Washington's Forest Resources, 2002–2006

Five-Year Forest Inventory and Analysis Report

General Technical Report
PNW-GTR-800
April 2010

USDA United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

Technical Editors

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Cover

Mount Rainier, Washington. Photo by Joel Thompson

Abstract

Campbell, Sally; Waddell, Karen; Gray, Andrew, tech. eds. 2010. Washington's forest resources, 2002–2006: five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-800. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 189 p.

This report highlights key findings from the most recent (2002-2006) data collected by the Forest Inventory and Analysis Program across all ownerships in Washington. We present basic resource information such as forest area, land use change, ownership, volume, biomass, and carbon sequestration; structure and function topics such as biodiversity, older forests, dead wood, and riparian forests; disturbance topics such as insects and diseases, fire, invasive plants, and air pollution; and information about the forest products industry in Washington, including data on tree growth and mortality, removals for timber products, and nontimber forest products. The appendixes describe inventory methods and design in detail and provide summary tables of data and statistical error for the forest characteristics sampled.

Keywords: Biomass, carbon, dead wood, diseases, fire, forest land, insects, invasive plants, inventory, juniper, lichens, nontimber forest products, ozone, timber volume, timberland, wood products.

Summary

The growing population of Washington depends on forests for recreation, clean water, clean air, wildlife habitat, and products. Thus, monitoring and interpreting change in forest conditions over time, the core charge of the U.S. Forest Service, Forest Inventory and Analysis (PNW-FIA) Program, is critical to assuring we conserve and use our natural resources sustainably. This report is a snapshot of conditions on Washington's diverse and extensive forests in the first half-decade of the 21st century.

The following summary of key findings shows the importance of monitoring the status and change in our forest resources:

- Washington's total land area is 43 million acres, 22 million of which are forested. Forested acreage is divided somewhat evenly between the western and eastern parts of the state, along the Cascade Crest.
- Washington's timber harvest volume has been declining since 1989. However, between 2000 and 2006, total lumber production increased. Washington will likely continue to be one of the top three softwood lumber producing states.
- Washington's forests are presently a net sink for carbon. Growth of trees significantly exceeds harvest and mortality overall, owing to trends on public lands. Through modeling work by FIA, accumulated forest biomass is being evaluated for its potential to furnish energy and income for rural communities. The rising interest in biomass as an alternative source of energy will accelerate the need to understand how much biomass is available and where it is located.
- As federal forest management has moved toward a greater emphasis on nontimber resources, the job of providing timber now rests with private landowners. Private landowners currently provide most of Washington's wood products, timber-related employment, and timber revenue. Most noncorporate forest owners are older than 50, suggesting that their lands will change ownership in the next 20 to 40 years. Private forest land generally has a higher proportion of productive land in younger age classes. These immature trees will take time to grow before they are available for timber harvest. Additionally, ownership and land use changes may take significant acreage out of production altogether.
- The character of corporate forest ownership is changing rapidly as some traditional timber companies (those whose primary business is manufacturing forest products) sell their lands to investment companies such as real-estate investment trusts (REITs) and timberland investment management organizations (TIMOs). It is unclear what the ownership shift from forest products companies to TIMOs and REITs means for the management of Washington's corporate forests and the impact on land use conversion.

- Forest land is being converted to other uses throughout Washington but particularly near urban areas. Inventories in the 1990s found large losses of private timberland (0.5 percent per year) to urban development in western Washington during the 1980s and 1990s.
- With fragmentation and increased disturbance, forest land and rangeland are increasingly susceptible to invasive exotic and aggressive native organisms. Nonnative invasive plant species already are well established in Washington's forests. The greatest insect- or disease-related changes in Washington's forests are likely to come from introduced organisms, although native pests can become a problem in response to drought, changes in stand density, or climate.
- The majority of old-growth forest is now found on federal land, although the current percentage of total forest in old-growth condition is estimated to be less than half of that existing before Euro-American settlement. The percentage will gradually increase if national forests follow recent successional trends. Changes in climate and disturbance regimes are expected to play important roles in the development of older forest types.
- Large-diameter dead wood is not common in Washington's forests. Wildlife species that depend on large dead wood for nesting, roosting, or foraging may be limited by the amount of suitable habitat currently available.
- Air quality in and near forests is generally good, although nitrogen pollution as indicated by the occurrence of certain lichen communities is a problem in some west-side forests, particularly in the Puget Trough ecoregion where much of western Washington's agricultural and metropolitan areas lie. Ozone-sensitive plant species show some signs of damage in the Columbia River Gorge.
- A single fuel-treatment prescription does not fit all landscapes in Washington. Based on crown fire models and assuming severe fire weather, just over half of Washington's forested lands are predicted to develop crown fires, with less than a quarter expected to develop active crown fire. Although the total area that may benefit from fuel treatment is substantial, treatment to reduce crown fire may only be required in a relatively small proportion of strategically-located stands.

The analyses and tools that PNW-FIA continues to develop will help land managers and the public better understand how Washington's forests are changing. We have implemented a nationally consistent inventory design that will help us to monitor overall forest change and detailed changes in forest structure, species composition, size class, ownership, management, disturbance regimes, and climatic effects.

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Chapter 1: Introduction[1]

This report highlights the status for many of Washington's forest resources. The dedicated work of the field crews at the Pacific Northwest Research Station (PNW), Forest Inventory and Analysis (FIA) Program forms the core of the information reported here. Our analyses describe the amount and characteristics of Washington's forests, summarized primarily from field plots measured in the years 2002 through 2006.

The FIA Program was created within the U.S. Department of Agriculture, Forest Service in 1928 to conduct unbiased assessments of all the Nation's forested lands for use in economic and forest management planning. The FIA Program was charged with collecting forest data on a series of permanent field plots, compiling and making data available, and providing research and interpretations from those data. Four FIA units are responsible for inventories of all forested lands in the continental United States, Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands, and several Pacific Island groups. Originally all plots were assessed within a period of 1 to 3 years with periodic reassessments, typically every 10 years in the West.

Starting in 2000, as required by the Agricultural Research Extension and Education Reform Act of 1998 (the Farm Bill), FIA implemented a new standardized national inventory method in which a portion of all plots in each state were measured each year. Appendix A explains the differences between the previous and current inventory methods. The effect of the change is that, for the first time in 70 years, all FIA units are using a common plot design, a common set of measurement protocols, and a standard database design for compilation and distribution of data. Under this unified approach, FIA is now poised to provide unbiased estimates of a wide variety of forest conditions over all forested lands in the United States in a consistent and timely manner. The new design will eventually enable FIA units in every state to consistently monitor changes in forest conditions, ownership, management, disturbance regimes, and climate effects that occur through time.

This report covers all forested lands in Washington (fig. 1). All estimates are average values for the time between 2002 and 2006. Field crews visited each inventory plot to measure forest characteristics (fig. 2). Most measurements use national protocols, but several are specific to forest issues in Washington; these have been developed with input from our clients.

The base set of field plots (called "phase 2") are spaced at approximate 3-mile intervals on a hexagonal grid throughout forested lands in Washington (figs. 3 and 4). One out of every 16 phase 2 plots is a "phase 3" plot, where detailed information on forest health is collected. Plots span both public and privately owned forests, including lands reserved from industrial wood production (e.g., national parks, wilderness areas, and natural areas). The annual inventory involves a cycle of measurements for 10 systematic subsamples, or panels; each panel represents about 10 percent of the approximately 4,000 forest land plots in Washington. A panel takes about 1 year to complete (fig. 3). This report presents the principal findings from the first five panels, which make up 50 percent of data from the new annual inventory, collected from 2002 through 2006 (fig. 4). This report also includes data from spatially intensified plots (on a 1.7-mile spacing) measured concurrently using the same protocols on national forest land outside wilderness. Additional information about annual inventories is available in appendix A of this report and at http://fia.fs.fed.us/.

The data we collect allow us to present a broad array of findings that cover many of Washington's current forest issues and concerns. This report presents basic resource information, such as forest area and ownership, and describes the composition, structure, and functions of Washington's forests. It includes data on wildlife habitat, biodiversity, biomass, and riparian areas. Results from

[1] Author: Dale Weyermann.

Figure 1—Washington land cover (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

Figure 2—Forest Inventory and Analysis field crews measure live and dead trees, down wood, understory vegetation, and many other variables on each forested plot they visit.

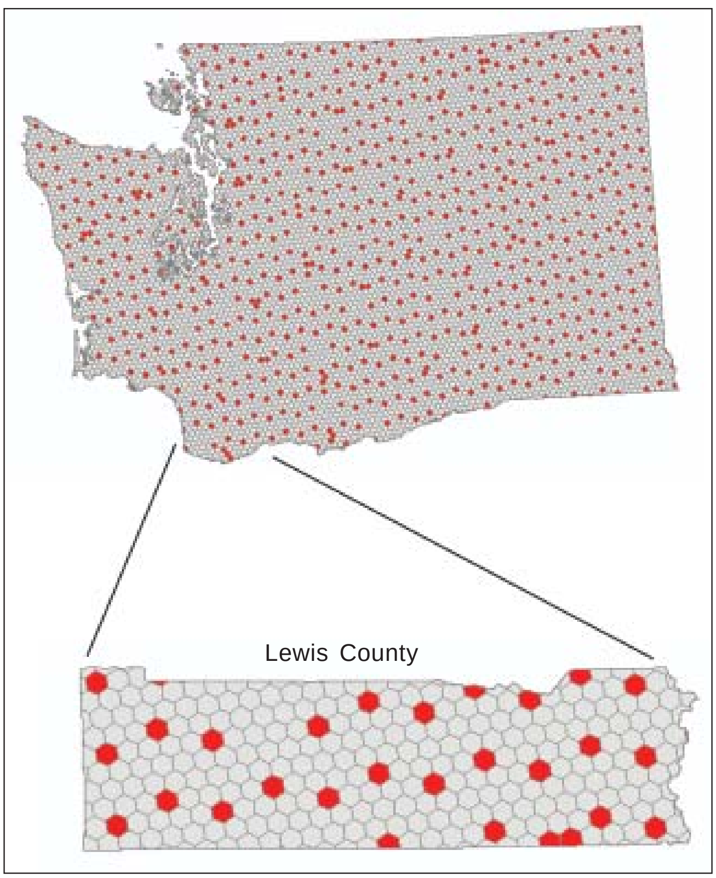

Figure 3—Example of the hexagonal grid and panel system used to locate Forest Inventory and Analysis plots. Although there are over 10,000 phase 2 hexes in Washington, only about 7,687 of them are forested field plot candidates. One-tenth of the forested plots are visited each year (red dots).

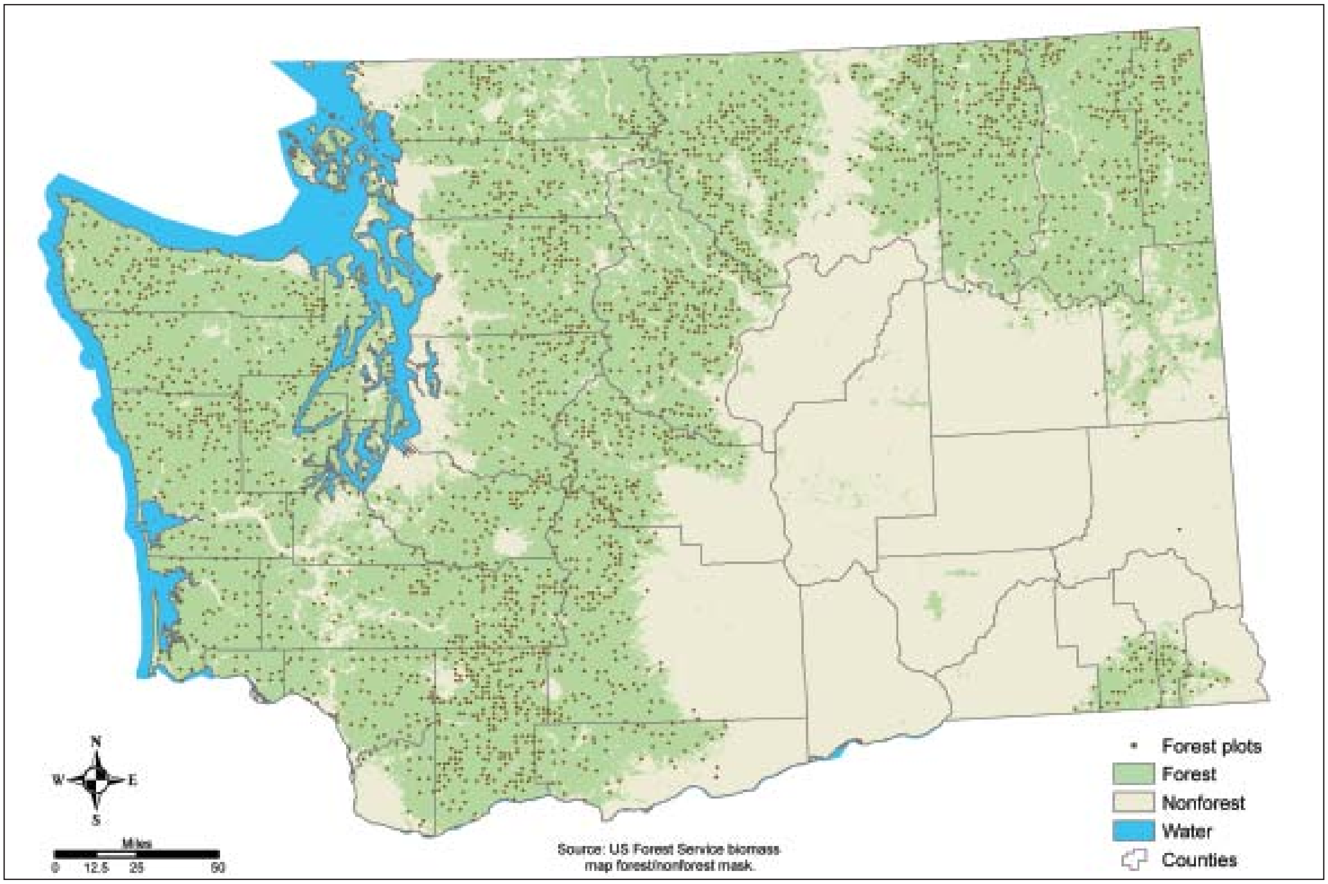

Figure 4—Forested plots measured between 2002 and 2006 and thus included in this report. Locations are approximate (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

monitoring forest disturbance (e.g., air pollution, fire, invasive plants, insects, and diseases) are likewise included. We also present information on forest products, including timber volume, mill outputs, and nontimber products.

Data are summarized by various geographic and ecological boundaries that we felt would be useful to a variety of readers (figs. 5 through 8). Narrative discussions of each topic include background information, key findings from the FIA inventory, and a few interpretive comments. Appendix B of this report presents the summarized data in tabular form with error estimates. These tables aggregate data to a variety of levels, including ecological units (e.g., ecological section or ecosection) (Cleland et al. 1997, 2005; McNab et al. 2005), owner group, survey unit, forest type, and tree species, allowing the inventory results to be applied at various scales and used for various analyses. Plot and tree-level data are also available for download at www.fia.fs.fed.us.

John Chase

Figure 5—Washington counties (forest/nonforest geographic information system layer: Blackard et al. 2008).

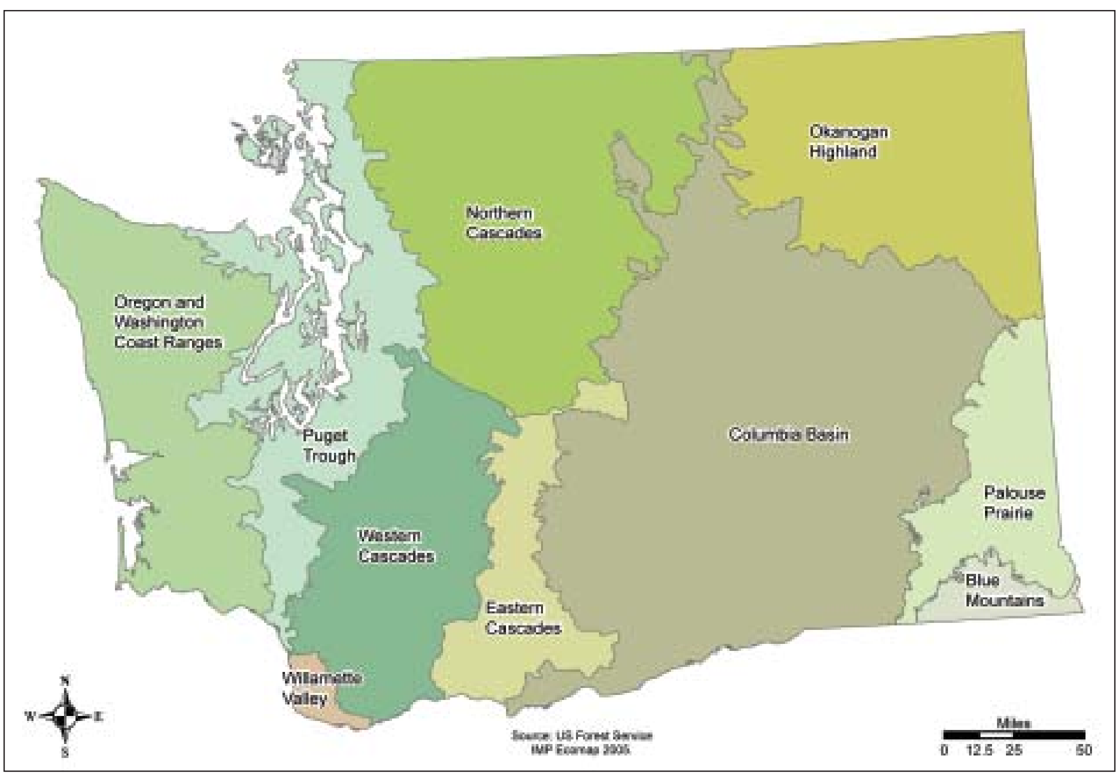

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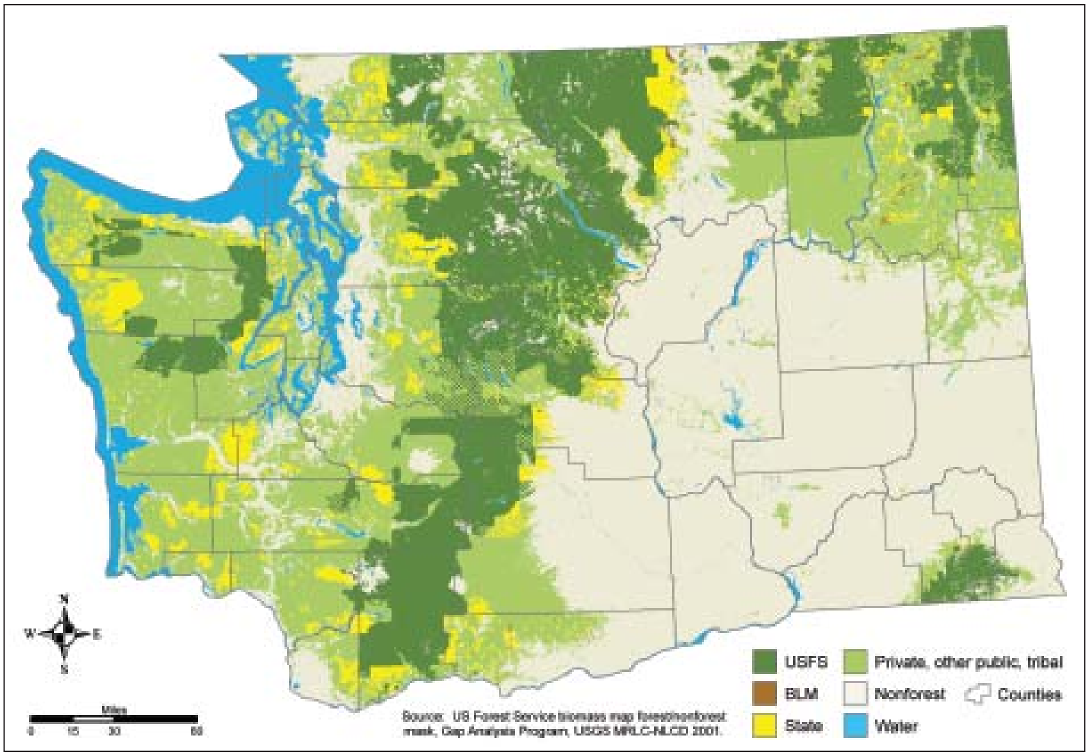
Figure 6—Washington ecosections (ecosection geographic information system layer: Cleland et al. 2005).



John Chase

Figure 7—Washington forest ownership categories (ownership geographic information system [GIS] layer: GAP Analysis Program, 2000; urban/water GIS layer: Homer et al. 2004).

John Chase

Figure 8—Washington Forest Inventory and Analysis (FIA) survey units (county groupings used in this report) (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

Dense Douglas-fir trees.

Chapter 2: Basic Resource Information

This section provides a broad look at the distribution, extent, and ownership of Washington's forests and the amount of wood (volume and biomass) in them. It lays the groundwork for more specialized analyses and summaries in the coming sections. Highlights include discussions of forest ownership in Washington, the status of five-needle pines, and biomass and carbon accumulation.

Forest Area[2]

Background

The trend in forest area over time is the most basic measure of forest health. The Forest Inventory and Analysis (FIA) Program tracks the trend in forest area to provide meaningful data for international assessments and for state and national assessments such as the U.S. Department of Agriculture's Resource Planning Act (Smith et al. 2004).

"Forest land" is defined as land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover and not currently developed for a nonforest use. The minimum area for classification is 1 acre. The distribution of forest land in Washington is influenced foremost by climate, which is in turn shaped by major geographic features such as the Olympic and Cascade Ranges, as well as the Willapa Hills paralleling the southern Washington coast, the Okanogan Highlands in northeastern Washington, and the Columbia basin in southern and central regions of the state (fig. 9). These features divide the state into distinctly different ecological sections that support different types of forests (fig. 6). The distribution of forest land is also influenced by human use, particularly urban development.

The FIA protocol uses a combination of remote sensing (aerial photos or satellite data) and on-the-ground observation to determine the extent of forested area. Field

[2] Author: Glenn Christensen.

Figure 9—Mountain ranges influence the diversity of forests and their distribution in Washington.

crews determine the proportion of each plot that is forested; these proportions are then expanded and summed to provide an overall estimate of forested acres. Specific information on sampling methodology can be found in the introduction to this volume and in appendix A. Spatial and temporal trends in forested area are tracked at various levels—survey unit, ecological section, and state as a whole—producing long-term data that inform possible mechanisms of change, whether from human or ecological causes.

Findings

Of Washington's total land area of 42.6 million acres, about 22.4 million are forested. Forested acreage is divided roughly evenly between the western and eastern sides of the state. The Cascade crest separates the Central and Inland Empire survey units from the Puget Sound, Southwest, and Olympic Peninsula survey units (fig. 8) and serves as a convenient division for acreage discussion.

Area by land class—

Most forest land in Washington is classified as timberland, (about 18.3 million acres) that is, forest land capable of producing more than 20 cubic feet of wood per acre per year and not legally restricted from harvest. Timberland makes up over 40 percent of all acreage in the state (fig. 10). Most of it lies in the larger Central and Inland Empire survey units, 20 and 25 percent, respectively. The majority (76 percent) of timberland is distributed among four ecosections (fig. 6): the Okanogan highlands (21 percent), the Northern Cascades (20 percent), the Washington Coast Range (19 percent) and the Western Cascades (16 percent).

Area by forest type group—

The FIA protocol classifies forest land based on the predominant live tree species cover. About 86 percent of Washington's forests (19 million acres) are softwood conifer forest types. Within these types are four primary forest type groups (i.e., combinations of forest types that

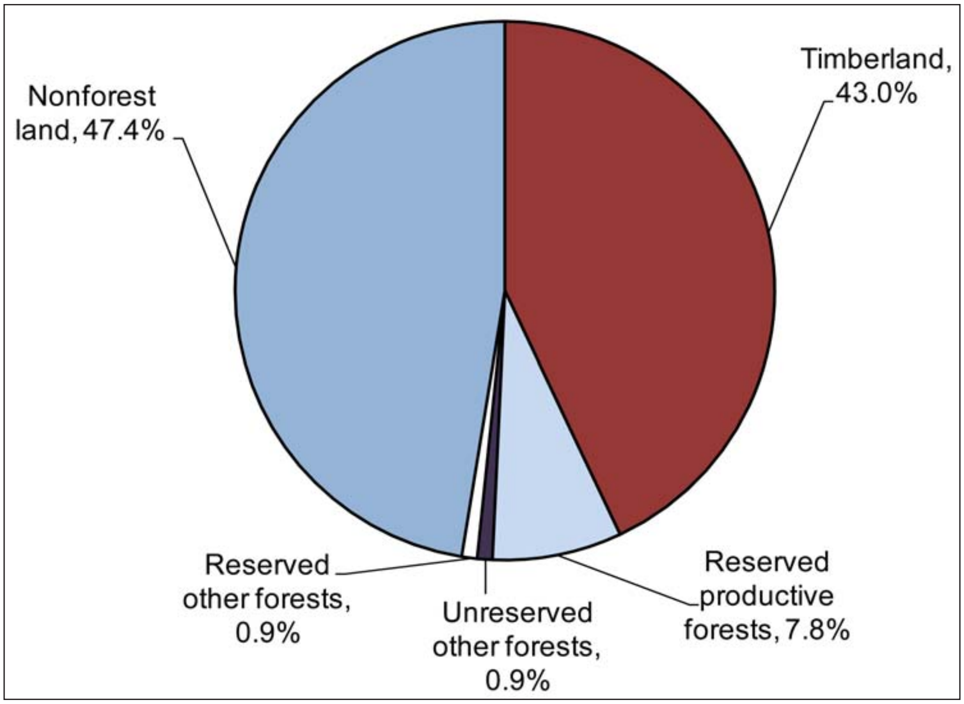


Figure 10—Percentage of area in Washington, by land class category, 2002–2006.

share closely associated species or productivity requirements). These are Douglas-fir, fir/spruce/mountain hemlock, western hemlock/Sitka spruce, and ponderosa pine (see "Common and Scientific Plant Names" section).

