develop and validate the models and data. It combines integrating ecosystem sampling, gradient modeling, remote sensing, and ecosystem simulation to create the spatially explicit landscape inventories. The LANDFIRE charter requires that products and practices must comply with applicable National Wildfire Coordinating Group Information Resource Management standards.

Treatment data will be reported from a large number of sources (federal, state, local) using a variety of sampling and measurement methodologies. Use of guides, photo series and software will improve the quality of the data. Validation of the data collected, however, will be minimal in some cases.

**Repeatability:** The LANDFIRE charter requires that the data be periodically updated and maintained. The current plan is remap every five years. If federal funding or changes in national priorities prevent these updates from occurring, all the data and processes will be open source, allowing Oregon to continue the updates at our own expense. Any future changes in LANDFIRE or FLAMMAP methodology will necessitate making retroactive runs to make change analysis valid.

Collection of treatment data over time will require a system and funding that currently doesn't exist. Following development of the data collection system, a commitment will need to be made to implement the sampling, data collection, and data processing to report this indicator.

#### **References:**

- LANDFIRE: [www.landfire.gov](http://www.landfire.gov); Fire Regime Condition Class: [www.frcc.gov](http://www.frcc.gov); 10-Year Comprehensive Strategy Implementation Plan: [www.westgov.org/wga/initiatives/fire/implement\\_plan.pdf](http://www.westgov.org/wga/initiatives/fire/implement_plan.pdf); Basic principles of forest fuel reduction treatments (Agee and Skinner): [www.sciencedirect.com](http://www.sciencedirect.com)

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- Fire Regime Condition Class: [www.frcc.gov](http://www.frcc.gov); 10-Year Comprehensive Strategy Implementation Plan: [www.westgov.org/wga/initiatives/fire/implement\\_plan.pdf](http://www.westgov.org/wga/initiatives/fire/implement_plan.pdf)
- Fuel Characteristic Classification System (FCCS); [www.fs.fed.us/pnw/fera/fccs/index.html](http://www.fs.fed.us/pnw/fera/fccs/index.html)
- National Fire Plan Operations and Reporting System: [www.nfpors.gov](http://www.nfpors.gov)
- Basic principles of forest fuel reduction treatments (Agee and Skinner): [www.sciencedirect.com](http://www.sciencedirect.com)
- Natural Resource Projects Inventory used in California: [www.ice.ucdavis.edu/nrpi/](http://www.ice.ucdavis.edu/nrpi/).

## ***Forestry Program for Oregon Strategy G: Enhance carbon storage in Oregon's forests and forest products.***

### **G. a. Carbon stocks on forestlands and in forest products**

*For a given time period, this indicator will spatially map changes in carbon stocks on forestlands where forests, forestland losses, forestland gains, and forest products are acting as: a) net sources of carbon dioxide through releases of carbon to the atmosphere, b) net sinks for carbon storage through the removal of carbon dioxide from the atmosphere, or c) neither sources or sinks.*

**Desired trend:** Rates of storage of carbon in Oregon forests and Oregon forest products are stable or increasing.

**Relevance:** Many scientists, policy-makers, and others believe that climate change from increasing atmospheric levels of greenhouse gases needs to be addressed by reducing or offsetting human-induced sources of greenhouse gases, in particular carbon dioxide. Proponents for taking action feel that doing nothing is too risky, and that inaction forecloses opportunities to achieve other benefits such as conserving energy, developing alternatives to fossil fuels, and placing greater emphasis on maintaining healthy, productive forests to mitigate carbon dioxide emissions. Others question whether climate change from increased levels of carbon dioxide is occurring, and if it is, whether humans are causing the changes and whether society needs to be concerned. Through the use of this indicator, forest managers, policy makers and the public will be able to see the changes in the carbon sink capacity on the state's forestlands from the interaction over a given period of time of disturbance, land use change, forest management, and forest product manufacture efficiency and utilization. By comparing indicator results over successive time periods, one can learn if forest policies and actions are maintaining or enhancing the carbon sink capacity of Oregon's forestlands over time.

**Overall Data Availability:** The indicator will be derived by combining models of how carbon stores change with remotely sensed data for forest cover and forest canopy losses due to disturbance and timber harvest. The remotely sensed data to be used to determine forest cover has been provided through the analysis of LandSAT satellite imagery. There is some uncertainty whether LandSAT satellite imagery will be available in the future because there has been no announced program to launch new satellites for this purpose. However, given the popularity and widespread use for this type of data, it is likely that some type of satellite imagery will be available for this purpose. Through contract with Sanborn Inc. (formerly Space Imaging), the Oregon Department of Forestry has recently completed a spatial data layer of canopy change (at least 50 percent reduction in canopy cover) from disturbance and timber harvest detectable for areas at least five continuous hectares in size for all of Oregon's forestlands using change detection analysis of LandSAT satellite imagery. The data covers the periods 1973-1982, 1983-1992, 1993-2000 and 2001-2004. The department has plans to update this layer on a four to five year cycle. For extensive new disturbances, a more local update of disturbances can be made. The USDA Forest Service, Pacific Northwest Research Station and the Oregon State University, College

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of Forestry, Department of Forest Science maintain and continuously update models that can assess carbon storage in forest products and models of on-site carbon storage that include the relevant tree physiology, tree mortality, woody debris decomposition, litter, humus and soil organic material processes to predict changes in these stores.