Douglas-fir forests cover the largest area, nearly 9 million acres (39 percent of total forest land acres), followed by fir/spruce/mountain hemlock forests at about 4 million acres (18 percent), western hemlock/Sitka spruce at 3 million acres (15 percent), and ponderosa pine forests at 2 million acres (9 percent) (fig. 11). Hardwood forest types account for an additional 2.6 million acres (12 percent). About 625,000 acres (nearly 3 percent) are classified as nonstocked.[3] The most common hardwood forest type group in Washington is the alder/maple group, which occupies 1.9 million acres (9 percent) of forested land throughout the state (fig. 12).

[3] "Nonstocked" forest land means land that is less than 10 percent stocked by trees, or, for some woodlands, less than 5 percent crown cover.

Area by productivity class—
Overall, most forest land (64 percent) has the potential to produce between 50 and 164 cubic feet per acre per year of merchantable wood. Approximately 4 million acres (17 percent) is classified as highly productive (i.e., capable of growing more than 165 cubic feet per acre per year of wood). About 41 percent of this acreage is in the Douglas-fir forest type group (fig. 13). Lands of the next highest productivity grouping, capable of growing 85 to 164 cubic feet per acre per year, are also dominated by Douglas-fir. Most other forest land (about 8 million acres, or 38 percent) is classified as lower productivity, capable of growing between 20 and 84 cubic feet of wood per acre per year.

Interpretation

Statewide estimates of timberland area declined from 1953 to 1997 (Smith et al. 2004), although the most

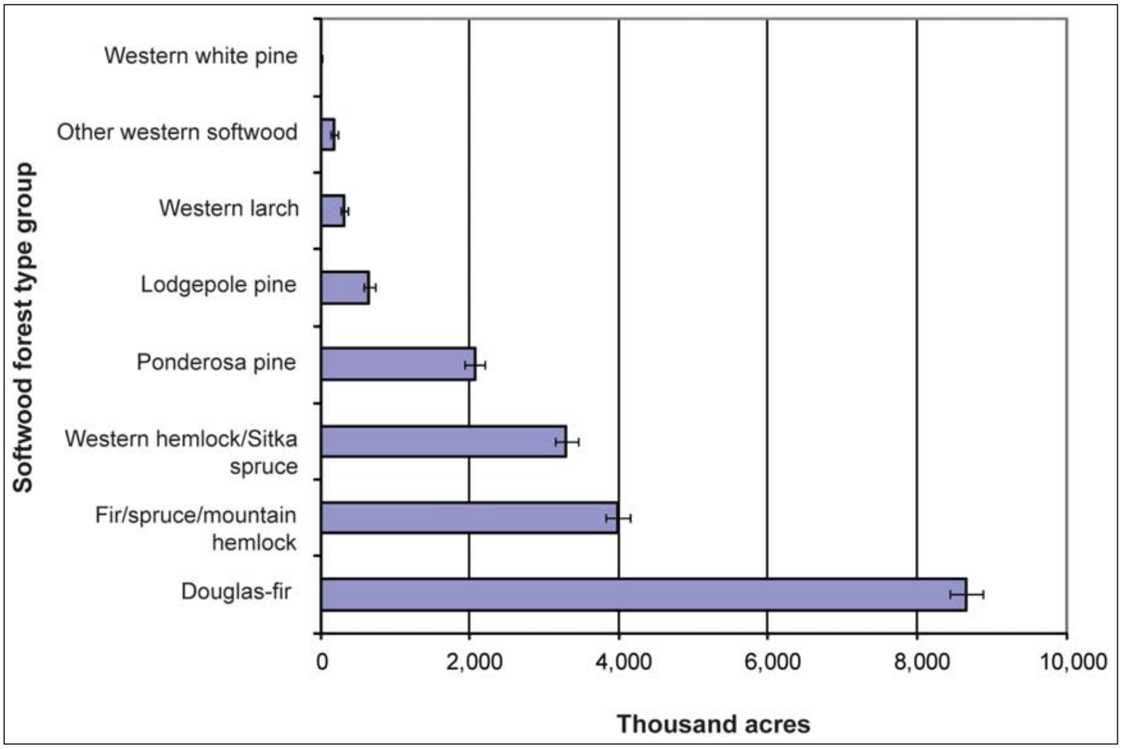


Figure 11—Area of forest land in Washington, by softwood forest type groups, 2002–2006. Lines at end of bars represent ± standard error.

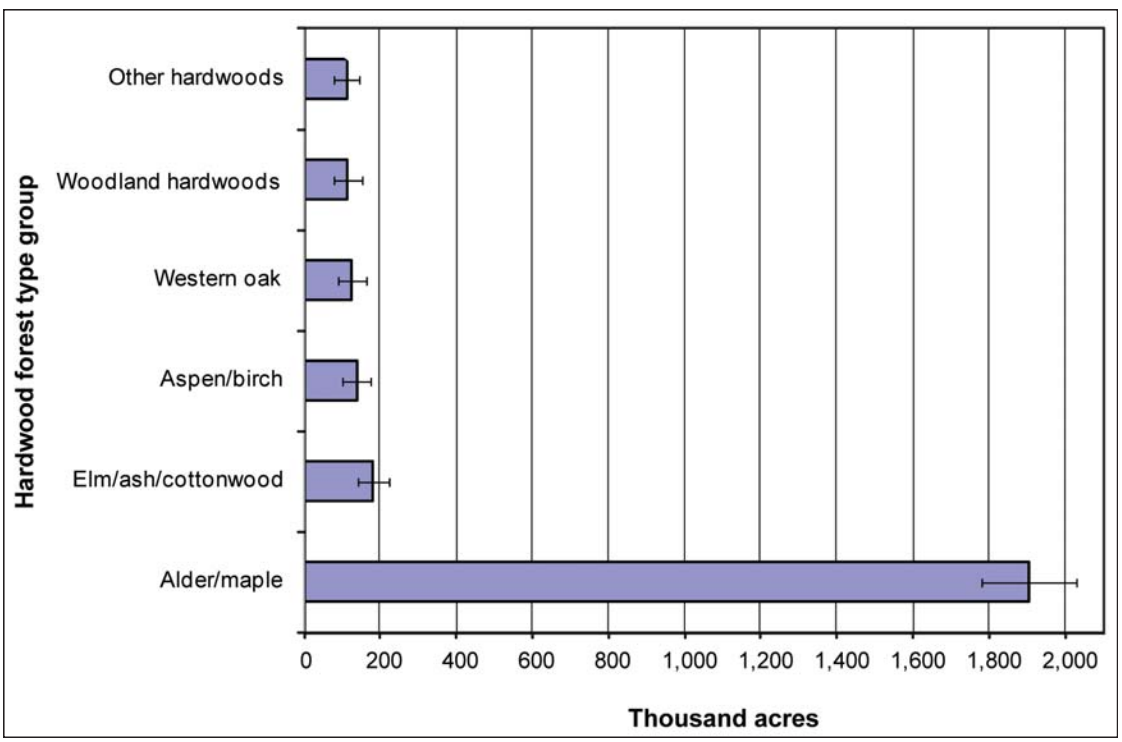


Figure 12—Area of forest land in Washington, by hardwood forest type groups, 2002–2006. Lines at end of bars represent ± standard error.

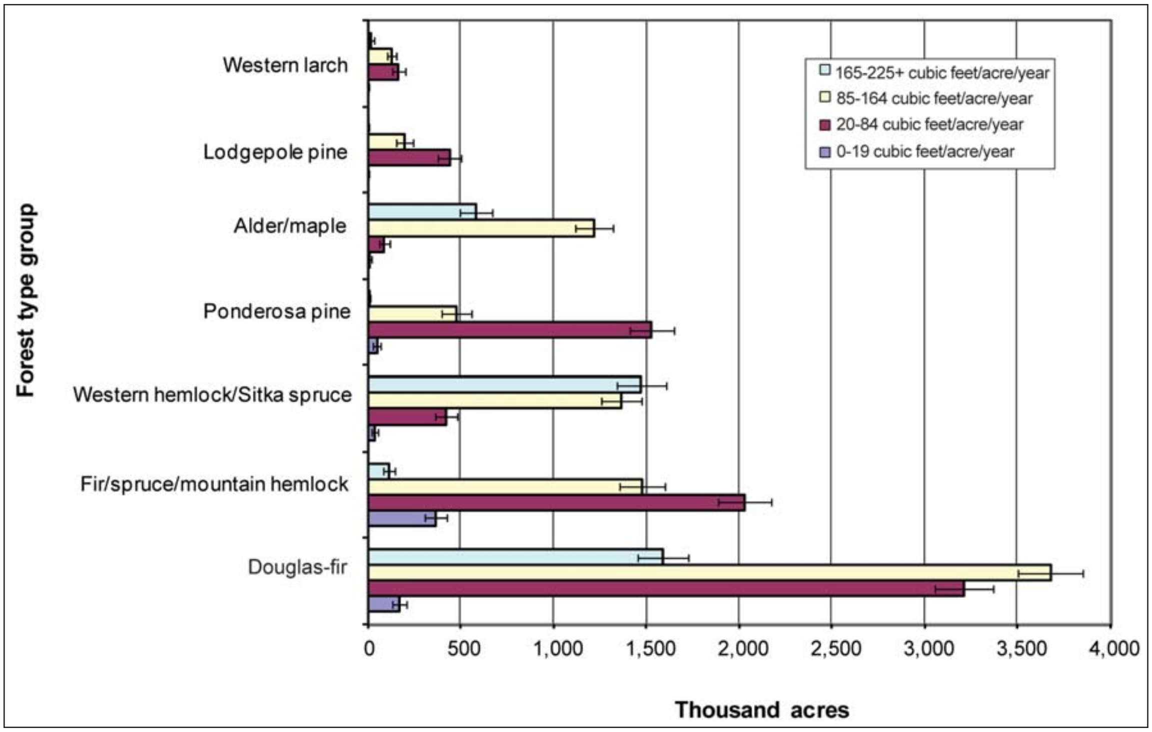


Figure 13—Area of forest land in Washington, by cubic-foot productivity classes and forest type group, 2002–2006. Lines at end of bars represent ± standard error.

recent estimates show an increase in timberland (fig. 14). The most recent estimate is confounded by differences between the previous periodic and current annual inventory methods in distinguishing between timberland and other forest land. Inventories in the 1990s (Gray et al. 2005, 2006) showed the same statewide proportion of forest land (53 percent) as this current inventory. The same inventories found large losses of private timberland (0.5 percent per year) to urban development in western Washington during the 1980s and 1990s.

Forest Area Tables in Appendix B

Table 1—Number of Forest Inventory and Analysis plots measured in Washington 2002–2006, by land class, sample status, owner group

Table 2—Estimated area of forest land, by owner class and forest land status, Washington, 2002–2006

Table 3—Estimated area of forest land, by forest type group and productivity class, Washington, 2002–2006

Table 4—Estimated area of forest land, by forest type group, owner group, and land status, Washington, 2002–2006

Table 5—Estimated area of forest land, by forest type group and stand size class, Washington, 2002–2006

Table 6—Estimated area of forest land, by forest type group and stand age class, Washington, 2002-2006

Table 7—Estimated area of timberland, by forest type group and stand size class, Washington, 2002-2006

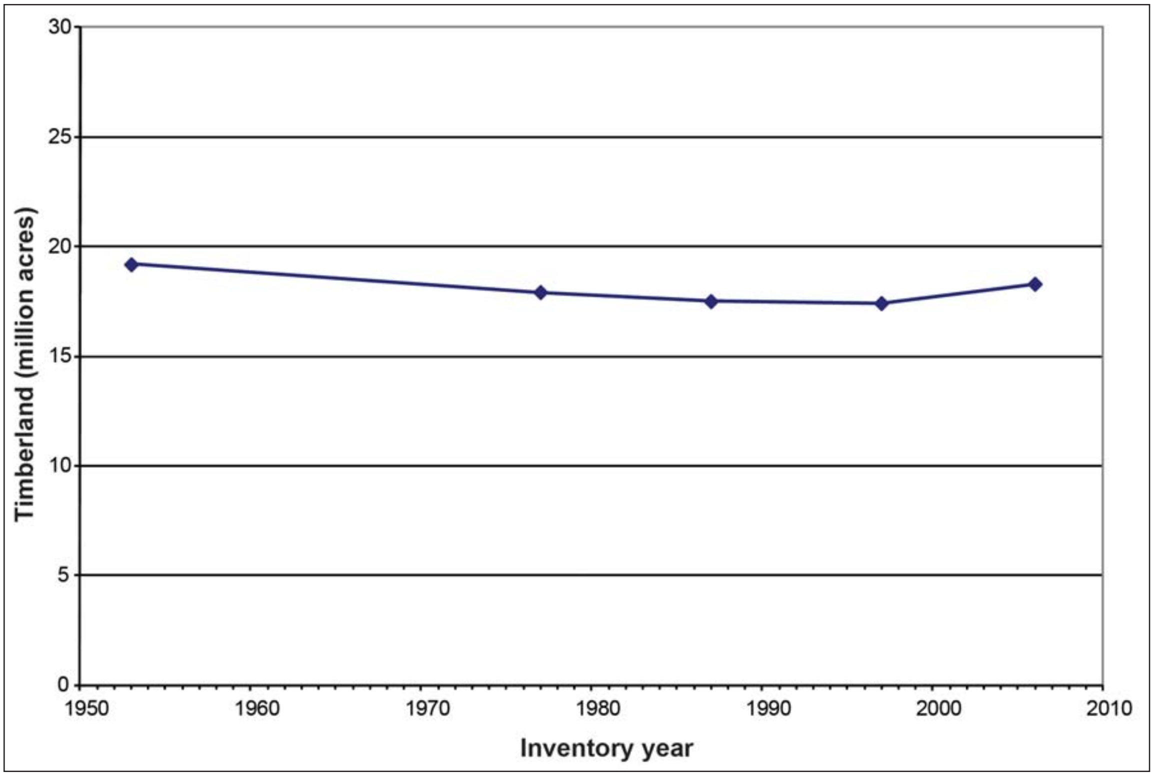


Figure 14—Area of timberland in Washington by inventory year (Smith et al. 2004), 1953–2005. Note: The 2002–2006 timberland area estimate is based on the annual inventory design and protocols; the previous area estimates are based on periodic inventories with different designs and protocols. Key differences between current and previous estimates, apart from real change, are due in large part to (1) application of plot stockability factors and stockable proportions to different sets of plots in the periodic and annual inventories, which affects the classification of a plot as timberland or not, and (2) changes in definitions and protocols arising from national standardization of the inventory for qualification as tree, forest land, reserved land, and timberland.

Ownership[4]

Background

The management and use of western forests often depends on their ownership, and management intentions differ between owners. Federal owners must consider multiple management objectives including water, wildlife, recreation, conservation, biological diversity, and wood products, whereas corporate and other private owners often focus on outcomes that are more specific such as aesthetics, wood production, or real estate investment (fig. 15).

[4] Author: Dave Azuma.

Findings

The federal government manages about 44 percent of Washington's 22.4 million acres of forested land. The National Forest System (NFS) and the National Park Service (NPS) administer most of this acreage (fig. 16). The state also has substantial holdings, mostly managed by the Washington Department of Natural Resources (WDNR) with about 2.5 million acres.

Public ownership—
Land administered by the federal government tends to be at higher elevations and to contain older forests. Federal forests typically contain bigger trees on less productive sites; about 8 percent of federal forest land is considered highly productive (capable of producing more than 165

Figure 15—Almost 10 million acres are privately owned in Washington.

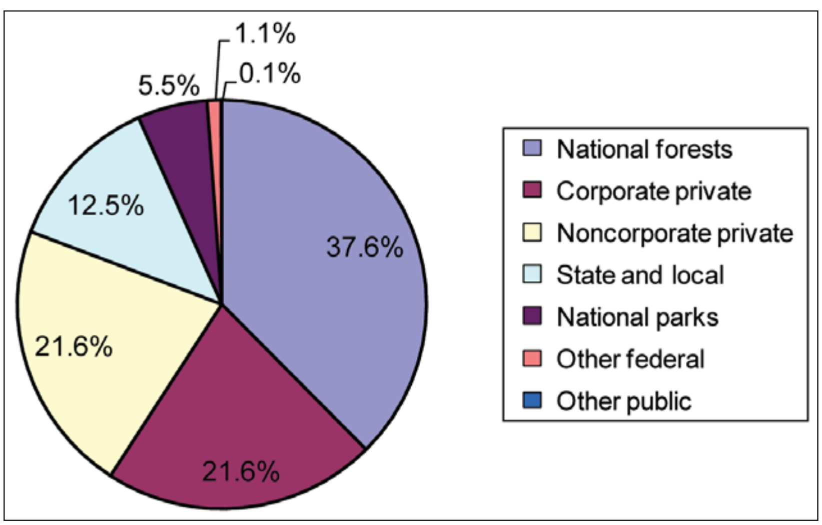


Figure 16—Percentage of forest land area in Washington, by owner group, 2002–2006.

cubic feet per year) and 23 percent of private lands fall into that category. State lands have roughly 31 percent in the high productivity class.

The majority of stands over 100 years old are in national forests (fig. 17), many of them in reserved areas. Federal owners manage the vast majority of the 3.7 million acres of reserved forest lands (those withdrawn by law from production of wood products). Reserved lands are distributed among Forest Service wilderness areas; the Olympic, North Cascades, and Mount Rainer National Parks; Mount St. Helens National Volcanic Monument; and state parks. Many of these reserves contain high-elevation forests that are ecologically and scenically unique. The reserved forest tends to be in older age classes; over 66 percent (2.4 million acres) of reserved forest land contains stands older than 100 years as opposed to 22 percent of the nonreserved forest land.

Although the majority of federal land does not meet the FIA definition of legally reserved, a substantial fraction of it cannot be considered available for wood production. Congressionally reserved land accounts for 26 percent of the 8.4 million acres of national forest land. Other administratively withdrawn areas within the NFS, including but not limited to riparian and late-successional reserves, may not be available for production of wood products. These congressionally and administratively withdrawn areas may produce some wood products, but they are managed primarily for other objectives.

Beginning in the late 1980s, the management emphasis on federal forests began to shift away from primarily wood production. The average contribution of federal forests to Washington's total annual harvest decreased from 19 percent average between 1965 and 1990 to 4 percent between 1991 and 2002 (see "Removal" section in chapter 5).

Other publicly owned forest lands include forests administered by other federal agencies, such as the U.S. Fish and Wildlife Service, the Bureau of Land Management (BLM), and the Department of Defense. The majority of other public lands are those administered by the WDNR with about 2.5 million acres.

Private ownership—
Private owners include families, individuals, conservation and natural resource organizations, unincorporated partnerships, associations, clubs, corporations, and Native American tribes. Excluding the Native American owners, the vast majority of the noncorporate owners own parcels of 500 or fewer acres, and over 70 percent of them use the land as their primary residence. Most noncorporate owners are older than 50 (Butler et al.

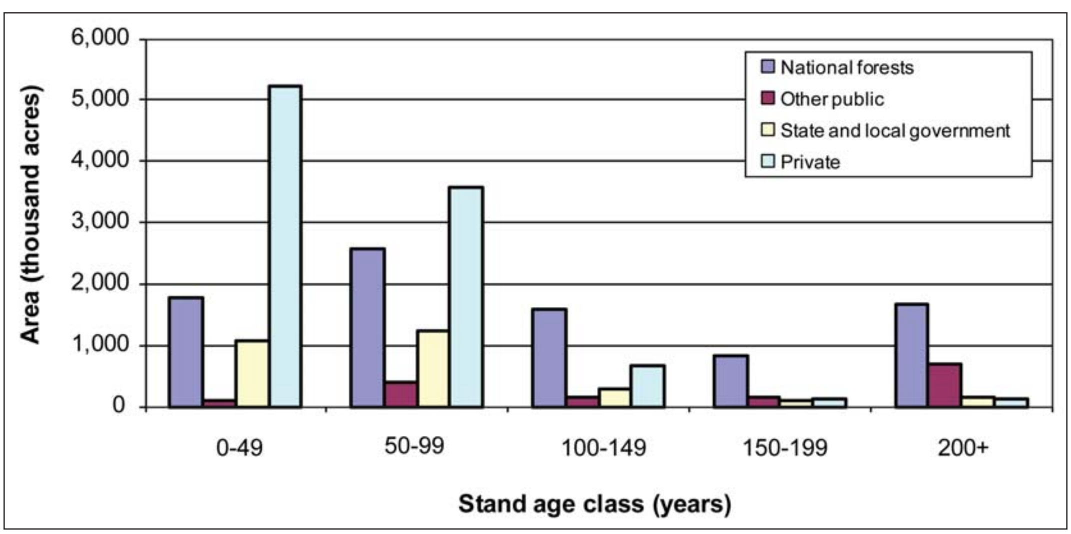


Figure 17—Area of forest land group in Washington, by owner group and age class, 2002–2006.

2005), suggesting that these lands will change ownership or be passed to other generations in the next 20 to 40 years. Private lands tend to contain a higher proportion of productive land, and the forests tend to be in younger age classes. Although these lands have no official reserved status, some environmental protection is conferred by various state and federal laws.

The character of corporate forest ownership has changed in recent years. Some large, publicly owned timber companies have transitioned into real estate investment trusts (REITs) and timberland investment management organizations (TIMOs). The REITs and TIMOs own forest land as investment vehicles that compete with and complement alternative investments; these entities may or may not own wood-processing facilities. The difference between them is that REITs directly own forest land, whereas TIMOs manage lands owned by investors.

Interpretation

Because the forest products industry is one of the leading economic drivers in Washington, the management choices made and the constraints placed on harvest for Washington’s forests significantly affect the state’s economy. As the NFS has moved toward a greater emphasis on nonwood resources, timber production has been shifted onto other public and private lands. Because noncorporate forest landowners are aging, and because a high proportion of noncorporate forest lands are used as primary residences, these lands may be less available to provide timber products in the future.

It is unclear what the ownership shift from forest products companies to TIMOs and REITs means for the management of Washington’s corporate forests. As these owners pursue higher returns, it is possible that more land will be converted to nonforest uses. The level of forestry research funding provided by timber companies may be changing as well. If investment returns can be linked to continued research, companies will likely continue to support research. In this regard, TIMOs and REITs are active members of industry organizations and research cooperatives.

Ownership Tables in Appendix B

Table 2—Estimated area of forest land, by owner class and forest land status, Washington, 2002–2006

Table 4—Estimated area of forest land, by forest type group, owner group, and land status, Washington, 2002–2006

Family-Owned Forests: A Survey[5]

The National Woodland Owner Survey, a questionnaire-based survey conducted by FIA, provides some insight into private family forest owners and their concerns, their current use and management, and their future intentions for their forests (fig. 18) (Butler et al. 2005). In Washington, 99.5 percent of family owners surveyed between 2002 and 2006 own parcels of 500 or fewer acres; these owners account for 84 percent of the family-owned forest land acres (fig. 19). Only about 13 percent of the surveyed owners had written management plans, and participation in programs such as sustainable forest certification (green certification) or cost-share was low (less than 3 percent). The greatest concerns of respondents were development of nearby lands, high property taxes, and misuse of forest land; other concerns were trespassing or poaching, keeping lands intact for heirs, damage or noise from motorized vehicles, and dealing with endangered species. Plans for forest land differ; 3 to 8 percent of surveyed owners planned to sell, subdivide, or convert their forests.

Joseph Donnegan

Figure 18—Family forest owners in Washington manage their lands for a variety of objectives.

Family forest land ownership will certainly change as owners age and pass their land on to heirs who may or may not retain it as forest land. Average parcel size has gotten smaller over the last 20 years and probably will continue to do so. Land use laws and regulations will influence the rate of conversion or subdivision.

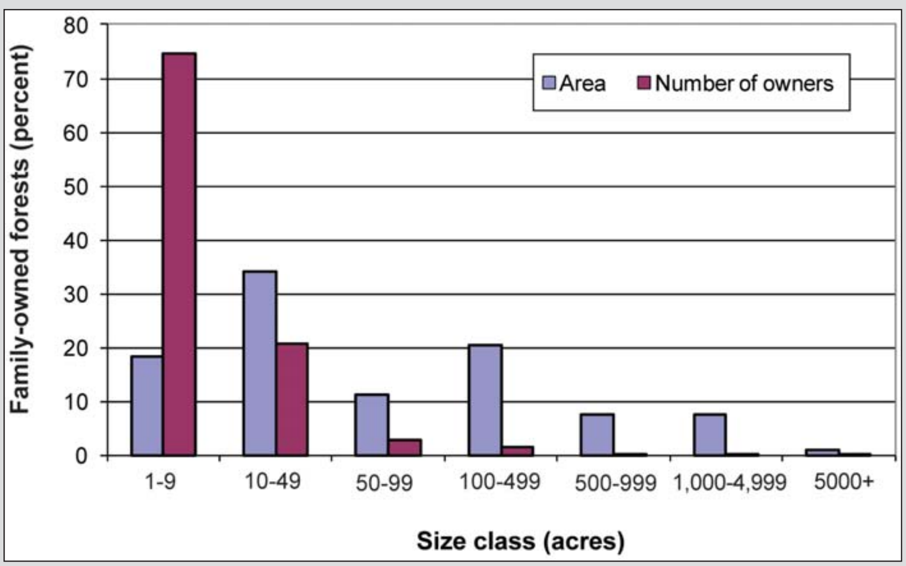


Figure 19—Percentage of area and percentage of family-owned forest holdings in Washington, by size class, 2006.

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[5] Author: Sally Campbell.

The ownership survey revealed the following demographics of Washington family forest landowners:

- 71 percent are older than 55 years.
- 31 percent have earned a bachelor's or graduate college degree.
- 88 percent are Caucasian.
- 65 percent are male (does not include joint male/female owners).
- 47 percent have owned their land for more than 25 years.
- 80 percent use their land as their primary residence.
- About 19 percent have harvested timber, firewood, posts or poles, or nontimber forest products from their land in the 5 years preceding the 2002–2006 survey.

Volume[6]

Background

The current volume of live trees provides the foundation for estimating several fundamental attributes of forest land, such as biomass, carbon storage, and capacity for provision of wood products (fig. 20). Forest volume, when placed in the context of stand age and disturbance history, can be an indicator of forest productivity, structure, and vigor, which together serve as a broad indicator of forest health. Species-specific equations that include tree diameter and height are used to calculate individual tree volumes; these are summed across all trees to provide

Andy Gray

Figure 20—The highest volume of wood is found on older forests on federal lands.

[6] Author: Glenn Christensen.

estimates for different geographic areas. The net volume estimates provided in this report for live trees do not include volume of any observed tree defects such as rotten and missing sections along the stem.

Findings

Washington has approximately 95 billion net cubic feet (413 billion board feet, Scribner) of wood volume on forest land (all owners, reserved and unreserved) with a mean volume of about 4,231 cubic feet (18,433 board feet) per acre. The greatest proportion of this volume is from softwood tree species such as Douglas-fir, western hemlock, and true firs (see "Common and Scientific Plant Names" section), which collectively make up 73 percent of all live-tree volume on Washington forest land (fig. 21). Hardwood species such as red alder, maple, and oak make up 7 percent of live-tree volume.

The majority (43 percent) of live-tree volume is on Forest Service land (fig. 22). Most of the remaining volume is fairly evenly distributed between other federal government (15 percent), state and local governments (15 percent), noncorporate private (including Native American tribal lands) (14 percent), and corporate (13 percent) owners. Federal and state forest land tends to have more volume per acre, on average, than privately owned forest land (fig. 23).

Forest land volume by survey unit—
Most forest land wood volume is in the heavily forested western half of the state (fig. 24). The west-side survey units (Puget Sound, Olympic Peninsula, and Southwest)

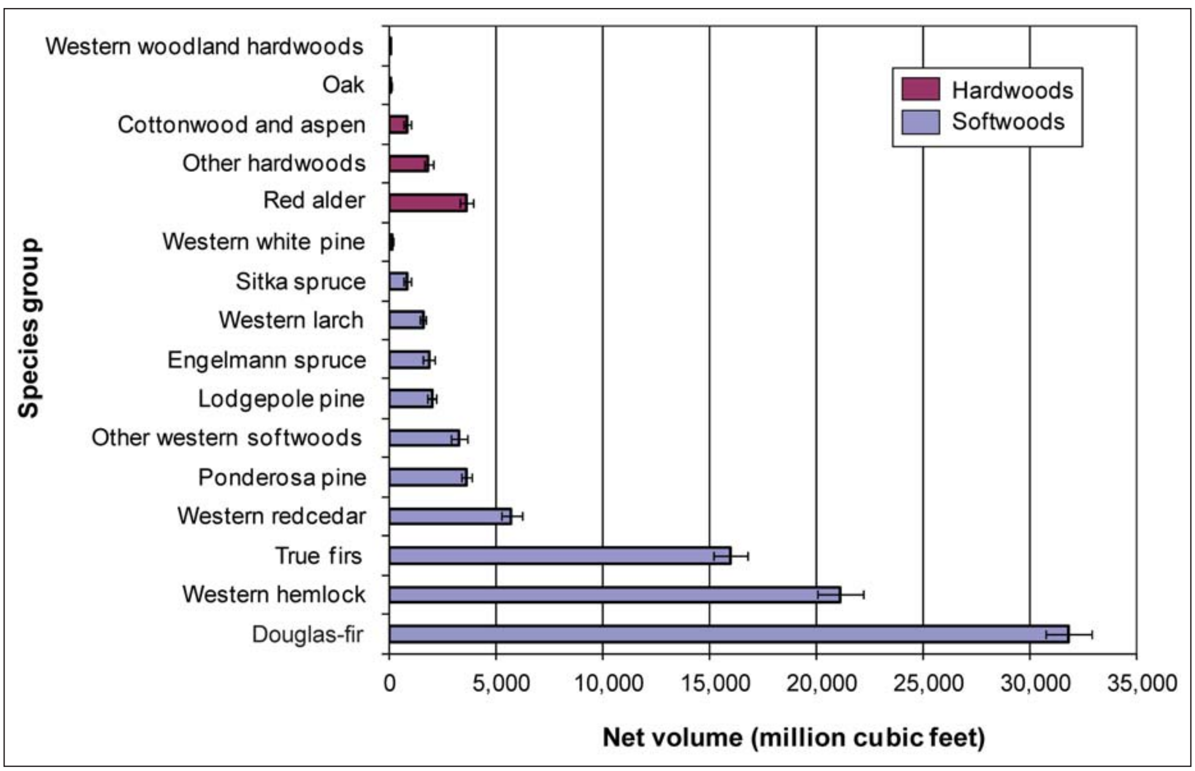


Figure 21—Net volume of all live trees on forest land in Washington, by species group, 2002–2006. Lines at end of bars represent ± standard error.

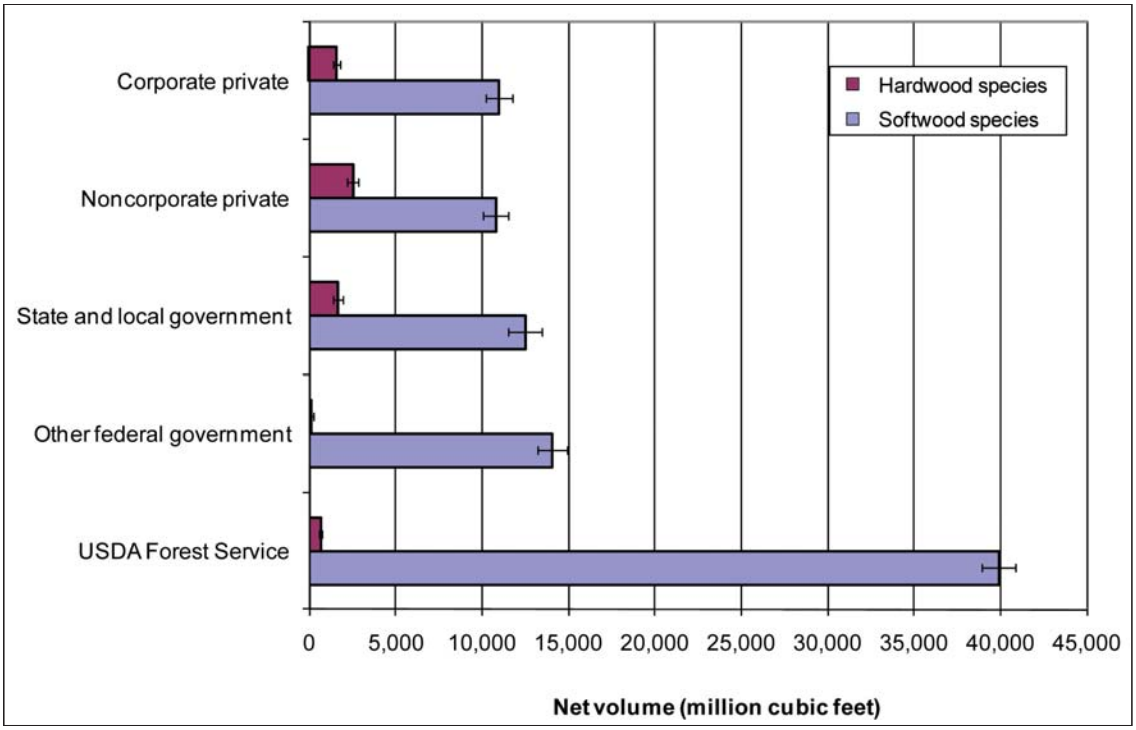


Figure 22—Net volume of all live trees on forest land in Washington, by owner group, 2002–2006. Lines at end of bars represent ± standard error.

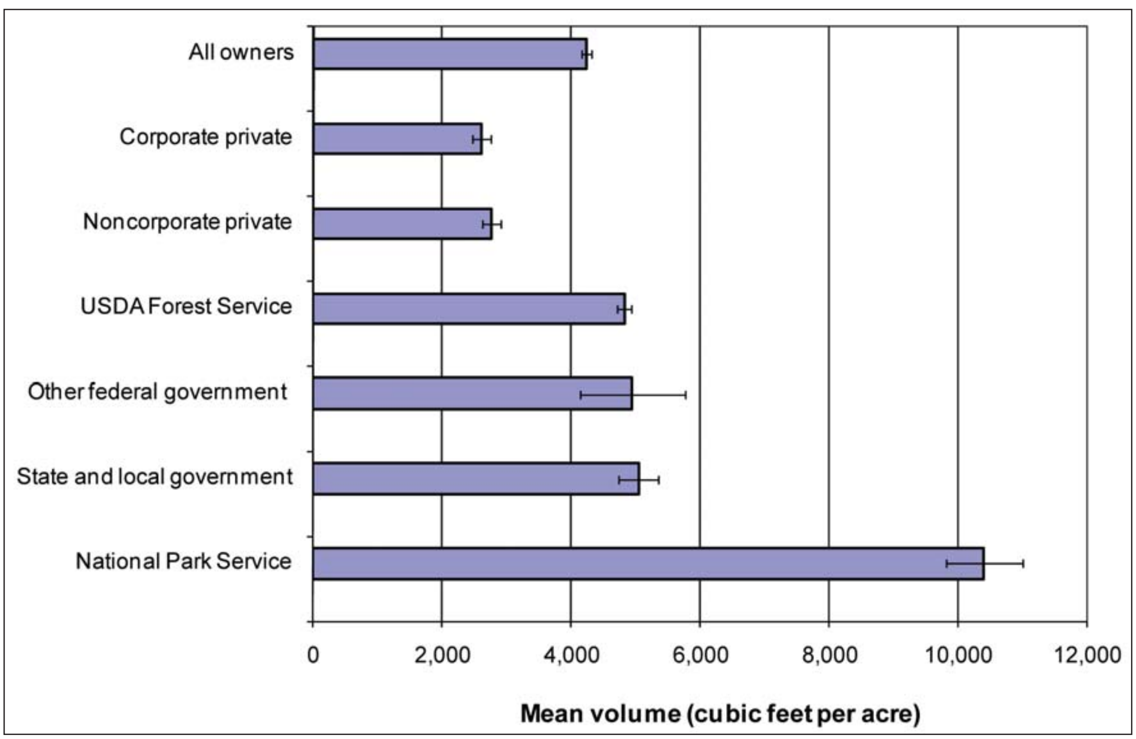


Figure 23—Mean net volume per acre of all live trees on forest land in Washington, by owner group, 2002–2006. Lines at end of bars represent ± standard error.

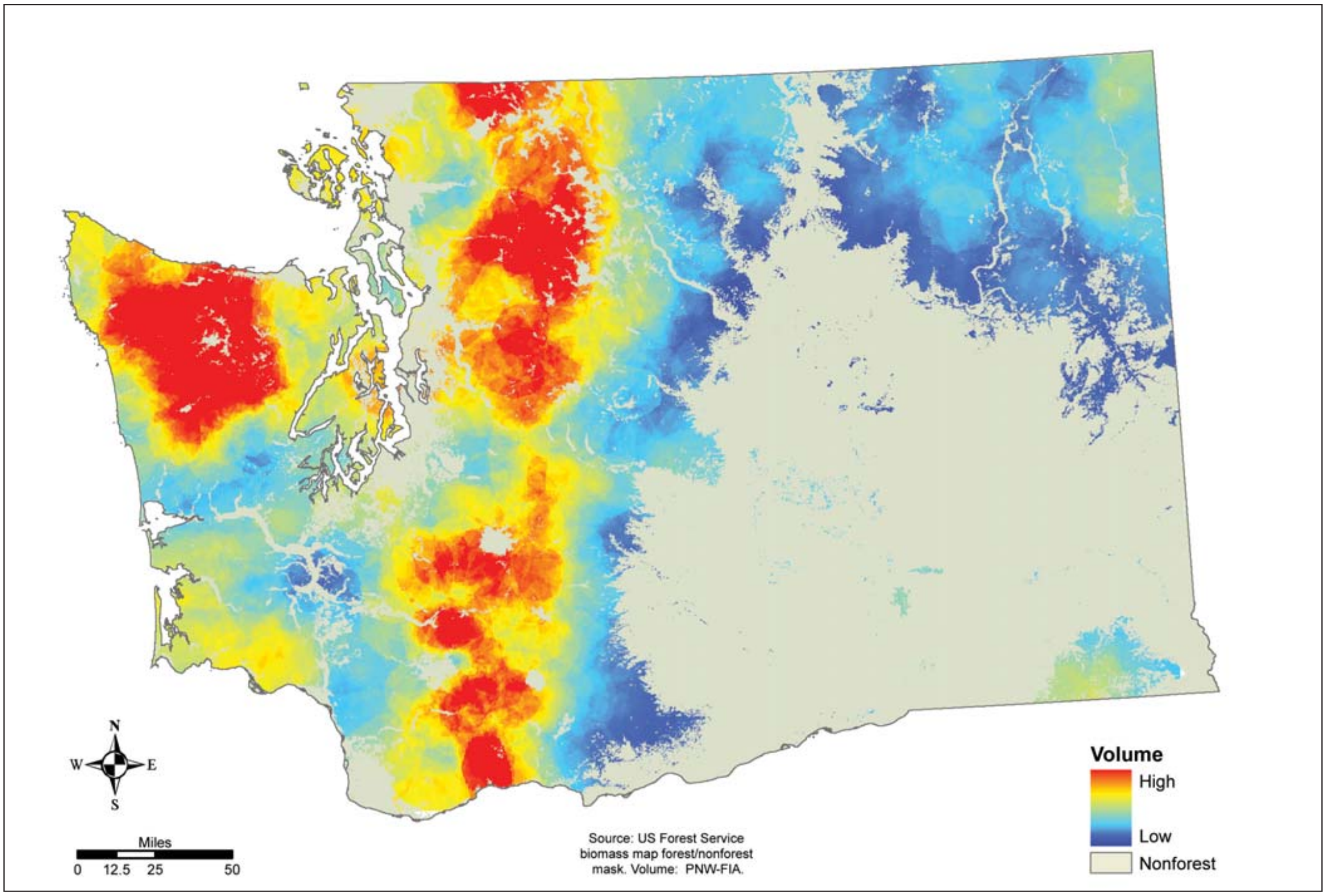


Figure 24—Estimated live-tree volume (net ft^3/acre), Washington, 2002-2006. Red color indicates higher predicted per-acre volumes. Estimates are kriged predictions of likely volume per acre on forest land; predictions are based on estimates of mean net cubic-foot volume per plot (forest/nonforest geographic information system layer: Blackard et al. 2008).

(fig. 8) account for approximately 73 percent of all live-tree cubic-foot wood volume. The high productivity of these west-side forests is apparent in their high volume-per-acre estimates:

Survey unit	Total volume (SE[a])			Mean volume per acre (SE)	
	Billion cubic feet	*Billion board feet (Scribner)*	*Percent*	*Cubic feet*	*Board feet (Scribner)*
Puget Sound	27 (1)	118 (6)	28	6,042 (222)	26,553 (1,185)
Olympic Peninsula	23 (1)	104 (6)	25	5,876 (262)	25,119 (1,425)
Southwest	19 (0.8)	80 (4)	20	4,934 (196)	20,430 (965)
Central	16 (0.7)	72 (4)	17	2,649 (105)	11,996 (583)
Inland Empire	9 (0.4)	39 (2)	10	2,293 (85)	9,568 (441)
Total	95 (1.8)	413 (10)	100	4,231 (80)	18,433 (420)

Note: Includes all ownerships, reserved, and unreserved land.

[a]SE = standard error.

Forest land volume by diameter class—

For both softwoods and hardwoods, trees 5 to 20.9 inches diameter at breast height (d.b.h.) contain approximately 54 percent of all live tree volume (fig. 25). An estimated 14 percent of live tree volume is in the largest diameter class of trees (≥37.0 inches d.b.h.); nearly all these trees are softwoods. Federal lands tend to have a greater proportion of acres in the oldest forests (fig. 17; also see "Ownership" section in this chapter), which contain the highest volumes of wood. Ownership categories can thus be arrayed along a gradient of diameter class (fig. 26). A similar trend is found for tree size: the proportion of volume by ownership changes along the gradient from smaller to larger trees. Within the smallest diameter class, 41 percent of the volume is on national forests and 23 percent is on corporate forest land. In contrast, 48 percent of the volume within the largest diameter group (≥33.0 inches d.b.h) is on national forests and 2 percent is on corporate forest land.

Forest land volume by species group—

Over 80 percent of live-tree volume on Washington's forest land is in five major softwood species groups: Douglas-fir, western hemlock, true firs, western redcedar, and ponderosa pine. Approximately 34 percent of all live-tree volume is in Douglas-fir (fig. 21). The western hemlock species group accounts for about 22 percent of live tree volume, the true fir species group accounts for about 17 percent, the western redcedar species group accounts for about 6 percent, and the ponderosa pine group accounts for about 4 percent. Of the hardwood species, red alder accounts for the most hardwood volume statewide (about 56 percent) and makes up 4 percent of the total cubic-foot wood volume for all species.

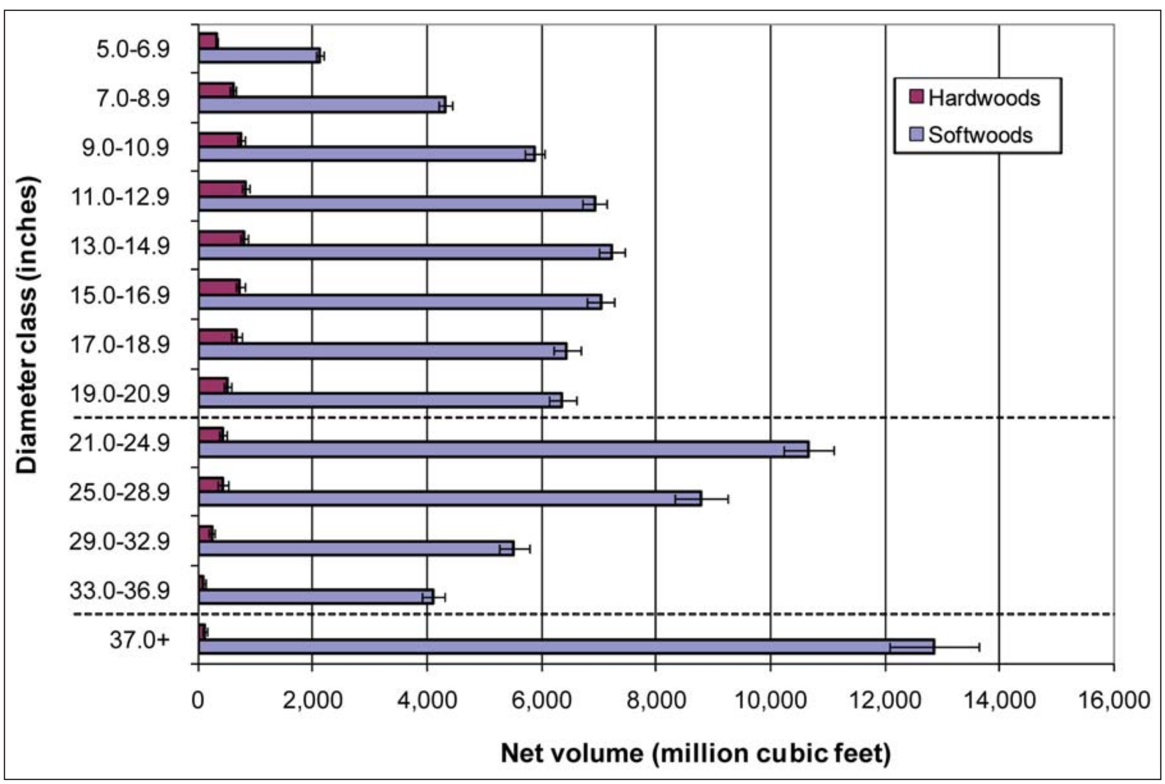


Figure 25—Net volume of all live trees on forest land in Washington, by diameter class, 2002–2006. Lines at end of bars represent ± standard error.

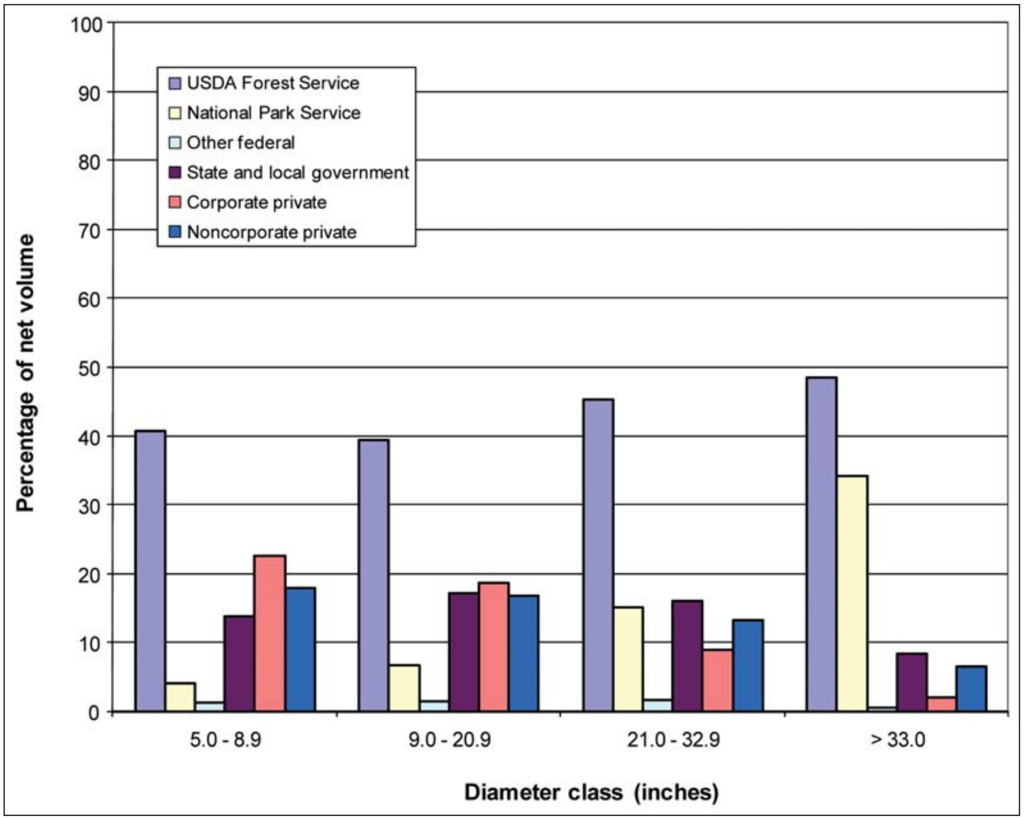


Figure 26—Percentage of net volume (ft^3) of all live trees on forest land in Washington, by diameter class and owner group, 2002–2006.