The metric can be reported with respect to various carbon pools (e.g., live trees, dead trees and down wood, humus and litter, soil organic material, forest products) as well as reported with respect to various change agents (e.g., growth, mortality, land use change, timber harvest, natural disturbance).

**Background:** Forests can either be net sources, sinks or neither sources or sinks of carbon dioxide (i.e., neutral) to the atmosphere. If a forest is a net sink, the forest (through photosynthesis) and attendant bio-physical processes is sequestering more carbon dioxide from the atmosphere and storing it as carbon in live vegetation, dead woody material (both standing and down) and leaf litter, humus and soil organic material than it is releasing through respiration, decomposition or disturbance. The status of a forest area as a source, sink or being neutral can change over time. Disturbance by natural agents and processes, land use change, forest management and the efficiency in wood product manufacture and utilization are the controlling factors determining whether an area of forestland has been acting as a net source of carbon dioxide emissions over some time period or as a net sink for removing carbon. At any given point in time, the net change in carbon stocks (i.e., stored carbon) on a forested area since a previous point in time (i.e., the change in carbon stocks being the carbon flux) can either be positive (i.e., sink), negative (i.e., source) or zero (i.e., neutral – neither source or sink). The outcome is dependent on the time period used, the initial and ending conditions of carbon stocks at the beginning and the end of the period, and the legacy influences still present from prior disturbance, land use change and forest management that occurred prior to the period.

#### **Related State, National, or International Indicators:**

*Montréal Process:* Criterion 5--Maintenance of forest contribution to global carbon cycles: 2003 Indicator 26: Total forest ecosystem biomass and carbon pool by forest type, age class and successional stage; 2003 Indicator 27: Absorption and release of carbon in standing biomass, woody debris, and soil carbon (contribution to global carbon budget); 2003 Indicator 28: Contribution of forest products to the global carbon budget; 2010 Indicator 22: Total forest ecosystem carbon pools and fluxes; and 2010 Indicator 23: Total forest product carbon pools and fluxes..

*Northeastern Area:* Total forest ecosystem biomass and carbon pool (Ecosystem biomass (tons); carbon pool (metric tons)) and Contribution of forest ecosystems to the total carbon budget (Carbon flux)

*Heinz Center:* Carbon stored in trees, soils, plant litter and wood products (billion metric tons – currently developed for trees only)

*Oregon Benchmarks: Environment—77:* Carbon dioxide emissions as a percent of 1990 emissions; 82: Percent of Oregon's non-federal forest land in 1974 still preserved for forest use.

*Oregon State of the Environment Report:-*The amount of carbon dioxide emitted

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*Mt. Hood National Forest Local Unit Criteria and Indicators Development: Principal 2 – Ecological Integrity: Ecosystem Function: Carbon Sequestration (soil carbon and carbon sinks)*

**Metric Descriptions**

<b>Metric</b>	<b>Data Source</b>	<b>Reporting Scale</b>	<b>Reporting Cycle</b>	<b>Reporting Responsibility</b>	<b>Limitations/Considerations</b>
<p>Status of forest carbon stocks in various carbon pools, including forest products. (Expressed as mass/area)</p> <p>Status of changes in forest carbon stocks where forests and forest products acting as a source or as a sink. (Expressed as mass/area/unit of time)</p>	<p>USDA Forest Service Pacific Northwest Research Station</p> <p>Oregon State University, College of Forestry, Department of Forest Science</p> <p>Oregon Department of Forestry</p>	<p>Stand (at least five hectares) with spatial representation and aggregation to a watershed or eco-region scale.</p>	<p>Every five years.</p>	<p>USDA Forest Service Pacific Northwest Research Station</p>	<p>Adapt indicator to utilize the approach to determining forest cover and structure for indicator E.b - Extent of area by forest type in protected area categories.</p> <p>Ground truthing of remote sensing derived data for forest cover and disturbance is needed. Ground truthing should include field measurements of changes in carbon stocks.</p>

**Description:** Researchers have developed a strategy for estimating carbon flux on forestlands that are spatially explicit (i.e., can be mapped), complete, non-overlapping and adequately reflect land use pattern and forest productivity classes (Cohen *et al.* 1996). The strategy relies on the use of remotely sensed data of forest cover and disturbance, spatial biogeoclimatic data, harvest maps, models of forest product manufacturing and end use and mechanistic models of tree physiology, tree mortality, woody debris decomposition, litter, humus and soil organic material processes to estimate carbon fluxes at both the stand and aggregated regional scale over a given time period.