Net volume of sawtimber-sized trees on timberland[7]**—** Douglas-fir accounts for 41 percent of the net cubic-foot volume from sawtimber-sized trees on timberland (fig. 27); the western hemlock group accounts for about 21 percent, the true fir group accounts for 12 percent, the western redcedar group accounts for 6 percent, and the ponderosa pine group accounts for 5 percent. This volume is potentially available for manufacturing wood products. Among the hardwood species, red alder contributes the most to sawtimber volume and represents about 4 percent of total sawtimber volume for all species in Washington.

[7] Sawtimber trees are commercial species trees large enough to produce usable logs (9.0 inches d.b.h. minimum for softwoods, 11.0 inches d.b.h. minimum for hardwoods), from a 1-foot stump to a minimum top diameter (7.0 inches outside bark diameter for softwoods, 9.0 inches outside bark diameter for hardwoods).

Interpretation

Statewide estimates of timber volume over the past 50 years show an overall increase from the 1953 inventory (Smith et al. 2004) to the current inventory estimate (2002-2006) reported here (fig. 28). As with our estimate of timberland area, the current estimate of volume is partly confounded by differences between the previous periodic and recent annual inventory methods in distinguishing timberland from other forest, and the lack of consistent data over time on national forest lands. However, we found no major departures from prior volume estimates grouped according to survey units traditionally used by FIA for Washington

Most of the volume is found in the moist forests of the west-side units, the Puget Sound, Olympic Peninsula, and Southwest (fig. 7). Overall, the tree species contributing the most to total volume on forest land are Douglas-fir, western hemlock, true firs, western redcedar, ponderosa

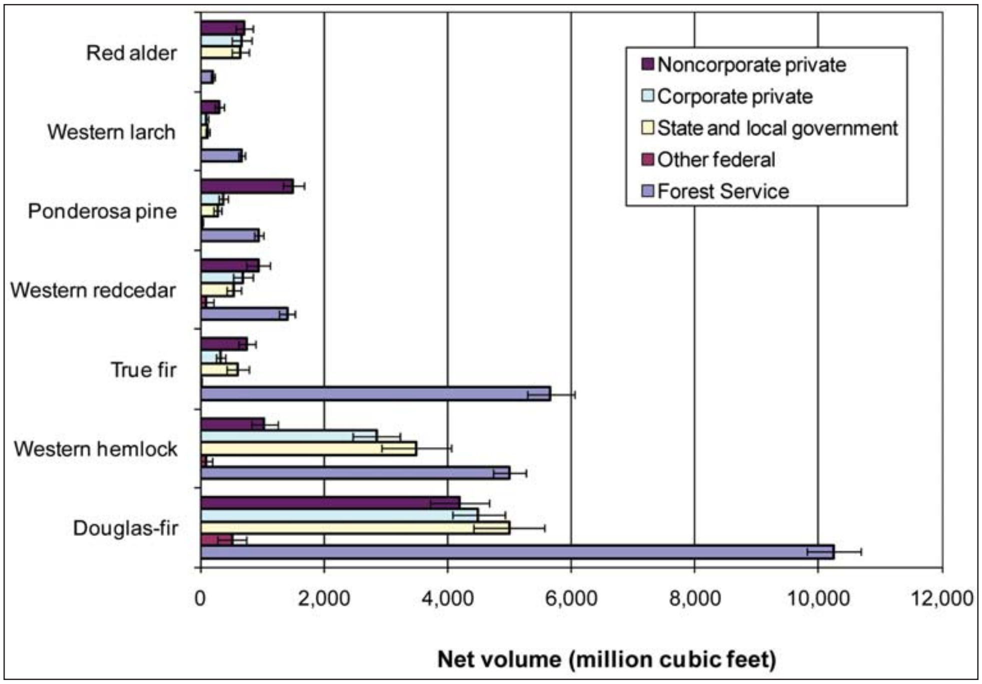


Figure 27—Net volume of sawtimber-sized trees on timberland in Washington, by owner group, 2002–2006. Excludes miscellaneous mixed softwood and hardwood species groups and species groups that contribute <1 percent of total sawtimber volume. Lines at end of bars represent ± standard error.

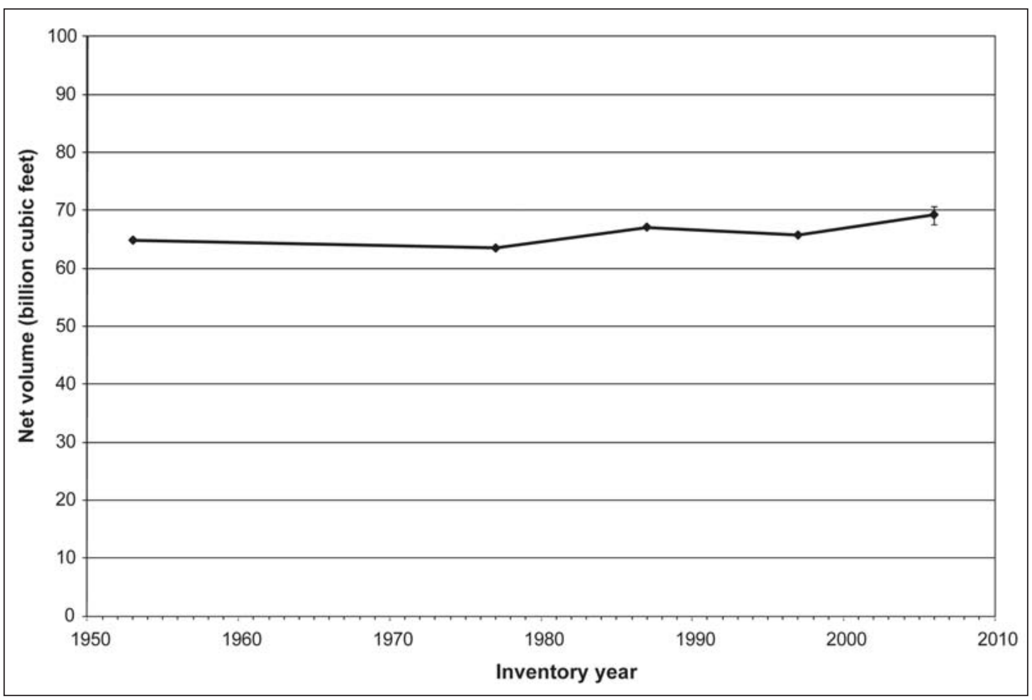


Figure 28—Net volume of growing stock on timberland in Washington, by inventory year (Smith et al. 2004), 1953–2005. Note: The 2002-2006 timberland volume estimate is based on the annual inventory design and protocols; the previous volume estimates are based on periodic inventories with different designs and protocols. Key differences between current and previous estimates, apart from real change, are due in large part to (1) application of plot stockability factors and stockable propor-tions to different sets of plots in the periodic and annual inventories, which affects the classification of a plot as timberland or not, and (2) changes in definitions and protocols arising from national standardization of the inventory for qualification as tree, forest land, reserved land, and timberland.

pine, and red alder, which are also the most important commercial species. Continued measurement of FIA plots will allow tracking of forest volume estimates that are useful for monitoring a wide variety of resource attributes.

Volume Tables in Appendix B

Table 8—Estimated number of live trees on forest land, by species group and diameter class, Washington, 2002-2006

Table 9—Estimated number of growing-stock trees on timberland, by species group and diameter class, Washington, 2002-2006

Table 10—Estimated net volume of all live trees, by owner class and forest land status, Washington, 2002-2006

Table 11—Estimated net volume of all live trees on forest land, by forest type group and stand size class, Washington, 2002-2006

Table 12—Estimated net volume of all live trees on forest land, by species group and owner group, Washington, 2002-2006

Table 13—Estimated net volume of all live trees on forest land, by species group and diameter class, Washington, 2002-2006

Table 14—Estimated net volume of growing-stock trees on timberland, by species group and diameter class, Washington, 2002-2006

Table 15—Estimated net volume of growing-stock trees on timberland, by species group and owner group, Washington, 2002-2006

Table 16—Estimated net volume (International ¼-inch rule) of sawtimber trees on timberland, by species group and diameter class, Washington, 2002-2006

Table 17—Estimated net volume (Scribner rule) of sawtimber trees on timberland, by species group and diameter class, Washington, 2002-2006

Table 18—Estimated net volume (cubic feet) of sawtimber trees on timberland, by species group and owner group, Washington, 2002-2006

Biomass and Carbon[8]

Background

Forest biomass and carbon accumulate in live trees, snags, and down wood in a mosaic of patterns across Washington (fig. 29). During forest succession (the aging and maturing of a forest stand), plant biomass builds up at different rates, sequestering atmospheric gases (principally carbon dioxide) and soil nutrients into woody tree components over time (Perry 1994). Biomass estimates from comprehensive forest inventories are essential for quantifying the amount and distribution of carbon stocks, evaluating forests as a source of sustainable fuel (biomass for energy production), and conducting research on net primary productivity (Houghton 2005, Jenkins et al. 2001, Whittaker and Likens 1975).

In this chapter, we focus on the aboveground live-tree components of forest biomass and make brief comparisons with dead-wood biomass, which is addressed more fully in the "Dead Wood" section in chapter 3. Cubic-foot volume and specific gravity constants for each species were used to compute the dry weight of the entire tree stem (all references to weight in this section are in bone-dry, or oven-dry, tons). Stem biomass was combined with branch biomass to compute the total aboveground dry weight of the tree. Carbon mass was estimated by applying conversion factors to the biomass estimates.

Karen Waddell

Figure 29—Biomass estimates are useful for analysis of productivity, carbon sequestration, and utilization studies, and for general reporting for various criteria and indicator assessments.

[8] Author: Karen Waddell.

The discussion that follows focuses on an analysis of total aboveground (including whole stem and branches, and excluding foliage) biomass and carbon of live trees on forest land in Washington.

Findings

Over 1.8 billion tons of biomass and almost 1 billion tons of carbon are present in live trees (≥1 inch d.b.h.) primarily on timberland managed by the U.S. Forest Service (fig. 30). Reserved forest land, such as wilderness areas and national parks, contains about 489 million tons of biomass, just over 26 percent of the state total. Statewide, softwood forest types have 12 times the amount of live tree biomass and carbon of hardwood types, with biomass estimates ranging from a low of 0.3 million tons in the western white pine type to a high of 700 million tons in the Douglas-fir type (fig. 31). The dominant hard-wood type is alder/maple, accounting for 120 million tons of live-tree biomass in Washington's forests.

Because Douglas-fir is the most abundant tree species in Washington, it is no surprise that it dominates the biomass and carbon figures. The 641 million tons of Douglas-fir biomass represents about 334 million tons of carbon sequestered in live trees. Live biomass is heavily concentrated in trees larger than 21 inches d.b.h. (fig. 32), a trend especially pronounced for softwood species. As a group, softwoods have almost 47 percent of the live tree biomass in this class alone. In contrast, biomass of hardwood species is fairly evenly distributed among trees ≥5 inches d.b.h., and only 19 percent of the total biomass is contained in the larger 21-inch class (fig. 32).

A comparison of live trees and dead wood biomass shows that snags ≥5 inches d.b.h. add 158 million tons, coarse woody material (CWM; defined as material ≥3 inches in diameter at the large end) adds 361 million tons of biomass, and fine woody material (FWM; defined as material <3 inches in diameter at the point of intersection with the sample transect) adds 108 million tons of biomass to the forest. Total estimated biomass in live trees and dead wood across Washington is 2.5 billion tons.

Stored carbon was about half that amount (1.3 billion tons), with about 1 billion tons found in live trees, almost 82 million tons found in snags, and 243 million tons stored as down wood (CWM and FWM combined). Softwood types store about 1.1 billion tons of carbon, of which 79 percent is in live trees, 15 percent in CWM, and

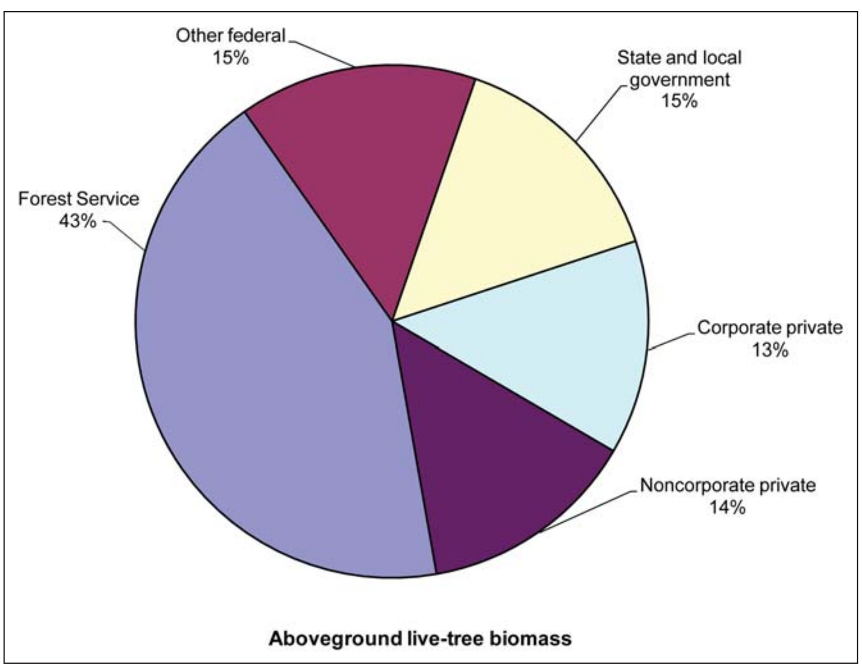


Figure 30—Aboveground live-tree biomass on forest land in Washington, by owner group 2002–2006.

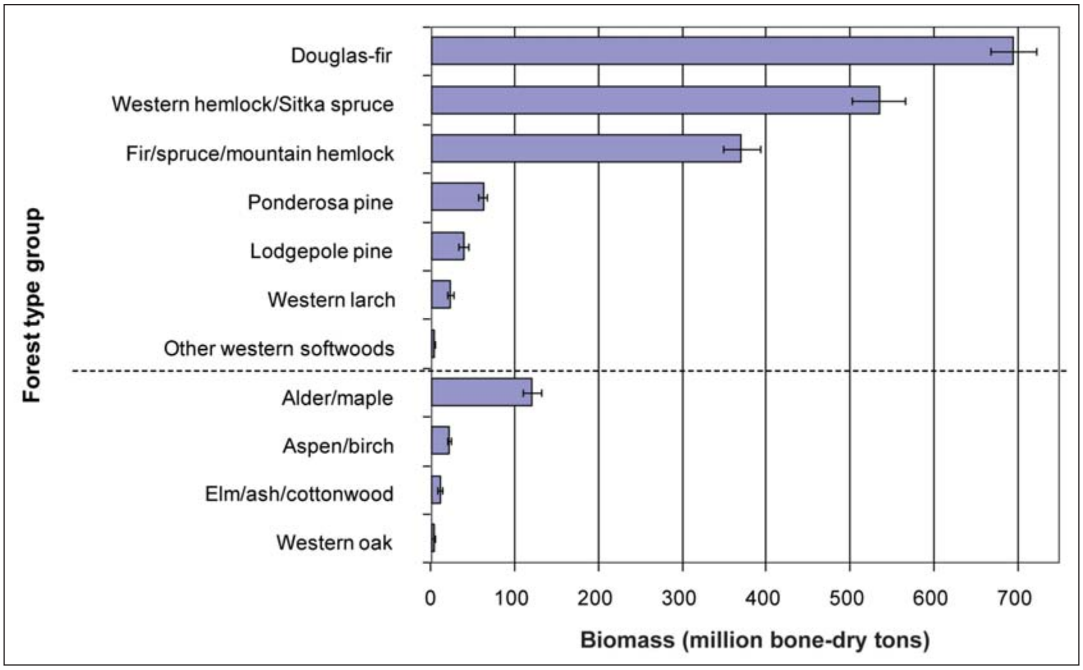


Figure 31—Aboveground live-tree biomass on forest land in Washington, by forest type group, 2002–2006. Lines at end of bars represent ± standard error.

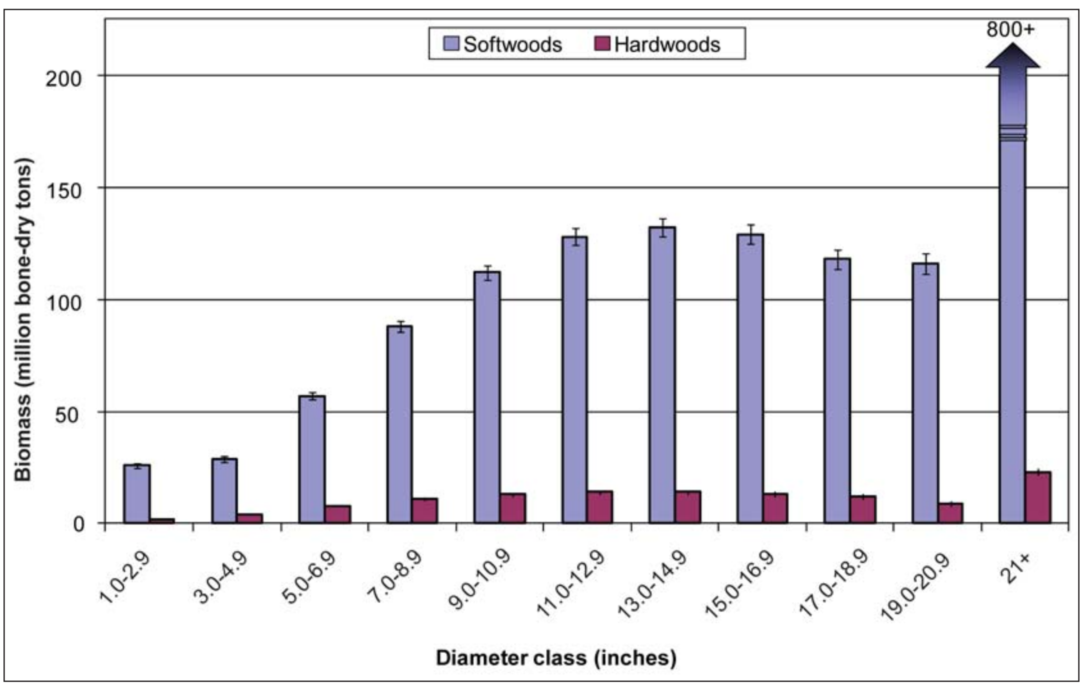


Figure 32—Aboveground live-tree biomass on forest land in Washington, by diameter class, 2002–2006. Lines at end of bars represent ± standard error.

6 percent in snags (fig. 33). The bulk of carbon is stored in the Douglas-fir forest type, and the smallest amount is in the western white pine type.

On average, the combined live and dead (snags and CWM) biomass amounted to an estimated 107 tons per acre, and the carbon mass amounted to about 55 tons per acre (fig. 34). The western hemlock/Sitka spruce type had almost twice the state average, with a mean of over 206 tons per acre of biomass and 107 tons per acre of carbon.

Interpretation

Substantial quantities of forest biomass and carbon are present in Washington forests. The current rising interest in biomass as an alternative source of energy will accelerate the need to understand how much source material is available and where it is located. The FIA inventory shows that there is almost three and one-half times as much live-tree biomass as dead-wood biomass. This is important because the preferred source of material for energy production comes from components of the live-tree resource, such as wood residues from harvest operations and sawmills, forest thinning, and biomass plantations. For example, in northern California, a small energy company operates a wood-fired powerplant that uses local mill wastes, chips, and unmerchantable whole logs to generate over 375 million kilowatt-hour (kWh) of electricity per year. With an estimated consumption rate of about 13,259 kWh per capita in Washington (California Energy Commission 2008) this is enough power for 28,000 people or about 14,000 two-person households.

As a market in carbon credits develops, the amount of carbon stored in forests may be used to help offset carbon released from urban or industrial sites. For such a system to function effectively, it will be important to monitor the various carbon pools. Resource managers can then make adjustments to stocks (such as planting trees or improving forest health) if live-tree carbon is lost to forest conversion, extensive insect outbreak, fire, harvest, or some

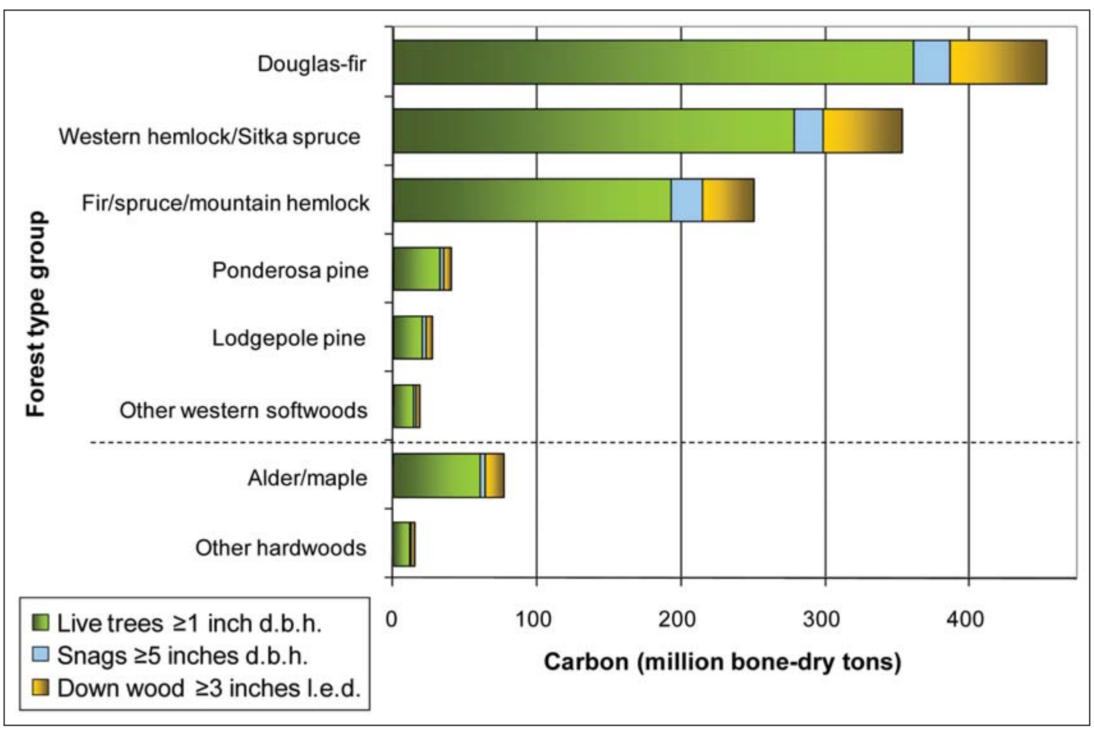


Figure 33—Carbon mass of live trees, snags, and down wood on forest land in Washington, by forest type group, 2002–2006; d.b.h. = diameter at breast height; l.e.d. = large-end diameter.

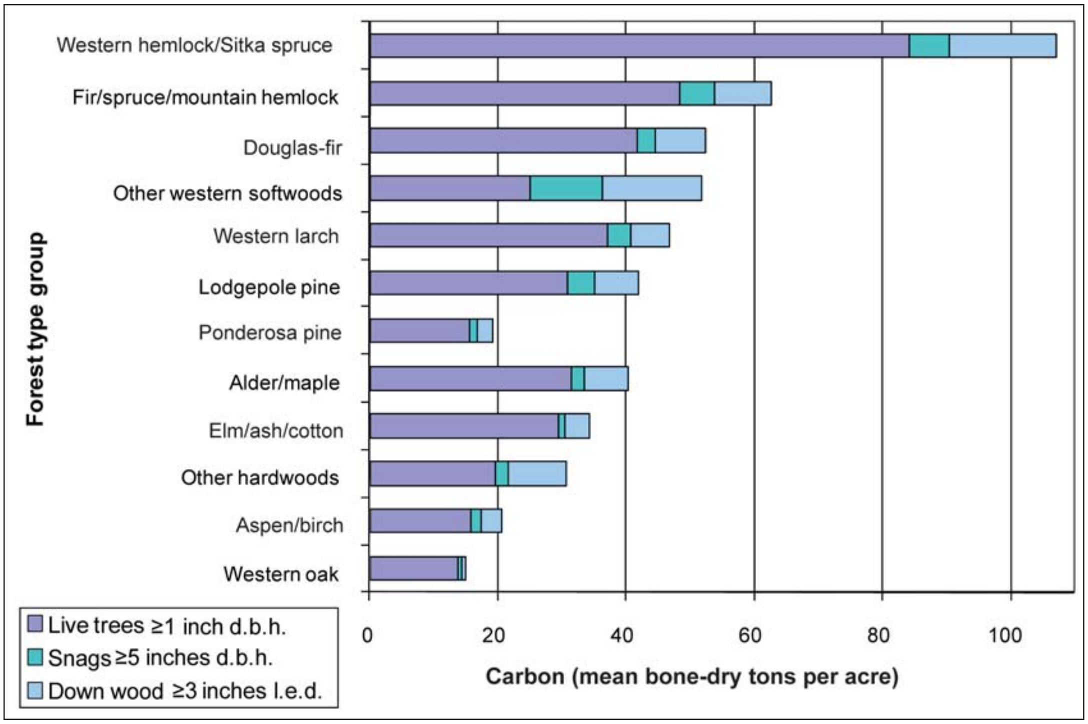


Figure 34— Carbon mass per acre of live trees, snags, and down wood on forest land in Washington, by forest type group, 2002-2006; d.b.h. = diameter at breast height; l.e.d. = large-end diameter.

other disturbance. When trees are harvested for solid wood products, monitoring activities must recognize this shift in carbon storage and account for the carbon sequestered within buildings, furniture, and other structural materials. Over time, the desired outcome is that Washington's forests become a net sink of stored carbon.

Biomass Tables in Appendix B

Table 19—Estimated aboveground biomass of all live trees on forest land, by owner class and forest land status, Washington, 2002-2006

Table 20—Estimated aboveground biomass of all live trees on forest land, by species group and diameter class, Washington, 2002-2006

Table 21—Estimated aboveground mass of carbon of all live trees on forest land, by owner class and forest land status, Washington, 2002-2006

Table 22—Estimated aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002-2006

Table 23—Average aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002-2006

Table 24—Estimated average biomass, volume, and density of down wood on forest land, by forest type group and diameter class, Washington, 2002-2006

Table 25—Estimated biomass and carbon mass of down wood on forest land, by forest type group and owner group, Washington, 2002-2006

Table 26—Estimated average biomass, volume, and density of snags on forest land, by forest type group and diameter class, Washington, 2002-2006

Table 27—Estimated biomass and carbon mass of snags on forest land, by forest type group and owner group, Washington, 2002-2006

Five-Needle Pines in Washington[9]

Five-needle pines, such as western white pine and white-bark pine, have diminished in abundance in Washington since the introduction in the early 1920s of white pine blister rust (*Cronartium ribicola* J.C. Fisch), a nonnative fungal disease from Asia. Western white pine is a component of many forest types in the Western United States and western Canada, growing in association with numerous other species, both woody and herbaceous (Graham 1990). It has long been valued as a commercial species, with widespread harvesting in the 20th century. By 1956, white pine blister rust had spread throughout the west coast region and had damaged or killed up to 95 percent of the original stands of western white pine (Liebold et al. 1995). Commercial harvesting and poor regeneration resulting from fire suppression have also contributed to its decline (Maloy 2001). Western white pine can still be found throughout western and eastern Washington (Graham 1990).

Whitebark pine plays a unique and important ecological role in the exposed high-elevation sites where it grows, contributing to soil and snow stabilization, wildlife hiding and thermal cover, and moderating microclimate conditions so that other species can establish within its vicinity (Arno and Hoff 1990). A number of wildlife species use the whitebark pine seeds as a food source; it enjoys a mutualistic relationship with the Clark's nutcracker (*Nucifraga columbiana*), depending on the bird to plant its seeds for regeneration (Tomback et al. 1990). White pine blister rust was first reported on whitebark pine in British Columbia in the 1920s (Hoff and Hagle 1990). Blister rust, mountain pine beetle (*Dendroctonus ponderosae* Hopkins), and poor regeneration owing to fire suppression have all con-tributed to a high mortality rate over the last 100 years.

[9] Authors: Sally Campbell and Andrew Gray.

Current blister rust infection rates are high for both species as illustrated below (2002–2006 annual inventory data):

	Live trees (>1 inch d.b.h.) with cankers[a]	Gross volume of live trees (>5 inch d.b.h.) with cankers[a]
	Percent	
Western white pine	23.99	13.81
Whitebark pine	24.47	33.04

[a] Cankers include those caused by white pine blister rust as well as those for which FIA field crews could not identify a causal agent. It is likely that the unidentified cankers were caused by blister rust.

Summaries of the area of white pine and whitebark pine forest types in the first comprehensive inventory of Washington (Andrews and Cowlin 1940, Cowlin et al. 1942) are not available because these types were usually grouped with subalpine forest types for reporting. Comparisons of volume of five-needle pine trees between the 1930s and 2006 can be made, but are approximate because inventory standards differ somewhat (e.g., 16-inch d.b.h. minimum for sawtimber in 1930s vs. 9-inch d.b.h. minimum in 2006). Nevertheless, the values suggest a dramatic decline in the abundance of five-needle pine forest types in Washington (estimates in 1930 are only available for both species combined).

The majority of the volume of five-needle pine species in the 1930s was found on the west side of the state; Cowlin and Moravets (1940) summarized the status of white pine as being "seriously depleted by many years of logging" in northeastern Washington and tending to be too scattered in mixed stands or at inaccessible high elevations to be of much commercial value. By 2006, the volume of both pine species combined in eastern Washington was similar and perhaps a bit higher, whereas the volume in western Washington was less than 10 percent of that estimated in the 1930s. The following tabulation shows tree volume of white pine and whitebark pine trees in the 1930s and 2006 in Washington:

	Species	1930s	2006
		Million board feet, Scribner	
Eastern Washington	White pine	nd[a]	522
	Whitebark pine	nd	224
	Both species	436	746
Western Washington	White pine	nd	192
	Whitebark pine	nd	1
	Both species	2,820	193
Total		3,256	939

[a] nd = no data available.

All of the whitebark pine recorded in 2002-2006 was at high elevations on the east side of the Cascade crest (fig. 35). Western white pine was also primarily found at high elevations, but substantial numbers were also found at lower elevations on both sides of the state (fig. 36). Seventy-nine percent of all white pine trees recorded in 2002-2006 were less than 5 inches d.b.h., compared to 57 percent for ponderosa pine and 46 percent for Douglas-fir, (app. B table 9) suggesting that the population is being maintained with reproduction by young trees before they succumb to blister rust (A. Gray, personal observation).

Survival of western white and whitebark pine is jeopardized by extremely high blister rust infection rates, bark beetle-caused mortality, and poor regeneration owing to fire suppression. Management options to maintain or preserve these two species include breeding and planting resistant stock and conducting prescribed fire in certain areas.

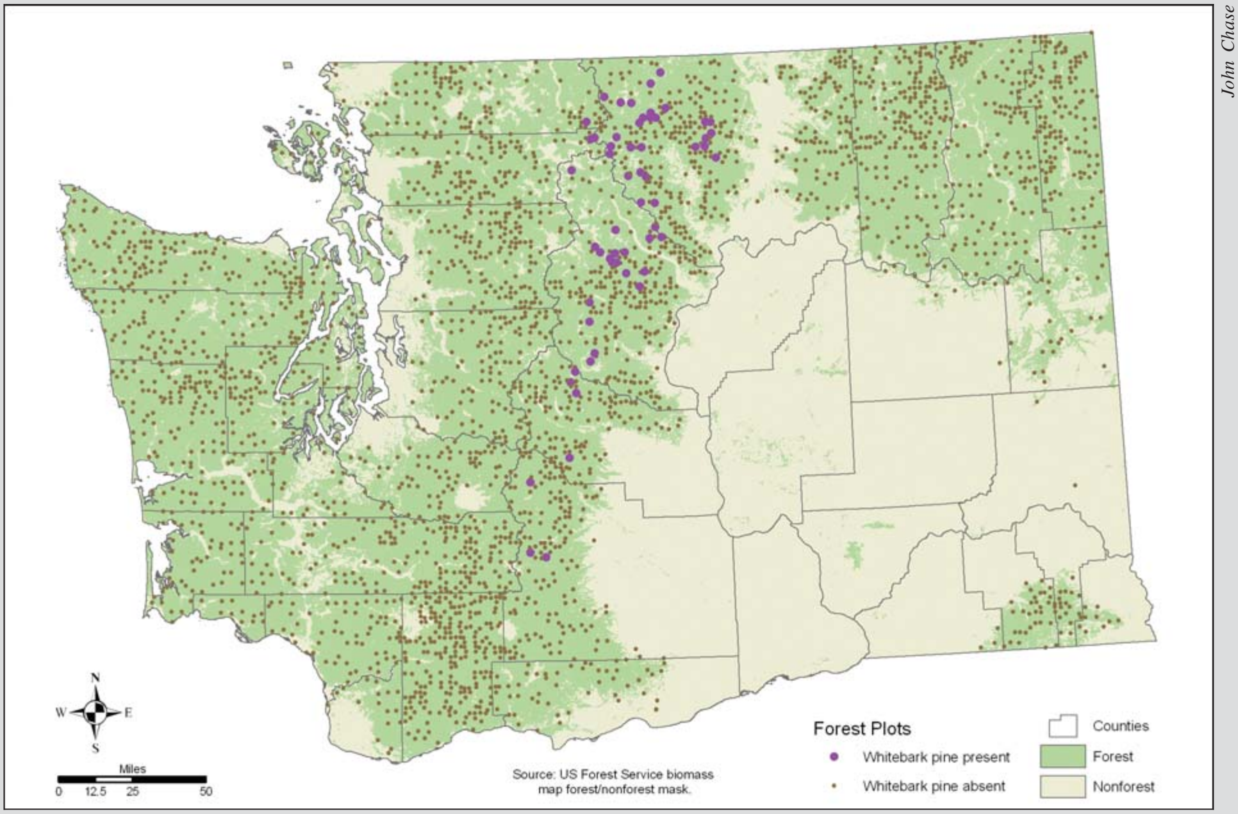


Figure 35— Distribution of whitebark pine in Washington, 2002-2006.

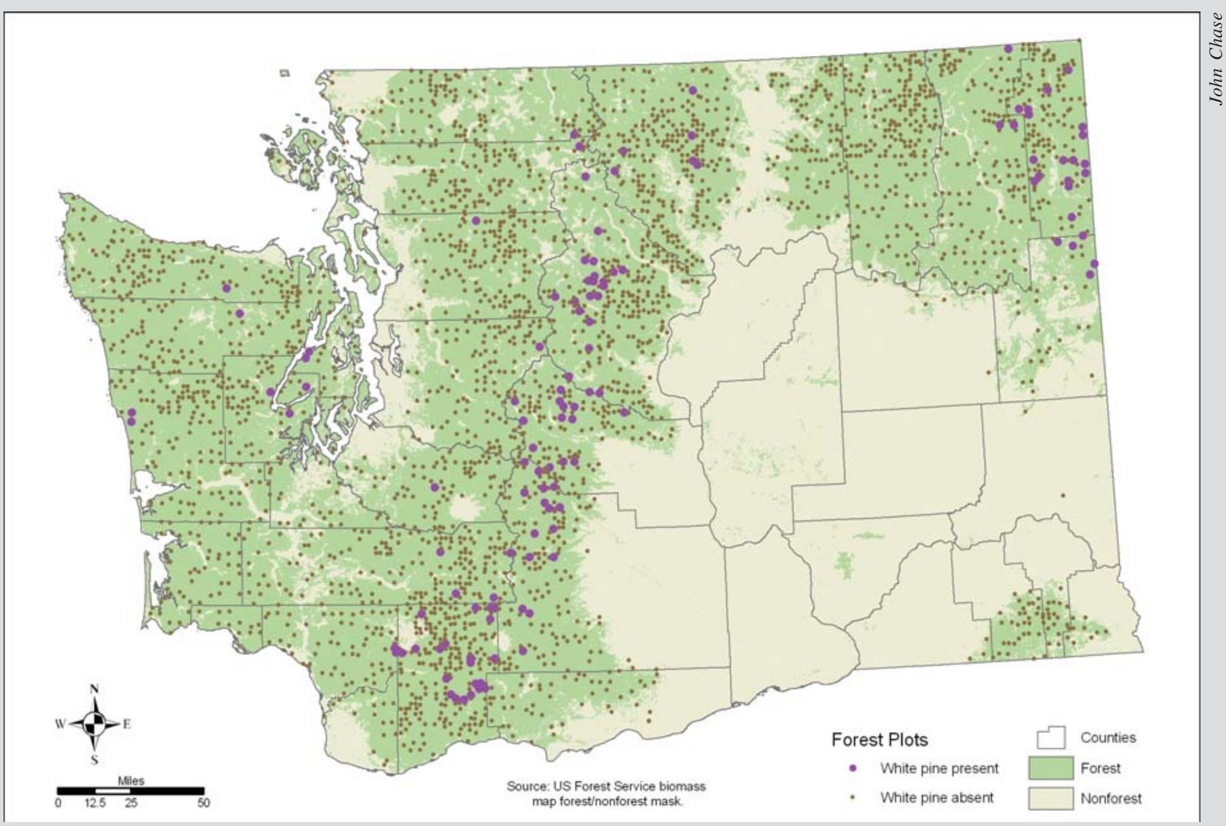


Figure 36—Distribution of western white pine in Washington, 2002-2006.

Tieton River, west of Yakima, Washington.

Chapter 3: Forest Structure and Function

The diverse topics presented in this chapter share a common objective: to characterize the structure and function of Washington’s forests. These forests are vital habitat for a wide variety of plant and animal species, and they provide many other ecological values. The Forest Inventory and Analysis (FIA) data help describe plant biodiversity in Washington’s forests, characteristics of special habitat types such as old-growth forests and riparian corridors, and status of forest components such as dead wood, tree crowns, and understory vegetation.

Older Forests[10]

Background

Old forests are an important part of the forest land matrix, contributing special habitat, aesthetics, recreational opportunities, functional resources, and ecological services not available in younger forests (Franklin et al. 1981). Disturbance is the norm in all forests and has helped shape old forests by creating openings and patches of older, resilient survivors. Contrary to popular belief, older forests are not simply forests where little or no disturbance has occurred for long periods.

The term “old” is relative; it depends on whose definition of “old growth” is used, the type of forest being

[10] Author: Joseph Donnegan.

considered, and the regional climate. Because many complex, interacting variables can be used to describe them, older forests are not easily defined. Typically, in Pacific Northwest forests, the structure, species composition, and functional attributes of older forests are attained by the age of 175 to 250 years (Franklin et al. 1981, 2005, 2007). In this section, we have purposely oversimplified the definition for older forests, reporting acreage by forest type for stand ages in the 160-year-old-plus and the 200-year-old-plus categories. More complex definitions for old-growth forests often cite a minimum age of 200 years, but definitions also depend on productivity classes and forest type (Bolsinger and Waddell 1993, Franklin et al. 1981, Old-Growth Definition Task Group 1986).

Our summary uses stand age as the basis for estimates of area and age distribution. The FIA field crews estimate stand age based on the average age of predominant overstory trees, assessed by counting the tree rings on a pencil-sized sample of wood (core) extracted with an increment borer (fig. 37). It is not possible to determine the age of some trees because of internal rot or because the radius of the tree is greater than the length of core that can be extracted; some species are not cored because the core wound might make them susceptible to pathogens.

Findings

Approximately 15 percent (3.3 million acres) of forest stands across Washington are at least 160 years old; and 11.5 percent (2.59 million acres) are older than 200 years. The vast majority of older forest is found on publicly owned land in national forests and national parks; only 5 percent of forests older than 160 years are privately owned (see "Ownership" section in chapter 2). The western hemlock and Douglas-fir forest types make up the majority of the older forest acreage in Washington. Western hemlock stands older than 160 years account for 3.5 percent of total forest acreage, and Douglas-fir stands older than 160 years account for 3.3 percent of total forest acreage (fig. 38). The remaining combined forest types

Joseph Donnegan

Figure 37—Increment cores are extracted from trees to determine their age.

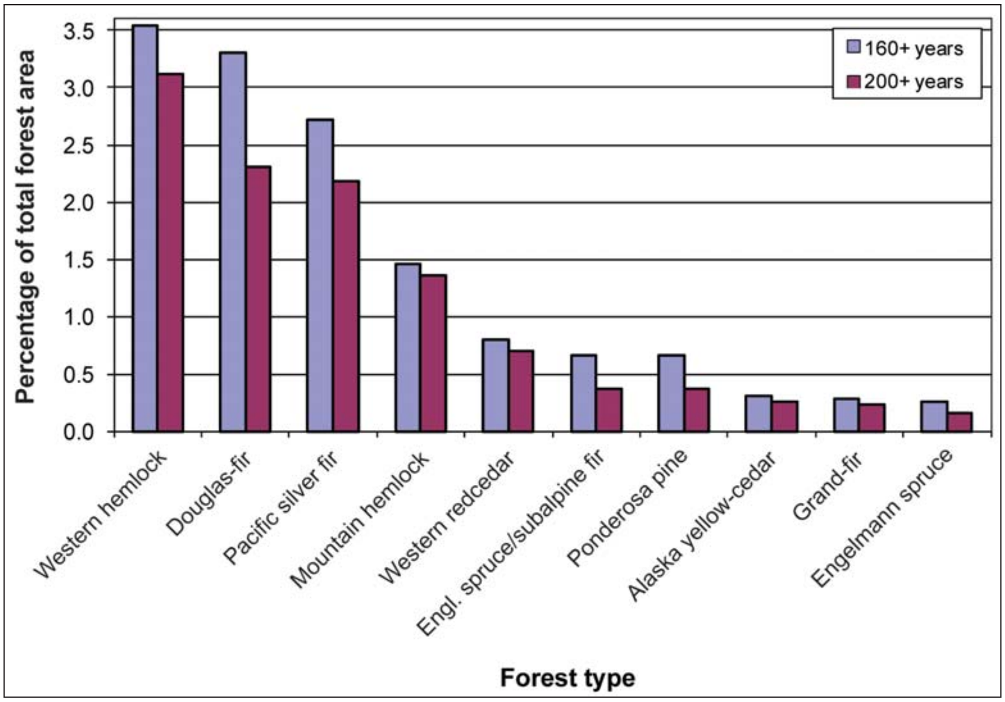


Figure 38—Percentage of total forest land area for stands in Washington, that are 160+ and 200+ years old, by forest type, 2002–2006.

with stand ages in excess of 160 years make up less than 8 percent of total forest area.

Alaska yellow-cedar leads all forest types in proportion of its acreage in older stands; 79 percent of Washington's Alaska yellow-cedar is older than 160 years (fig. 39), although the total acreage occupied by older yellow-cedar is relatively small, about 70,000 acres. Douglas-fir forest greater than 160 years old accounts for 8.5 percent of the area of all Douglas-fir forest.

Western hemlock leads all forest types in total acreage in older stands. However, these stands represent about 30 percent of the western hemlock forest type. There is great diversity in age and stand structure of western hemlock forests, with tree ages and diameters covering a broad range of classes (fig. 40). So although the total area of older western hemlock is relatively large and larger diameter classes are well represented, younger stands of seedlings and saplings are the most abundant size class.

Eastern and western Washington differ in terms of the extent and makeup of older forests. About 66 percent of forest older than 160 years is found in the western portion of the state. Western hemlock, Pacific silver fir, and mountain hemlock forest types dominate the acreage of older forests on the west side. Douglas-fir, ponderosa pine, and Englemann spruce/subalpine fir forest types dominate older forests on the eastern side of the state.

Interpretation

The area and distribution of older forests has been variable through time. Prior to the widespread logging of old forests (before the mid-1800s), these forests had been changing through time from disturbances such as fire and insect outbreaks of varying severity, recurrence intervals, and disturbance synchrony across the landscape (Winter et al. 2002). Estimates of the area of old-growth forest in Washington at the time of the first large-scale forest inventories in the 1940s suggest old growth occupied

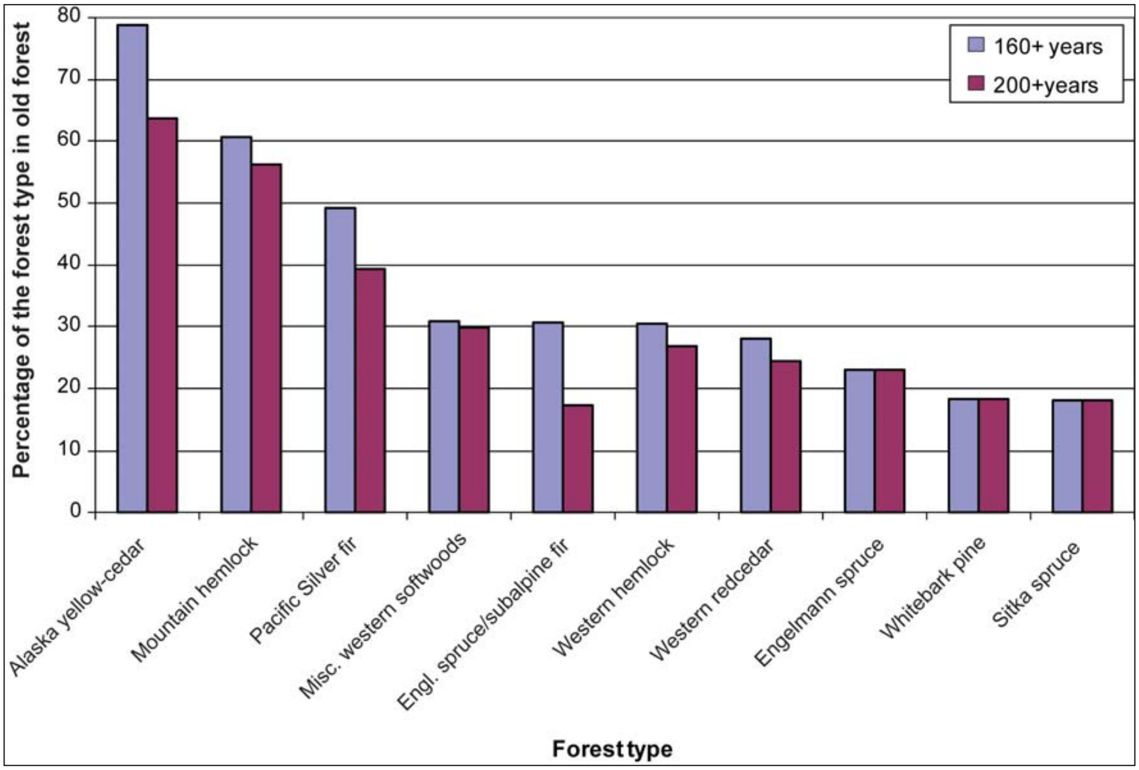


Figure 39—Percentage of each forest type in older forest, Washington, 2002–2006.

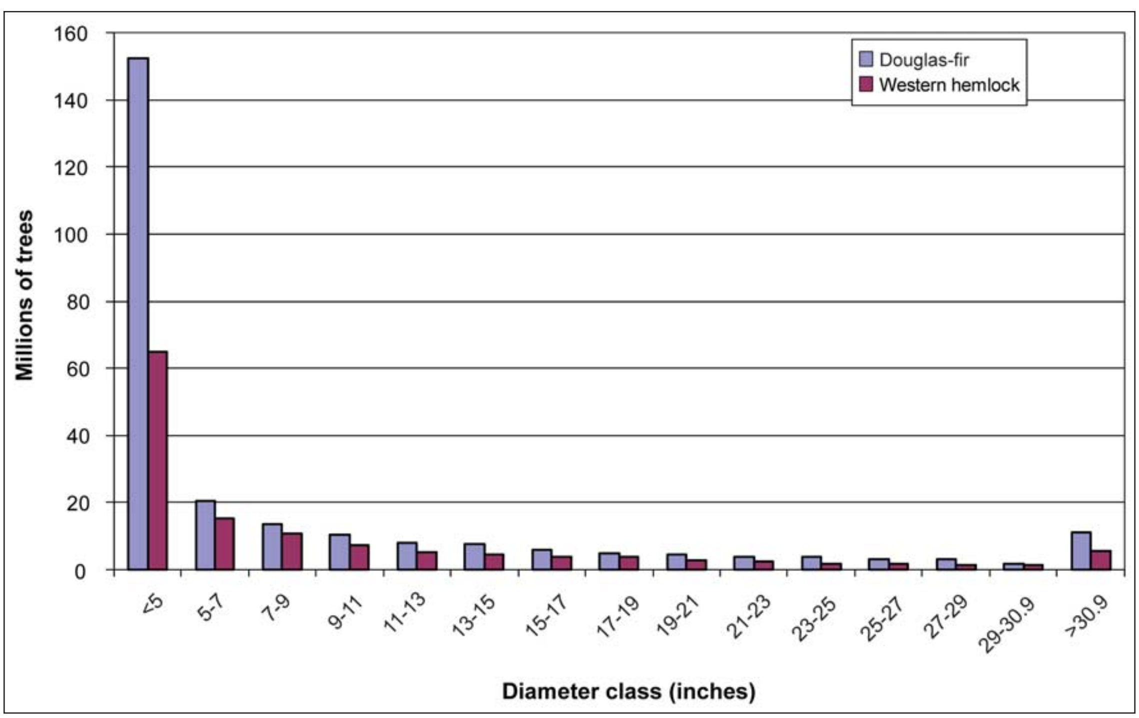


Figure 40—Number of trees by diameter class in older western hemlock and Douglas-fir forests (≥160 years old) on forest land in Washington, 2002–2006.

about 40 percent of forested area with approximately 9.1 million acres in old growth condition (Andrews and Cowlin 1940, Cowlin et al. 1942). Estimates published in 1993 show old-growth forest occupied less than 15 percent of the total forest area with about 2.8 million acres across the state (Bolsinger and Waddell 1993). Recent work for the Northwest Forest Plan area of Washington that combined remote sensing with plot-level data estimated the percentage of large (mean diameter at breast height [d.b.h] ≥30 inches), multistoried, older forest to be about 10 percent (Moeur et al. 2005). Using our simplified definition for older forests (minimum stand age of 200 years old), we estimate about 2.59 million acres (standard error [SE] = 133,000 acres) (11.5 percent of total forest area) currently exist statewide.