Estimated amounts of carbon in various forest products will remain spatially referenced to the geographic locations from which they were harvested and linked to the period at which they originated. These estimates will represent the average estimated store of forest

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products produced from a location. The carbon will actually be stored somewhere else. The exact amount of carbon stored in forest products stored depends on how the harvest is used. Data will likely not provide that level of detail, so indicator reports will be based on either an estimate of the average values or based on a range.

**Quality Assurance:** Mapping will follow conventional standards for accuracy in mapping remote sensing data. Data uncertainty involved in developing indicator reports will need to be quantified.

**Repeatability:** The carbon flux metric can be repeated using updated forest cover, disturbance, and harvest mapping data. Getting all three updates at the same point of time is the best situation for repeatability and may not always be possible. Parameters used in the models of forest product manufacturing and end use, and the mechanistic models of tree physiology, tree mortality, woody debris decomposition are updated based on continuing research. Trend analysis of the carbon flux metric will need to account for periodic differences arising from using new estimates of model parameters for one time period not used in another.

**References:**

- Cohen, Warren B., Mark E. Harmon, David O. Wallin, and Maria Fiorella. 1996. Two decades of carbon flux from forests of the Pacific Northwest. *BioScience* 46(11): 836-844.
- Harmon, M. E., J. M. Harmon, W. K. Ferrell, and D. Brooks. 1996. Modeling carbon stores in Oregon and Washington forest products: 1900-1992. *Climatic Change* 33:521-550.
- Wallin, D. O., M. E. Harmon, W. B. Cohen, M. Fiorella, and W. K. Ferrell. 1996. Use of remote sensing to model land use effects on carbon flux in forests of the Pacific Northwest, USA. pp. 219-237 In H.L. Gholz, K. Nakane, and H. Shimoda editors, *The Use of Remote Sensing in the Modeling of Forest Productivity*. Kluwer Acad. Publ., Dordrecht, The Netherlands.



## **Appendix A: Other Indicator Concepts for Potential Future Consideration**

For each *Forestry Program for Oregon* Strategy, many components were considered as the basis for possible indicators. Since the intent of the project was to develop a short list of relevant, understandable indicators, not every component is represented by an indicator in the committee's recommendations. However, the committee also recommends that, while the following indicator concepts are currently not being proposed for Board of Forestry adoption, they address other important and/or emerging issues that warrant more review at a future date.

### **Strategy A**

- Incentive and tax policy effects on forest investment
- Use of indigenous knowledge in forest management

### **Strategy B**

- Trends in forestland ownership, management strategies, and condition related to production of spiritual, existence, and other non-market values
- Forest-related personal income tax revenues to state and local governments
- Consumption of timber products and timber harvests in Oregon
- Forest products sector innovation, diversification, and clustering
- Clean water as an additional ecosystems services indicator metric

### **Strategy C**

- Non-timber forest products

### **Strategy D**

- Anadromous fish distribution and abundance
- Salmon habitat index of forest streams
- Soil productivity
- Drinking water quality

### **Strategy E**

- Terrestrial habitat quality index
- Population and distribution trends of "secure" forest plant and animal species
- Extent of area by forest canopy structure type in protected area categories

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**Strategy F**

- Area and percent of forestland subject to levels of air pollutants that may cause negative impacts on forest ecosystems
- Ecological functions and biotic integrity
- Spatial distribution and abundance of invasive plants

**Strategy G**

- Carbon offsets when forest products are used instead of alternative materials

## **Appendix B: Table of Acronyms Used**

ACES	U.S. Census Bureau Annual Capital Expenditures Survey
BLM	USDOJ Bureau of Land Management
DEQ	Oregon Department of Environmental Quality
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ESA	Federal Endangered Species Act
ESU	Evolutionary Significant Unit
FAR	First Approximation Report for Sustainable Forest Management in Oregon
FIA	Forest Inventory and Analysis Program
FRCC	Fire Regime Condition Class
FTE	Full Time Equivalents
GIS	Geographic Information Systems
GNN	Gradient Nearest Neighbor
HUC	Hydrologic Unit Classification
IBI	Index of Biotic Integrity
NAICS	North American Industry Classification System
NFPORS	National Fire Plan Operations and Reporting System
NWFP	Federal Northwest Forest Plan
O&C	Oregon and California Land Act
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ODR	Oregon Department of Revenue
OED	Oregon Employment Department
OFRI	Oregon Forest Resources Institute
ONHIC	Oregon Natural Heritage Information Center

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OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
PNW	Pacific Northwest Research Station
USFS	USDA Forest Service
USFWS	USDOI Fish and Wildlife Service
WQI	Water Quality Index