Future changes in the amount and distribution of older forests will depend on market pressures to harvest, potential legislative protection, and interacting disturbance regimes that include climatic changes, insects, disease, and fire. This preliminary summary is based on approximately half the sample that is planned to complete a full 10-year cycle of annual inventory.


Sarah Jovan

Figure 41—*Lobaria pulmonaria* (Lungwort) is a cyanolichen that grows abundantly in mature forests unaffected by air pollution in the Pacific Northwest.

Lichen and Plant Biodiversity[11]

Background

Diversity of lichens and vascular plants is included among the FIA forest health indicators (Gray and Azuma 2005, Jovan 2008). These organisms serve many basic and vital functions in forest ecosystems: they provide wildlife sustenance and habitat, influence stand microclimate, and contribute to nutrient dynamics. Individual species or groups of species are intimately linked to forest health. For example, invasive nonnative plants can have important economic impacts on land use, as well as ecological impacts on ecosystem function (Vitousek et al. 1996). Similarly, cyanolichens (fig. 41), a specialized group of native lichens that fix nitrogen, may make substantial contributions to forest fertility in nitrogen-limited stands of the Pacific Northwest (Antoine 2004).

The FIA crews surveyed for epiphytic (tree-dwelling) lichens on all phase 3 plots (see p. 119, app. A) between 1998 and 2003 and recorded the abundance of each species occurring within a 0.93-acre area, as shown in the tabulation below:

Code	Abundance
1	Rare (1-3 thalli[a])
2	Uncommon (4-10 thalli)
3	Common (>10 thalli; species occurring on less than 50 percent of all boles and branches in plot)
4	Abundant (>10 thalli; species occurring on greater than 50 percent of boles and branches in plot)

[a] A lichen body is known as a thallus.

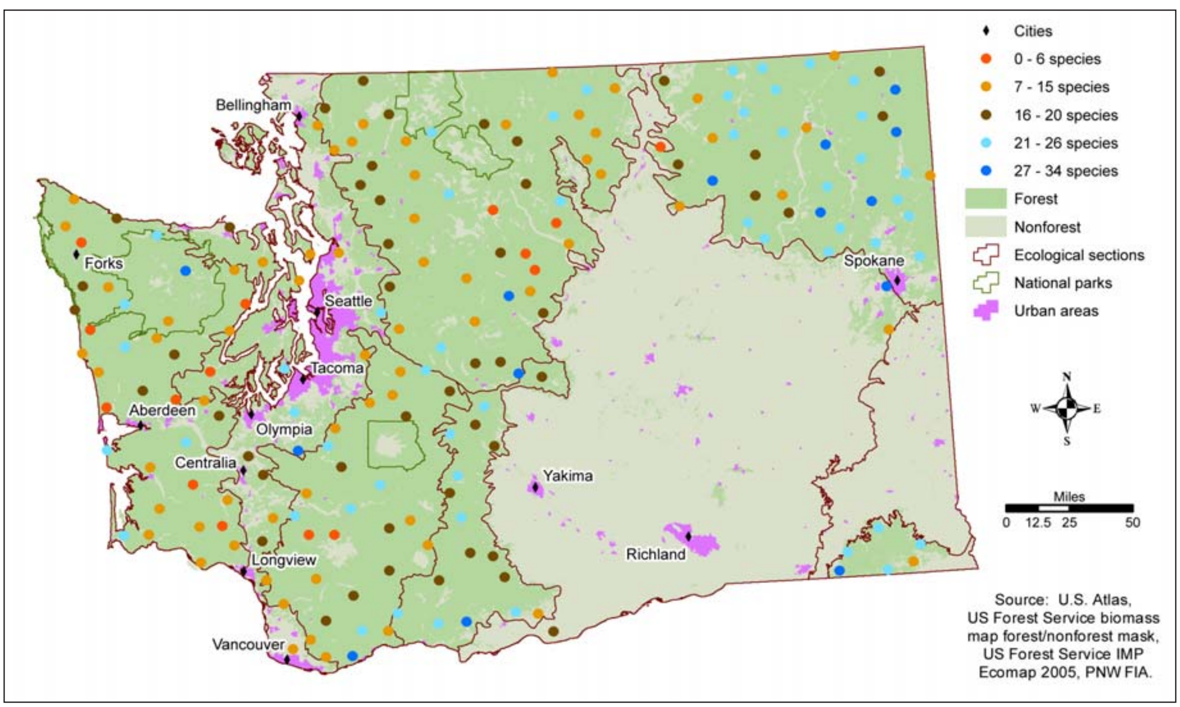
[11] Authors: Sarah Jovan and Andrew Gray.

Vascular plant species were recorded for a pilot implementation of the national vegetation indicator (Schulz et al. 2009) on 91 plots in 2004 and 2005. Plant species cover was estimated for each species on each 24-foot-radius subplot and on three 3.28-square-foot quadrats per subplot.

Findings

The diversity of lichen and vascular plant communities ranged widely by mapped ecological unit (ecosection) (figs. 42 and 43). A total of 168 lichen species were recorded in Washington, a sizeable portion (81 percent) of the diversity found for the entire Pacific Northwest (Jovan 2008). In contrast, 659 vascular plant species were detected, a small portion (21 percent) of the 3,100 estimated to occur in all habitats in Washington.

The Okanogan Highland ecosection in northeast Washington is a prominent biodiversity hotspot for lichens where 83 percent of plots had 16 or more lichen species (average diversity per plot = 22.2 species). Communities were notably rich with over 12 species of beard-like "forage" lichen (fig. 44). These ecologically important species are used for food and nesting material by local wildlife such as black-tailed deer (*Odocoileus hemionus*), Townsend's warbler (*Dendroica townsendi*), golden-crowned kinglet (*Regulus satrapa*), and Swainson's thrush (*Hylocichla ustulata*). In contrast, the Oregon and Washington Coast Ranges ecosection supported the lowest average plot-level lichen diversity (12.9 species) although regional diversity was among the highest: a total of 101 species were found in the Coast Ranges ecosection, second only to the Northern Cascades ecosection. The lowest diversity plots in the region were primarily associated with young stands. Large species of nitrogen-fixing cyanolichens were relatively frequent in the Coast Ranges ecosection (found at 30 percent of



John Chase

Figure 42—Lichen species richness index, Washington forest land, 1998–2003 (ecosection geographic information system [GIS] layer: Cleland et al. 2005; urban GIS layer: U.S. Geological Survey 2001).

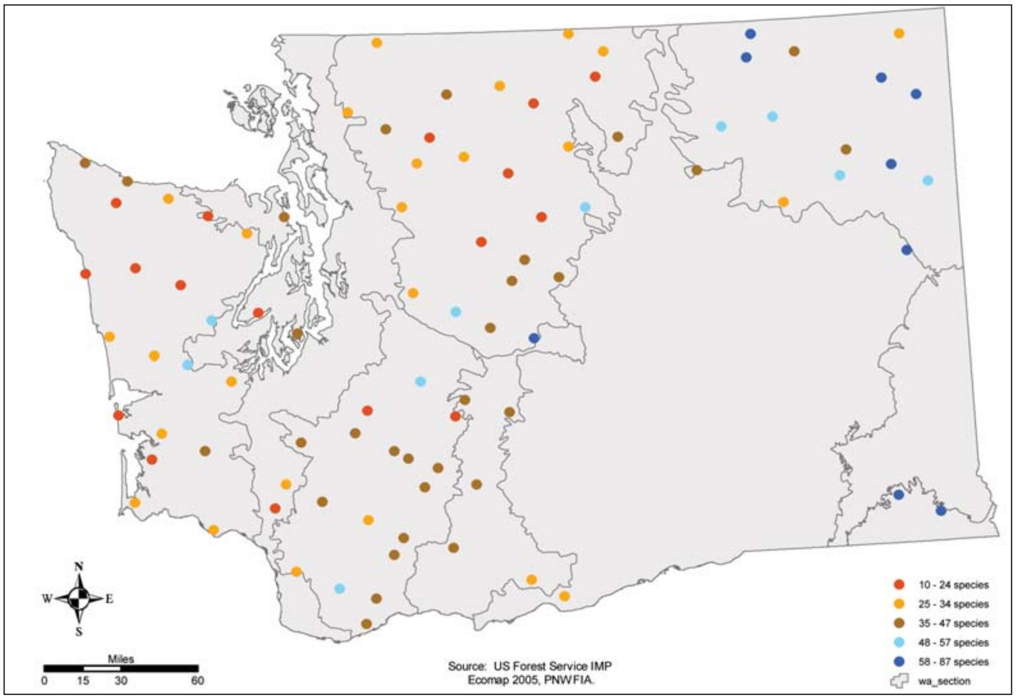


Figure 43—Vascular plant species plot-level richness index on forest land in Washington, 2002–2006 (ecosection geographic information system layer: Cleland et al. 2005).

Figure 44—Beard-like lichens such as *Alectoria sarmentosa* (witch's hair) are often used by wildlife for forage and nesting materials.

plots) as well as the Western Cascades ecosection (27 percent). Rarity of large cyanolichens in the drier and more continental forests of the Okanogan Highland ecosection (5 percent) is most likely due to inhospitable climate (McCune and Geiser 1997).

Geographic patterns of vascular plant diversity were similar to those of lichens, with high diversity in the Okanogan Highland ecosection (average of 53.6 species per plot), and low diversity in the Coast Ranges ecosection (30.3 species per plot) (fig. 45). However, the species found on different plots within each region were substantially different, as indicated by the similar species turnover (i.e., beta diversity) of 5.8 and 6.0, respectively. Across the state, plant diversity was similar across stand age classes; there appeared to be some differences within some forest types, but not enough plots have been sampled to date to resolve that question. Average plot-level diversity tended to be higher in lower elevation forest types (41.3 for Douglas-fir and 46.7 for ponderosa pine) than in higher elevation types (33.0 for both Pacific silver fir and lodgepole pine). However, plot diversity was also low for the low-elevation western hemlock forest types (29.1), possibly because of the dense shade and shallow roots of the dominant tree species.

Interpretation

A low diversity of plants or lichens is not necessarily unnatural, nor is a high diversity inherently good. Biodiversity patterns in Washington are driven by a multitude of factors, some human-caused (i.e., timber harvest, air quality), some natural (i.e., differences in moisture and temperature regime and herbivory pressure), and some of mixed origin (i.e., forest fires).

Andy Gray

Figure 45—Red elderberry is a common plant in the forests of western Washington.

Our inventory of species richness tends to underestimate diversity, both because surveys are time-constrained and because the low density of plots can result in severe underestimation of the total number of species at the ecosection level. However, the consistent methods and systematic sample design provide a unique ability to compare patterns of species abundance across the state. The diversity data presented here provide a baseline for future monitoring; major shifts in diversity will be investigated as needed.

Biodiversity Tables in Appendix B

Table 28—Index of vascular plant species richness on forest land, by ecological section, Washington, 2004-2005

Table 29—Lichen community indicator species richness on forest land, Pacific Northwest and Washington, 1998-2001, 2003

Dead Wood[12]

Background

Dead wood contributes to the structural complexity and biological diversity of forests throughout Washington. In this report we define "dead wood" as snags (standing dead trees) (fig. 46) and down wood (dead woody material on the forest floor) of various dimensions and stages of decay (fig. 47). The presence of dead wood in a forest improves wildlife habitat, enhances soil fertility through nutrient cycling and moisture retention, adds to fuel loads, provides substrates for fungi and invertebrates, and serves as a defining element in old-growth forests (Harmon et al. 1986, Laudenslayer et al. 2002, Rose et al. 2001). Because of this, the dead wood resource is often analyzed from a variety of perspectives—too much can be viewed as a fire hazard and too little can be viewed as a loss of habitat.

[12] Author: Karen Waddell.

The amount of dead wood in a forest can differ with habitat type, successional stage, species composition, management activities, and geographic location (Harmon et al. 1986, Ohmann and Waddell 2002). Here, we analyze data on snags and down wood collected by FIA crews on more than 2,970 forested phase 2 field plots in the state. Dead wood is described in broad terms at the statewide level, with comparisons between western Washington and eastern Washington when relevant.

Dead trees leaning less than 45 degrees and ≥5 inches d.b.h. were tallied as snags and measured under the same protocol as live trees. Down wood was sampled along linear transects on each plot under protocols that differed by diameter size class. Information was collected on fine woody material (FWM; pieces of wood <3 inches in diameter at the point of intersection with the transect) and on coarse woody material (CWM; branches and logs ≥3 inches in diameter at the point of intersection). Dead trees leaning more than 45 degrees were tallied as down wood. Estimates of density, volume, biomass, and carbon were developed from these data and are the basis for the analysis that follows.

Findings

Dead wood was found in every forest type sampled in Washington. We estimated almost 628 million tons (all references to weight refer to bone-dry tons) of dead wood biomass on forest land in the state, with about 75 percent attributable to down wood alone (CWM and FWM). Volume of snags and CWM was about 49 billion cubic feet, which is almost half of the total live-tree volume recorded in Washington. About 82 million tons of carbon is sequestered in snags, compared to 243 million tons stored in down wood (CWM = 188; FWM = 55). We estimated more than 6.9 billion down logs (CWM) and 549 million snags in forests statewide. Dead wood was most abundant and had the largest dimensions in western Washington where temperate forests have high productivity rates and longer fire-return intervals, producing heavy accumulations of biomass.

Dale Waddell

Figure 46—Snags provide critical habitat and structural diversity in Washington's forests. Birds and other mammals use snags as roosting and foraging sites and occupy cavities for nesting and cover.

Karen Waddell

Figure 47—Dead wood accumulates on the forest floor providing habitat, soil stability, and long-term carbon storage.

Assessment of dead wood attributes becomes more meaningful when expressed per acre. Statewide, biomass (also known as fuel loading) of down wood averaged 16 tons per acre and differed by forest type and diameter class (fig. 48).

The down wood component of Washington's total fuel load (amount of potentially combustible material) can be expressed as the average tons per acre within fuel hour-classes:

Location	1-hour class	10-hour class	100-hour class	1,000-hour class
	Mean tons/acre			
Western Washington	0.26	1.13	3.6	21.6
Eastern Washington	0.17	0.98	3.5	9.4
All Washington	0.22	1.06	3.55	16.14

The range in classes from 1 to 1,000 hours corresponds to the diameters of down wood pieces as follows: 1-hour (0.1 to 0.24 inches), 10-hour (0.25 to 0.99 inches), 100-hour (1.0 to 2.9 inches), and 1,000-hour (≥3 inches). Each class refers to how fast dead woody material will dry and burn relative to its moisture content.

The dimensions of down logs and snags are important when evaluating ecological characteristics of the forest.

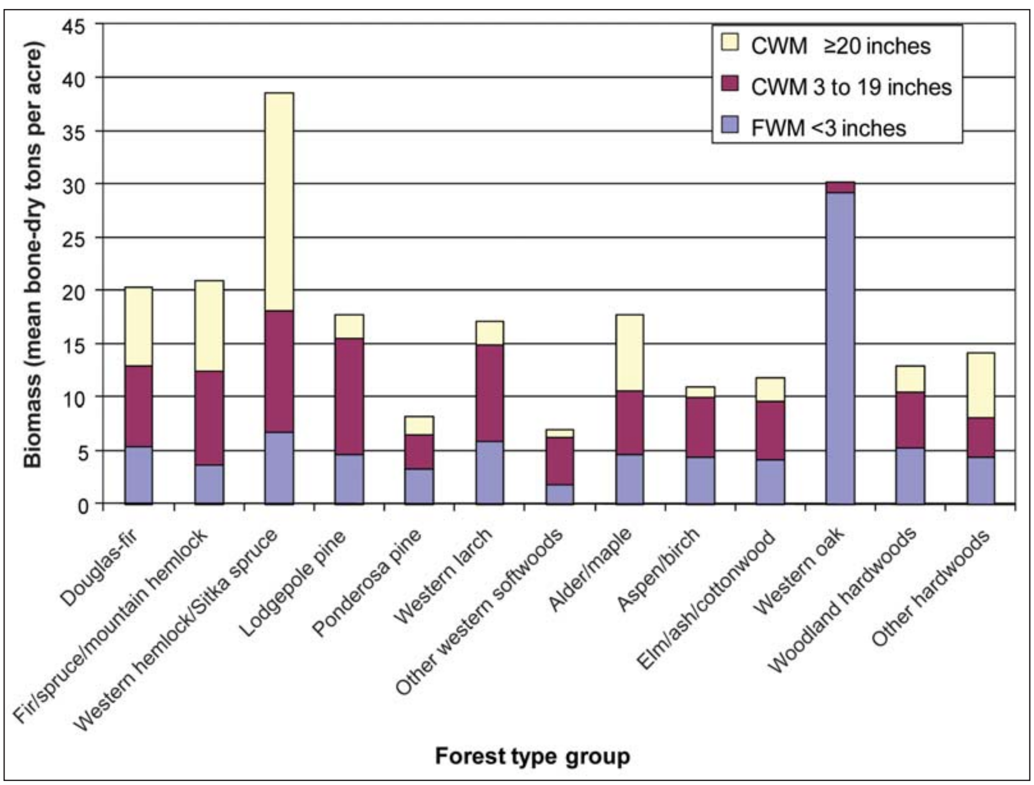


Figure 48—Mean biomass of down wood on forest land in Washington, by forest type and diameter class, 2002–2006; CWM = coarse woody material; FWM = fine woody material.

Although large logs (≥20 inches in diameter) represented the greatest mean volume and biomass per acre, they were present in significantly fewer numbers, with a mean of 15 logs per acre, compared to 285 logs per acre for small logs (3 to 19 inches in diameter). Western Washington forests had over five times as much biomass in large logs as those in eastern Washington (fig. 49).

Snags represented a mean biomass of 7 tons per acre and a mean density of 25 trees per acre across the state. Almost 90 percent of the snags were <20 inches d.b.h, and only 0.4 snags per acre were >40 inches d.b.h. Softwood forest types had the most biomass and the largest proportion of large-diameter snags (>20 inches d.b.h.) (fig. 50).

Although the total amount of dead wood present in a forest varies over time, the mean density of large-diameter snags and down logs generally increases with stand age (fig. 51), as shown below:

	Diameter classes			
	Snags		Down wood	
Stand age in years	5 to 19 inches	≥20 inches	3 to 19 inches	≥20 inches
	Mean trees/acre		*Mean logs/acre*	
1 to 50	10.9	1.2	359.8	21.2
51 to 100	27.8	1.5	245.4	9.5
101 to 150	33.9	2.8	267.6	9.0
151 to 200	32.7	5.4	271.5	17.2
201 to 250	20.9	7.8	273.6	19.9
251 to 300	21.1	7.0	258.6	25.8
300 plus	16.1	9.0	227.9	29.5
All stands	22.1	2.4	285.0	15.3

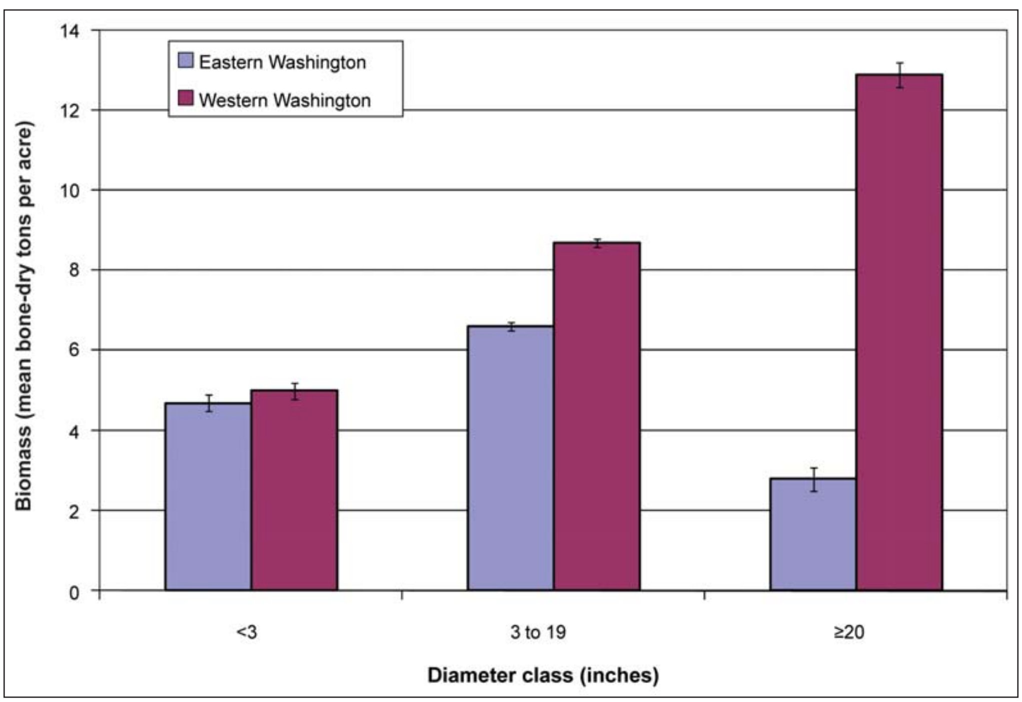


Figure 49—Mean biomass of down wood on forest land in eastern and western Washington, by diameter class, 2002–2006. Lines at the end of the bars represent ± standard error.

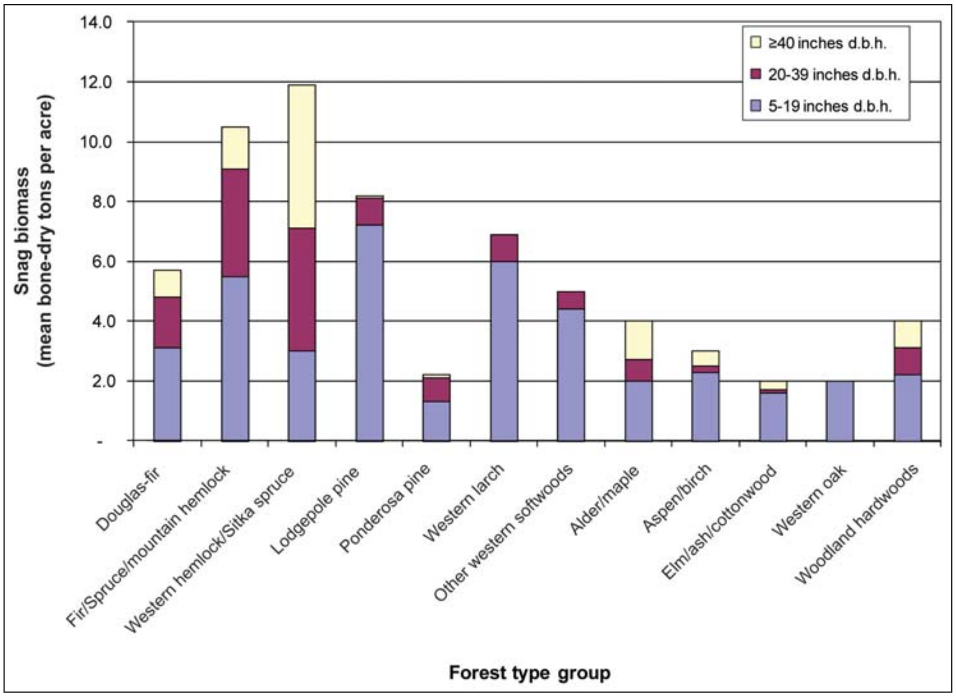


Figure 50—Mean biomass of snags on forest land in Washington, by forest type and diameter class, 2002-2006; d.b.h. = diameter at breast height.

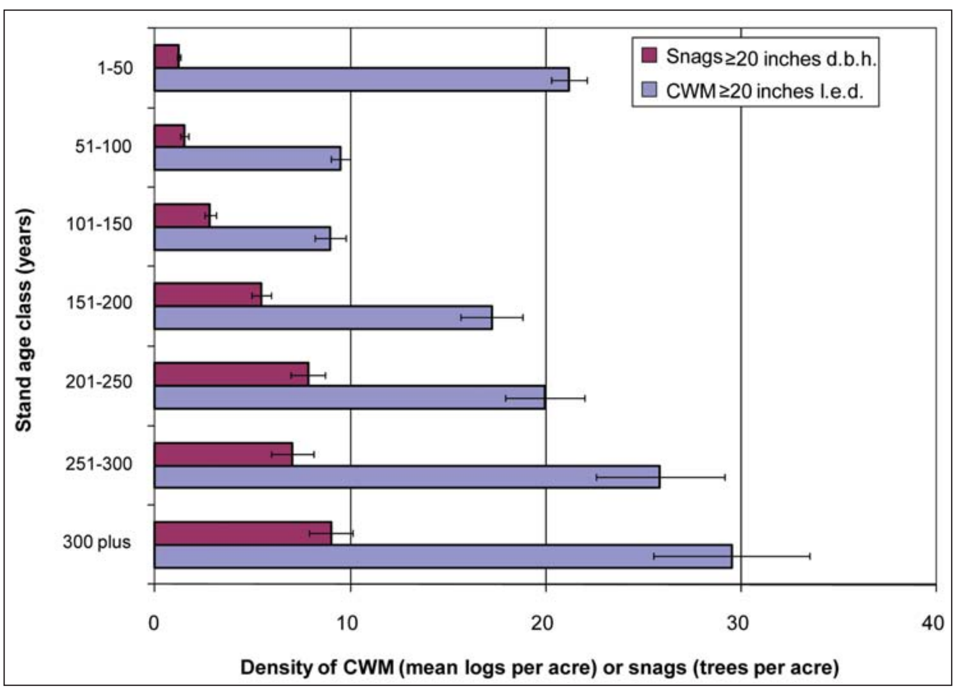


Figure 51—Mean density of coarse woody material (CWM) and snags for large-diameter (≥20 inches) logs or snags on forest land in Washington, by stand age class, 2002-2006; d.b.h. = diameter at breast height; l.e.d. = large-end diameter. Lines at the end of the bars represent ± standard error.

Large snags ranged from a mean of 1 tree per acre in young stands to 9 trees per acre in stands older than 300 years. In contrast, young stands appear to start out with a higher level of large down wood, which drops to less than half that density in stands 51 to 100 years old before gradually increasing to as many as 29.5 logs per acre in very old stands.

The difference seen here between snags and logs in young stands (high density of CWM and low density of snags) most likely reflects disturbance from harvest. Another common disturbance is wildfire, but this usually reduces the amount of logs from the previous stand and creates an abundance of snags of all sizes.

Interpretation

Dead wood accumulates in different patterns across the wide variety of forest types in Washington, creating a mosaic of habitats and fuels across the landscape. Many factors influence the size, abundance, and stage of decay of dead wood. The higher fuel loading observed in western Washington forests is likely due, in part, to the higher overall primary productivity rates west of the Cascades. These heavier fuel loads may suggest that forests in western Washington represent a greater fire hazard than those on the east side, but the moist climatic conditions on the west side tend to temper the effect of large accumulations of fuels.

In general, wildlife species that use dead wood for nesting, roosting, or foraging prefer large-diameter logs and snags (Bull et al. 1997). Although we found dead wood in this size class (>20 inches) throughout Washington, its density may be limiting the abundance of some wildlife species. For example, inventory results show a mean of 3.3 snags per acre in this size class in western Washington and 1.4 snags per acre in eastern Washington. This may indicate that large-diameter snags are currently uncommon in Washington habitat and that management may be necessary to produce a greater density of large snags if managing for snag-dependent species is a goal.

Various types of disturbance can radically change the attributes of a forest by shifting the balance of live and dead trees or FWM and CWM. Biologists and land managers may want to monitor these changes to determine whether the density, size distribution, and decay characteristics of dead wood are adequate for local management objectives, such as managing for the needs of a particular wildlife species. In addition, understanding the amount of biomass and carbon stored in dead wood will allow us to address requests pertaining to global carbon cycles.

There is a substantial amount of information about dead wood in FIA databases and summary tables that can be used for a more indepth analysis of this resource, including estimates of density, biomass, volume, and carbon for all dead wood components.

Dead Wood Tables in Appendix B

Table 22—Estimated aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002-2006
Table 23—Average aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002-2006
Table 24—Estimated average biomass, volume, and density of down wood on forest land, by forest type group and diameter class, Washington, 2002-2006
Table 25—Estimated biomass and carbon mass of down wood on forest land, by forest type group and owner group, Washington, 2002-2006.
Table 26—Estimated average biomass, volume, and density of snags on forest land, by forest type group, and diameter class, Washington, 2002-2006
Table 27—Estimated biomass and carbon mass of snags on forest land, by forest type group and owner group, Washington, 2002-2006

Riparian Forests[13]

Background

Riparian forests are forested areas adjacent to streams, lakes, and wetlands (fig. 52). Riparian forests typically make up a small portion of the total land base, but they play a very important role in maintaining the health and function of watersheds and aquatic ecosystems. The composition and structure of riparian forests are often different from those of upland forests, and thus these forests provide a unique habitat for many plant and wildlife species. Riparian forests help stabilize streambanks, regulate sediment inputs, and provide shade, nutrients, and large woody debris to the water body. Because of the critical role of riparian forests for fish and wildlife habitat and water quality, agencies have prescribed specific management rules on riparian areas, including requiring retention of certain levels of vegetation and restricting harvest and forest operations.

In this report, we examine the extent and attributes of riparian forests, defined as accessible forest land within 100 feet of a permanent water body, including rivers, streams, lakes, marshes, and bogs. Distance from each subplot center to permanent water features was estimated in the field by FIA crews.

Findings

Regional distribution of riparian forest area and volume—

On average, riparian forests cover an estimated 10.1 percent of all forest land area and hold 12.3 percent of the net volume of live trees in the state. The abundance of riparian forest varies dramatically within the state (fig. 53). In western Washington, 13.6 percent of the total forest area is estimated to be riparian forest, whereas 5.9 percent of forest in eastern Washington is estimated to be

Dale Waddell

Figure 52—Riparian forests are dense along creeks and rivers in Washington.

[13] Author: Vicente Monleon.

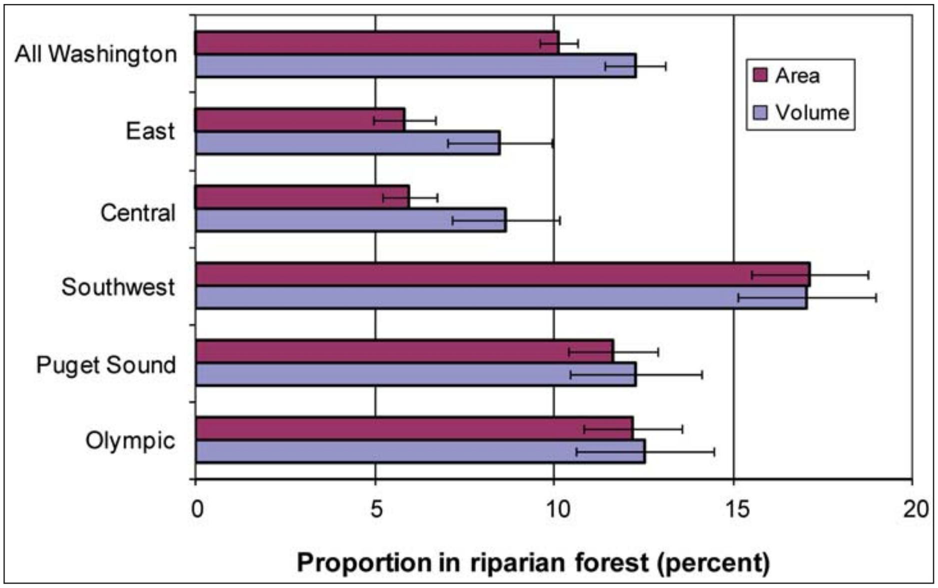


Figure 53—Riparian forest land area and net tree volume, as a percentage of forest land area and volume in Washington, by survey unit, 2002-2006. Lines at the end of the bars represent ± standard error.

riparian. Riparian forests account for about 13.7 and 8.6 percent of the total net volume of the west and east sides of the state, respectively.

Across the state, riparian forests tend to hold a greater timber volume per unit area than upland forests. However, most of this difference may be attributed to eastern Washington where the drier climate may limit the most productive forests to areas next to streams. The estimated mean net volume density of live trees in western and eastern Washington is shown in the following tabulation:

Region	Riparian forests: Volume density	Riparian forests: SE	Upland forests: Volume density	Upland forests: SE
	Cubic feet per acre			
Western Washington	5,752	364	5,696	154
Eastern Washington	3,913	353	2,615	84
All Washington	5,272	285	4,249	91

Ownership and species composition of riparian forests—

In relative terms, the extent and net volume of riparian forests on private and public land is similar (fig. 54). On private forest lands, 9.9 percent of the area and 13.5 percent of the timber volume is estimated to be in riparian areas, whereas on public lands, 10.3 percent of the area and 11.8 percent of the volume is estimated to be in riparian areas.

Riparian forests account for an estimated 20.7 percent of the total net volume of hardwood species, but only 11.6 percent of the total net volume of softwood species. Even though hardwood species are more abundant on average in riparian forests than in upland forests, softwood species dominate riparian areas and account for most of the tree vol-ume. The net timber volume of hardwood species is estimated to be 11.3 percent of the total volume in riparian forests, but only 6.0 percent of the total volume in upland forests (standard errors are 1.5 and 0.4, respectively).

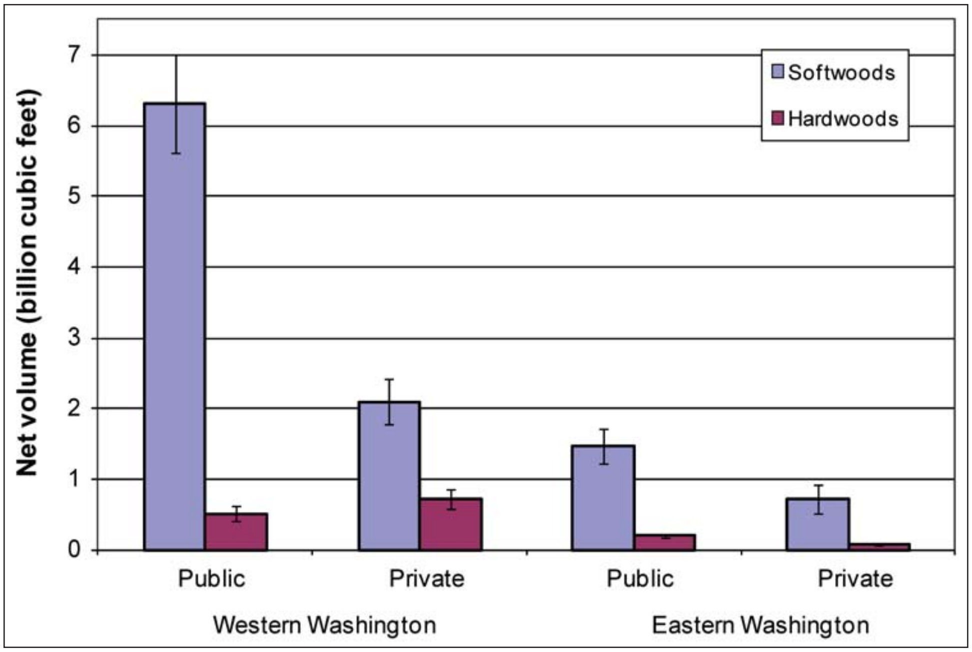


Figure 54—Net tree volume in riparian forests in Washington, by region, ownership, and species group, 2002-2006. Lines at end of bars represent ± standard error.

Interpretation

The distribution of riparian forests follows the broad climatic patterns of the state. The extent and net volume in riparian forests are much greater in the moister western region than in the drier eastern region. Climatic pattern may also explain some of the differences in structure and productivity between riparian and upland forests, such as the difference in volume per unit area and proportion of hardwood species. Currently, riparian forests are subject to special management regulations. Data collected by FIA may be used to examine the implementation and impact of those regulations at a broad scale. However, detailed information for small areas may be limited by the small sample size. Further, FIA does not collect information about stream characteristics, such as fish use, that may be important for evaluating existing regulations. Future collaboration with other agencies that collect this type of information could be fruitful.

Riparian Forests Tables in Appendix B

Table 30—Estimated area and net volume of live trees on riparian forest land by location and survey unit, Washington, 2002-2006

Table 31—Estimated area of riparian forest land, by forest type group, broad owner group, and location, Washington, 2002-2006

Table 32—Estimated net volume of live trees on riparian forest land, by species group, broad owner group, and location, Washington, 2002-2006

Tree Crowns and Understory Vegetation[14]

Background

This section highlights two important FIA forest health indicators: tree crowns and understory vegetation. Both are ecologically important as structural components in forest ecosystems. For example, the amount and vertical layering of different plant life forms (e.g., trees, shrubs, forbs, or grasses) are key determinants of wildlife habitat, fire behavior, erosion potential, and plant competition (MacArthur and MacArthur 1961, National Research Council Committee 2000). Tree-crown density, transparency, and dieback are indicators of tree vigor, impacts from disease or other stressors, and potential for mortality (Randolph 2006).

[14] Authors: Andrew Gray and Glenn Christensen.

The FIA crews visually estimated crown density, foliage transparency, and dieback on phase 3 plots across Washington. Crown density is the percentage of the area within an outline of a full crown viewed from the side that contains branches, foliage, and reproductive structures. Transparency is the percentage of the live foliated portion of the tree's crown with visible skylight. Crown dieback is the percentage of the foliated portion of a crown consisting of recent branch and twig mortality in the upper and outer portions of the crown (Randolph 2006).

Crews sampled understory vegetation on each phase 2 FIA subplot on forest land. Total cover was estimated for tree seedlings and saplings <5 inches d.b.h., shrubs, forbs, and graminoids. Total cover of all four of these life forms and of bare mineral soil was estimated. Crews also collected information on dominant plant species; those data are presented in other sections of this report.

The full functionality of these indicators cannot be fully realized with these first 5 years of data, and so the current status of each indicator is summarized only briefly below, to establish baselines for Washington's forests and to educate clients about the development of FIA forest health indicators. A major benefit of these indicators is that they will enable future tracking of deviations from baseline conditions.

Findings

Crown density ranged from 38 to 51 percent among species groups, with a mean of 43 percent. Mean foliage transparency was 23 percent and was greater for hardwoods than for softwoods (fig. 55). Recent crown dieback was detected in only 2.1 percent of the trees examined. Only the other western hardwoods species group had more than 5 percent of all trees with more than slight (i.e., 10 percent) crown dieback, at 8 percent.

Cover of understory vegetation in Washington was greater in hardwood forests than in softwood forests (fig. 56). Within the hardwood forest types, shrub cover was highest in the higher moisture forest type groups: elm, aspen, and alder/maple; within the conifer forest types, shrub cover was highest in the moderate-moisture Douglas-fir group and the high-elevation lodgepole pine group (fig. 57). Graminoid cover was generally highest in

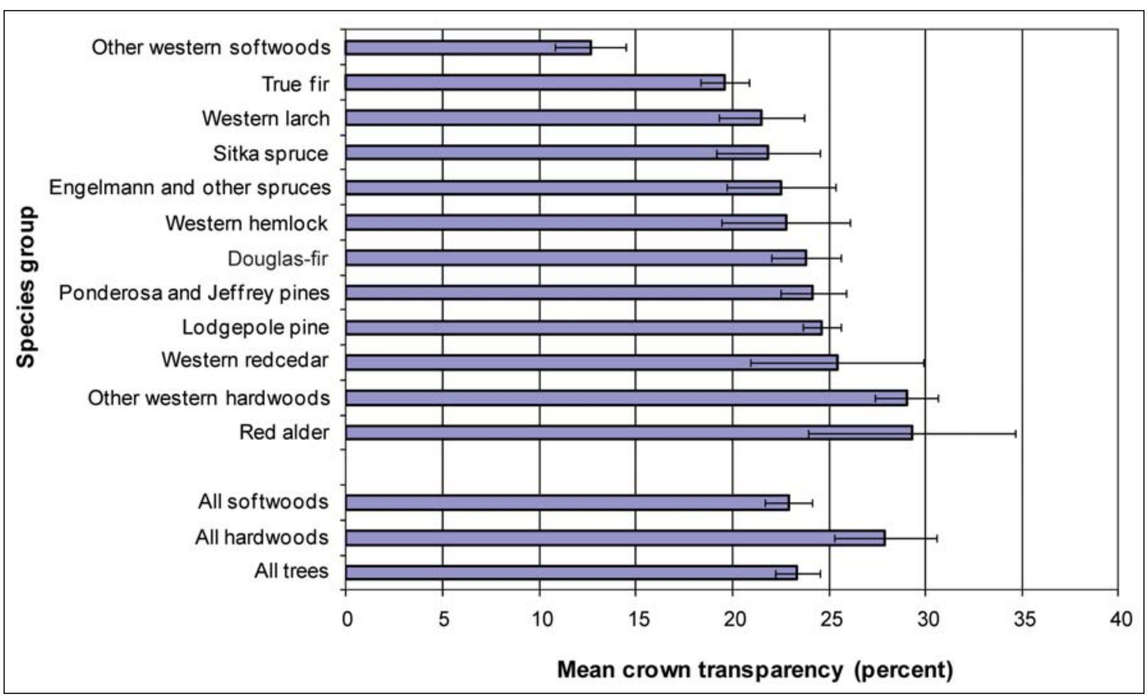


Figure 55—Mean foliage transparency in Washington, by species group, 2002–2006. Lines at the end of bars represent ± standard error.

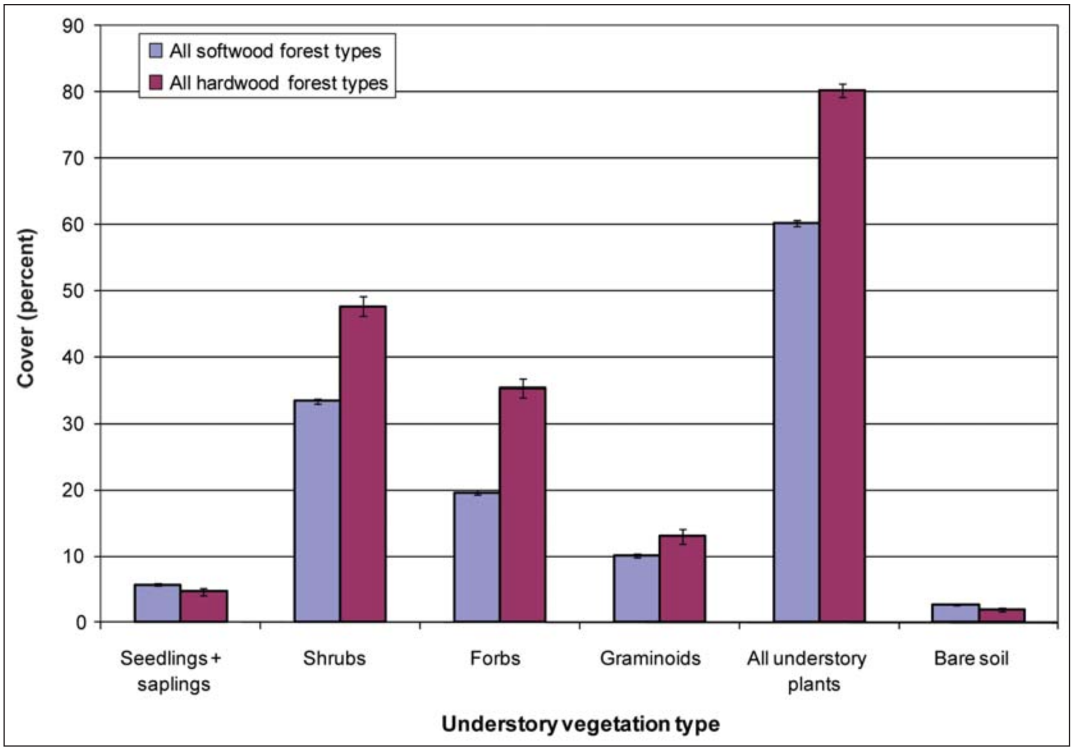


Figure 56—Cover of vegetation life forms and bare soil in Washington, by hardwood or softwood forest type groups, 2002–2006. Lines at end of bars represent ± standard error.

Figure 57—Dense understory cover of forbs and shrubs in a Douglas-fir forest.

the drier oak and pine groups. Forb cover was greatest in the white pine, hemlock, and alder/maple groups. Understory cover was similar among stands less than 80 years of age, and somewhat lower for stands over 80 years of age, primarily owing to differences in cover of shrubs and forbs (fig. 58).

Interpretation

Initial results suggest crown decline is not widespread in Washington, with most dieback found on minor forest types. Future remeasurements will provide more precise estimates of changes in crown health over time.

The amount and composition of understory vegetation differed greatly among the forest types and forest age classes of Washington. Although all life forms were represented in all forest types to some extent, their abundance appeared to differ according to forest type. Shrubs and graminoids appeared to be particularly sensitive to the overstory tree type (softwood or hardwood) as well as moisture availability within different forest type groups. Although vegetation abundance differed with age class, the conventional wisdom that dense young forests have very low cover of understory plants does not appear to be valid across Washington.

Crowns and Understory Vegetation Tables in Appendix B

Table 33—Estimated mean crown density and other statistics for live trees on forest land, by species group, Washington, 2002–2006

Table 34—Mean foliage transparency and other statistics for live trees on forest land, by species group, Washington, 2002–2006

Table 35—Mean crown dieback and other statistics for live trees on forest land, by species group, Washington, 2002–2006

Table 36—Mean cover of understory vegetation on forest land, by forest type group and life form, Washington 2002–2006

Table 37—Mean cover of understory vegetation on forest land, by forest type class, age class, and life form, Washington, 2002–2006

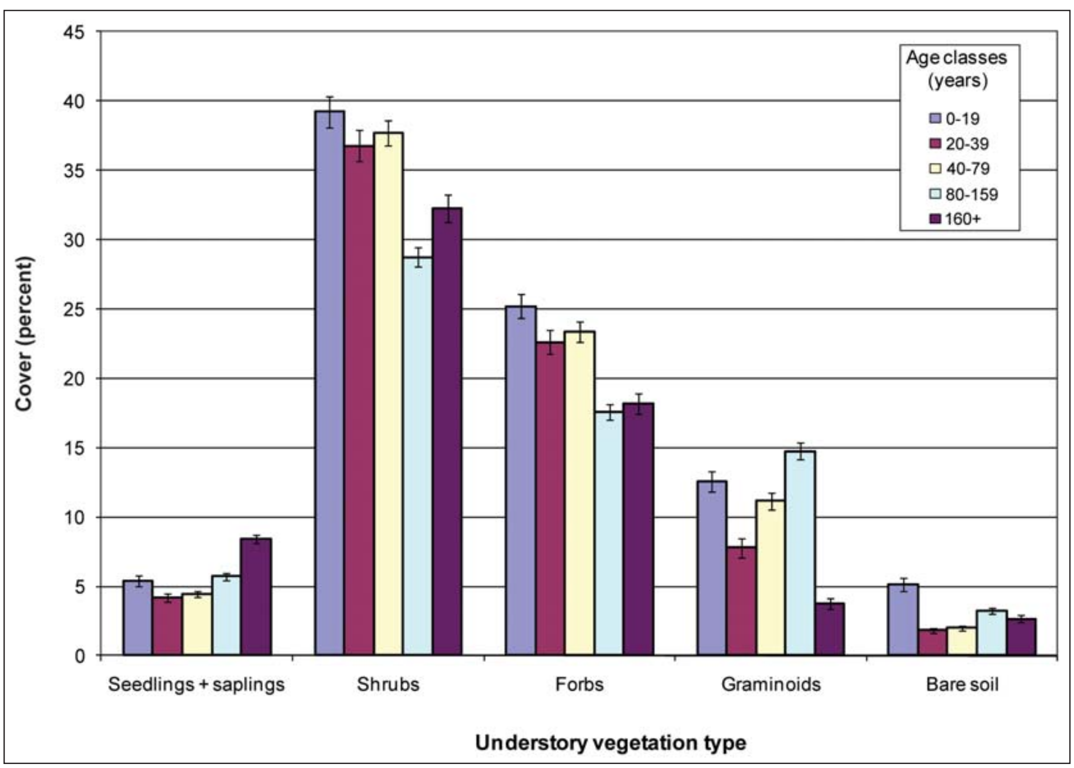


Figure 58—Cover of vegetation life forms and bare soil in Washington, by forest age class, 2002-2006. Lines at the end of bars represent ± standard error.

Sally Campbell

Wenatchee Mountains, Eastern Washington.

Andy Gray

Mountain hemlock on the Olympic Penninsula.

Continue

Chapter 4: Disturbance and Stressors

Major disturbance agents and stressors such as insects, diseases, invasive plant species, air pollution, and fire are among the most powerful influences on the structure, species composition, and ecological function of forests. We explore the influence of these agents through analysis of both plot data and predictive risk models.

Insects, Diseases, and Other Damaging Agents[15]

Background

Insects, diseases, and other damaging agents can have both detrimental and beneficial effects on forest ecosystems (fig. 59). The frequency and severity of damage to trees by biotic agents, such as insects or diseases, or abiotic agents, such as fire or weather, are influenced by a number of factors, ranging from the existing composition and structure of the forest to management policies and activities (Hessburg et al. 1994). Effects from damaging agents include defoliation, decay, reduced growth, increased susceptibility to other stressors (e.g., other insects and diseases or drought), top kill, and mortality. These impacts can affect ecosystem structure, composition, and function. Introduced insects and diseases such as balsam woolly adelgid (*Adelges piceae* Ratzeburg) or white pine blister rust often have more rapid and intense impacts than native organisms.

Joel Thompson

Figure 59—Diseases such as dwarf mistletoe on pine are found throughout Washington.

The Pacific Northwest (PNW) Forest Inventory and Analysis (FIA) Program collects data on damaging agents for each measured live tree, and also maps root disease, if present, on each plot. These ground-based data complement localized ground surveys and the annual aerial survey conducted by the Washington Department of Natural Resources (WDNR) and the Forest Health Protection Program of the USDA Forest Service; aerial surveyors map defoliation and mortality observed from the air. The FIA plot-based sampling protocol allows estimation of acres, trees per acre, basal area, and volume affected by each agent or agent group for forest types and for individual tree species. Our information on damaging agents is most reliable for those that are common and broadly distributed; it is less reliable for less common agents such as newly established nonnative pests. The FIA Program generally under-reports bark beetles, insect defoliators, and foliage diseases owing to a number of factors.[16]

Findings

About 22 percent of live trees greater than 1 inch in diameter at breast height (d.b.h.) showed signs or symptoms of insects or diseases; damage by animals, weather, or fire; or physical defects such as a dead or missing top, crack or check in the bole, or fork or crook in the stem. Twenty-two percent of Douglas-fir, 18 percent of western hemlock, and 25 percent of ponderosa pine had some

[15] Authors: Sally Campbell and Olaf Kuegler.

[16] These agents are likely under-recorded due to FIA's difficulty in detecting (1) symptoms of bark beetle attack on live trees prior to mortality, (2) defoliation events that are not evenly distributed geographically or temporally and thus are less likely to coincide with FIA plot visits, and (3) damage occurring on upper portions of trees in dense stands.

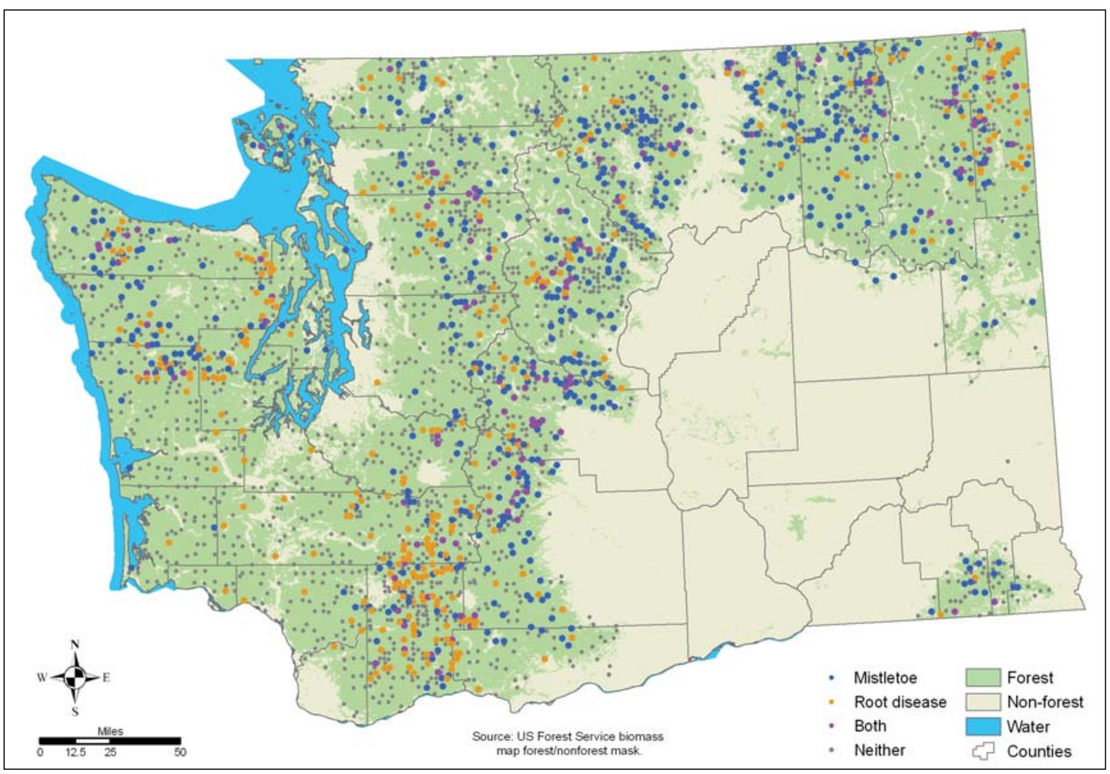
damage recorded. Overall damage levels on forest land were higher in eastern Washington than in western Washington, and they were higher on public lands than on private lands:

	Live trees ≥1 inch d.b.h. with damage	Acres with >25 percent basal area with damage	Gross volume of trees ≥5 inches d.b.h. with damage
		Percent	
Western Washington:			
Public	23.7	56.5	36.9
Private	11.2	27.0	19.7
Eastern Washington:			
Public	32.6	68.2	42.9
Private	19.5	46.4	31.1
Total Washington:			
Public	27.3	61.9	38.4
Private	14.1	35.5	23.1

Almost 11 million acres had greater than 25 percent of forest basal area affected by one or more damaging agents. The volume of live trees ≥5 inches d.b.h. affected by one or more damaging agents was 33.8 billion cubic feet. Root disease and dwarf mistletoe, which cause significant growth loss and mortality, were recorded on 4.7 and 2.3 percent of softwoods, respectively. Of all the biotic agents recorded, these two affected the greatest number of trees and acres of both softwoods and hardwoods and, along with stem decays, the highest volume (figs. 60 and 61). However, the most significant damage type overall was physical defect (broken or missing top, dead top, forks or crooks, bole checks or cracks) with the most trees, acres, and volume affected (fig. 62).

Interpretation

Some of the most common biotic (living) agents of forest disturbance, such as dwarf mistletoes and stem decays,



John Chase

Figure 60—Root disease and dwarf mistletoe incidence on Forest Inventory and Analysis plots in Washington, 2002-2006 (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

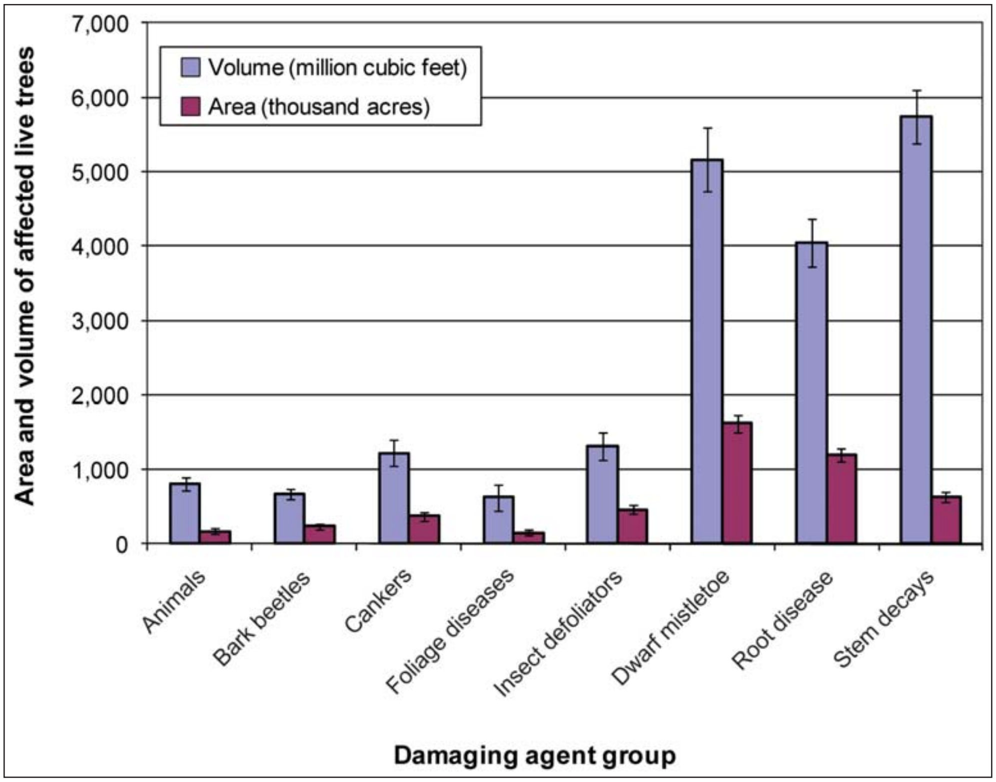


Figure 61—Area and volume of live trees affected by one or more biotic agents on forest land in Washington, 2002-2006. Area is that with ≥25 percent of basal area with damage. Volume is gross volume of affected live trees ≥5 inches diameter at breast height. Lines at the end of bars represent ± standard error.

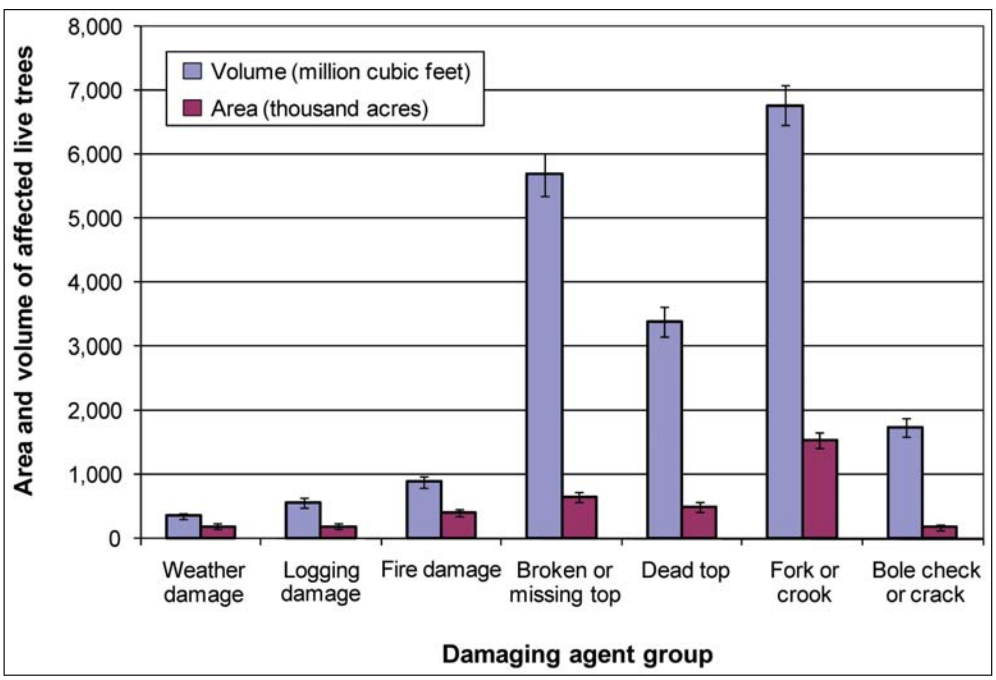


Figure 62—Area and volume of live trees affected by one or more abiotic agents on forest land in Washington, 2002-2006. Area is that with ≥25 percent of basal area with damage. Volume is gross volume of affected live trees ≥5 inches diameter at breast height. Lines at the end of bars represent ± standard error.

are more prevalent in unmanaged or older stands. If the current trajectory of management on federal forests continues, we would expect to see increases in these agents on national forests and other federal lands in the future; conversely, we would expect decreases or continued lower levels on private and nonfederal forests, where stands are younger and more intensively managed. Root disease, often widespread in older stands, may become more damaging in young stands that are established in infested areas. The incidence and impact of many insects and diseases are closely tied to past forest management practices that have influenced forest structure and composition (Campbell and Liegel 1996).

In the near future, the greatest insect or disease threats to Washington's forests are likely to come from introduced organisms, and also from native species whose populations and impacts are increased by drought, high stand densities, and climate changes (Pimentel et al. 2005). Recent bark beetle epidemics in southern California and British Columbia are attributed to a number of these factors (British Columbia Ministry of Forests 2006, Pedersen 2003, Walker et al. 2006). Results of widespread bark beetle epidemics should be observable in future FIA data on tree mortality. Annual aerial surveys can also provide excellent, timely information on insect- and disease-caused defoliation. Tracking the incidence and impact of insects, diseases, and other damaging agents over time will become particularly important as changes in climate and in human activities affect Washington's forests.

Insects, Diseases, and Other Damaging Agents Tables in Appendix B

Table 38—Estimated number of live trees with damage on forest land, by species and type of damage, Washington, 2002-2006

Table 39—Estimated area of forest land with more than 25 percent of the tree basal area damaged, by forest type and type of damage, Washington, 2002-2006

Table 40—Estimated gross volume of live trees with damage on forest land, by species and type of damage, Washington, 2002-2006

Table 41—Estimated damage to trees, by geographic region and broad owner group, Washington, 2002-2006

Invasive Plants[17]

Background

Invasions of nonnative plants into new areas are having a large impact on the composition and function of natural and managed ecosystems. Invasive plants can have a large economic impact, both by changing or degrading land use and through the costs of control efforts, now estimated at over $35 billion per year for the United States (Pimentel et al. 2005).

Nonnative plant invasions competitively exclude desired species, alter disturbance regimes, and are a primary cause of extinction of native species (D'Antonio and Vitousek 1992, Mooney and Hobbs 2000, Vitousek et al. 1996). Despite their importance, there is little comprehensive information about the extent and impact of invasive species. Most of the emphasis given invasive plants is in the context of local eradication efforts. Comprehensive numbers are not available to describe the magnitude of the problem, which plants are having the most impact, and where these plants are found.

The FIA phase 3 vegetation indicator (Gray and Azuma 2005, Schulz et al. 2009), conducted on a trial basis for several years now, provides a good source of information on plant composition. In 2004 and 2005, 91 plots were sampled in Washington with this protocol. Botanists visited plots during midsummer and identified and recorded all species found or collected samples for later identification. Because the definition of "invasive" can be quite subjective, all species that were listed as nonnative to the United States (USDA Natural Resources Conservation Service 2000) were selected for analysis. Vegetation data collected on the phase 2 (standard inventory) plots were also analyzed by selecting records of nonnative species that were readily identifiable by most crews (i.e., common shrubs or common and distinctive herbs).

[17] Author: Andrew Gray.

Findings

Fifty-four percent of the plots across Washington's forest land had at least one nonnative species growing on them. The percentage was highest in some of the eastern Washington ecosections (e.g., 100 percent of plots in the Blue Mountains and Columbia Basin) and lowest in the Northern Cascades (about 35 percent of plots) (fig. 63). (Note: the greater the number of plots sampled to date, the more reliable the result.) Invasive plants were pervasive on forest land in the Columbia Basin ecosection, with a surprisingly high mean of 11 nonnative species covering 46 percent of the plot area. The percentage of nonnative species decreased with increasing stand size class (fig. 64). The basic metric proposed by the Heinz Center (2002) for national reporting of the impact of nonnative plants simply sums the percentage cover of nonnative plants and divides by the summed cover of all plants. For Washington, this calculation indicates that 3.9 percent of all plant cover on forest land consists of nonnative plants (standard error = 1.1 percent). In comparison, in Oregon (the only other state with comparable data to date) nonnative plants covered 6.2 percent of forest land (Donnegan et al. 2008).

The most common invasive plant found on phase 3 plots in western Washington was Himalayan blackberry (see "Common and Scientific Names"), and the most common in eastern Washington was cheatgrass (fig. 65). These and some other nonnative species are readily identifiable through long field seasons, so the vegetation records on phase 2 plots provide an estimate of overall abundance on forest land. The area covered by each species on each plot was extrapolated to all forest land with standard inventory statistics. These data suggest that Himalayan blackberry covered 73,000 acres and cheatgrass covered 133,000 acres of forest land in Washington.

Interpretation

Nonnative invasive plant species already are well established in Washington's forested lands, making up a significant proportion of the species and plant cover present. Current trends suggest that their importance will

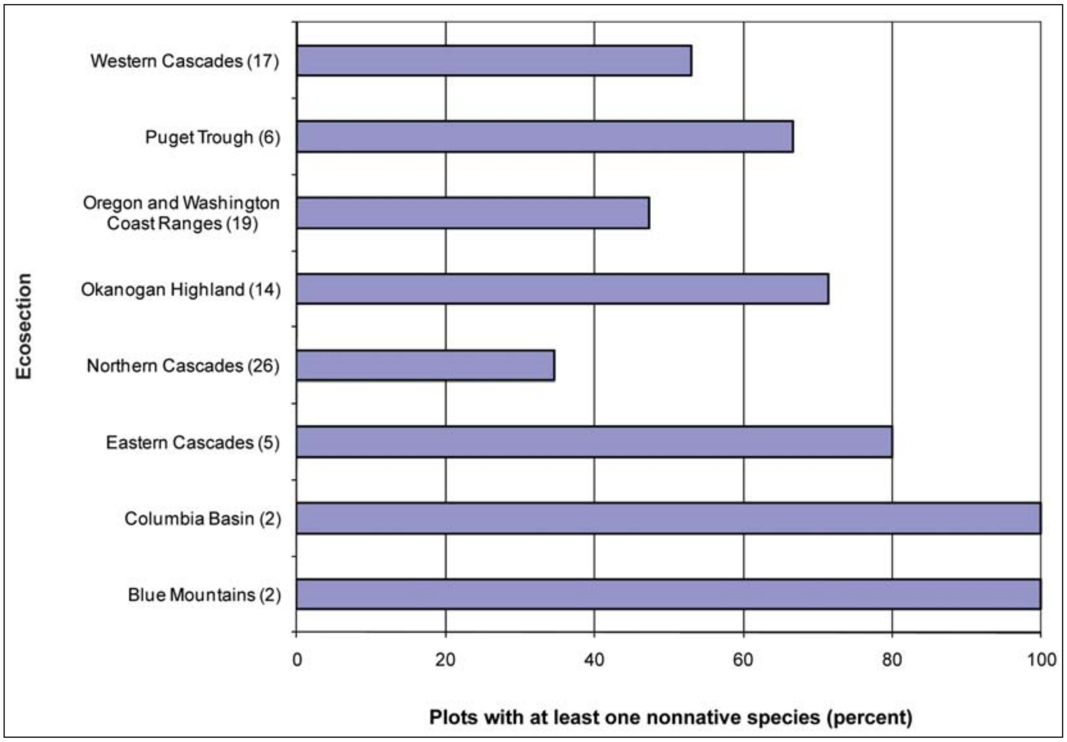


Figure 63—Percentage of plots with at least one nonnative species present on forest land in Washington, by ecosection, 2004–2005. Number in parentheses after ecosection name is the number of forested plots sampled for all species.

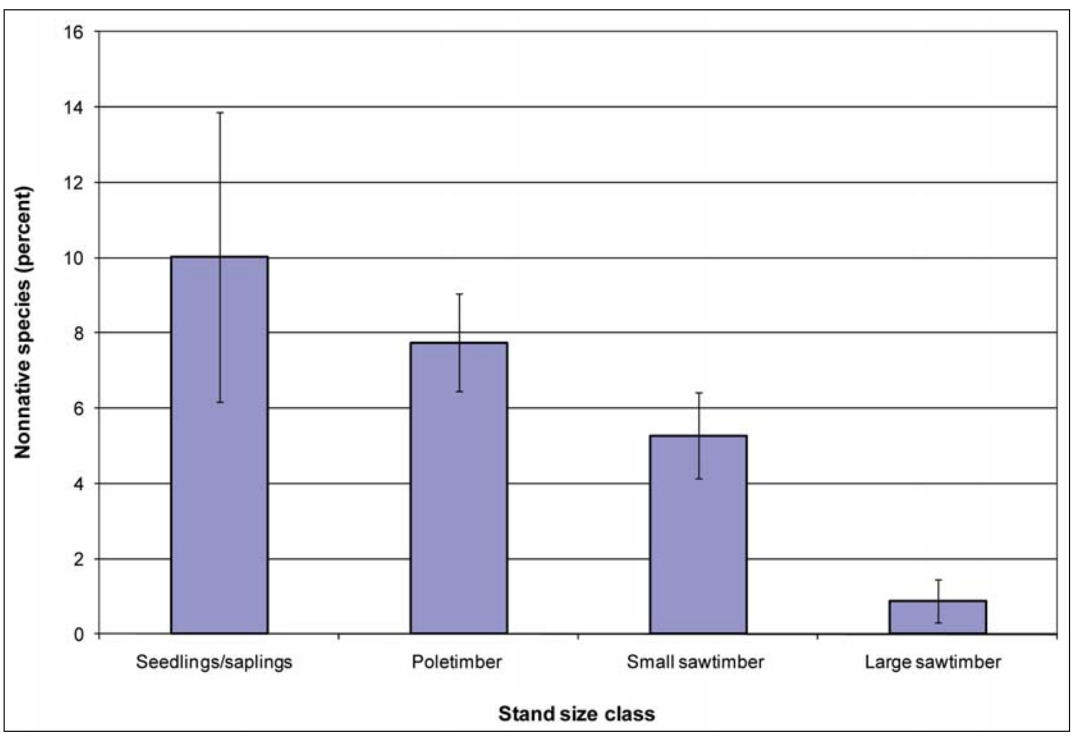


Figure 64—Mean percentage of species on a plot that were nonnative on forest land in Washington, by stand size class, 2004–2005. Lines at end of bars represent ± standard error.

Figure 65—Cheatgrass is the most common invasive plant in forests of Washington.

increase. For example, species like English holly and garlic mustard have been rapidly increasing in abundance in western Washington. Most species tend to be associated with young, recently disturbed stands, although the two species mentioned above are good examples of those well suited to shady, undisturbed forests. Although FIA's phase 3 vegetation indicator provides sufficient comprehensive information on species composition to inform national indicators, the plot density is too low to assess distribution of individual species. The FIA phase 2 sample does provide that information for species that are readily identifiable, and potentially for others of specific interest if crews are given dedicated identification training.

Invasive Plants Tables in Appendix B

Table 28—Index of vascular plant species richness on forest land by ecological section, Washington, 2004-2005

Table 42—Estimated area of forest land covered by selected nonnative vascular plant species and number of sample plots, by life form and species, Washington, 2002-2006

Air Quality[18]

Air quality in many of Washington's forests is fair to excellent, better than in many other parts of the country. Still, evidence of degraded air quality has been detected in some forests of the Columbia River Gorge National Scenic Area (Fenn et al. 2007) and the Puget Sound near major urban areas such as Seattle and Everett (Eilers et al. 1994, Geiser and Neitlich 2007). Air quality impacts to vegetation depend on many factors; among the most important are plant life stage, species, pollutants, site conditions, and degree of exposure. Effects commonly

[18] Authors: Sally Campbell and Sarah Jovan.

culminate in declines in stand productivity and shifts in community composition when sensitive individuals are damaged or killed. Changes can cascade through the ecosystem, especially if the affected species provide sustenance or habitat for wildlife or other important ecosystem services.

The FIA Program monitors two phase 3 (see p. 119 in app. A) indicators for air quality: (1) injury to ozone (O_3)-sensitive plants (fig. 66), and (2) the composition of epiphytic (i.e., tree-dwelling) lichen communities (fig. 67). Instruments that directly measure air pollutants are sparsely distributed in Washington's forests (U.S. EPA 2008). Thus, air quality monitoring with indicator species is indispensable, allowing for a spatially comprehensive assessment of risks to forest health across the landscape.

Figure 66—Ozone injury (chlorotic mottle) on Jeffrey pine needles, Columbia Gorge biosite.

Ozone Injury Background

Tropospheric (ground-level) O_3 is highly toxic to plants and is considered an important ecological threat to Washington's forest re-sources (Eilers et al. 1994). For the FIA O_3 indicator, three or more plant species known for their O_3 susceptibility (bioindicators) are scored for foliar injury at each O_3 plot (biosite). Injury data are combined into a biosite index that is used to predict local potential for O_3 damage (Coulston et al. 2003).

Figure 67—Lichens are well known for their high sensitivity to air quality. Bark covered by small orange *Xanthoria* species (left) is often a sign of nitrogen pollution. *Nephroma* species (right) are a typical indicator of clean air in mountainous areas.

Using geospatial interpolation of biosite indices averaged over a number of years, we can predict relative risk to susceptible forest vegetation across a broader geographic area and identify areas where O_3 is more likely to cause injury (Coulston et al. 2003). The FIA biosite network is the only statewide O_3 detection program that uses bioindicators to monitor ozone impacts to forest vegetation.

Ozone Injury Findings

In contrast to widespread O_3 injury detected on California biosites, O_3 injury was found on only one Washington biosite visited between 2000 and 2006 (Campbell et al. 2007) (fig. 68). This finding is consistent with low measurements from ambient O_3 sampling networks (fig. 69) (Eilers et al. 1994, U.S. EPA 2008) and no injury found on biosites in Oregon (Donnegan et al. 2008). Ozone injury was confirmed at one Washington biosite in the Columbia Gorge about 100 miles east of the Portland/Vancouver metropolitan area, where planted Jeffrey pine has shown injury 6 of the last 7 years. An assessment of risk using the geospatial interpolation method mentioned above shows very low or no risk to Washington's forests from O_3.

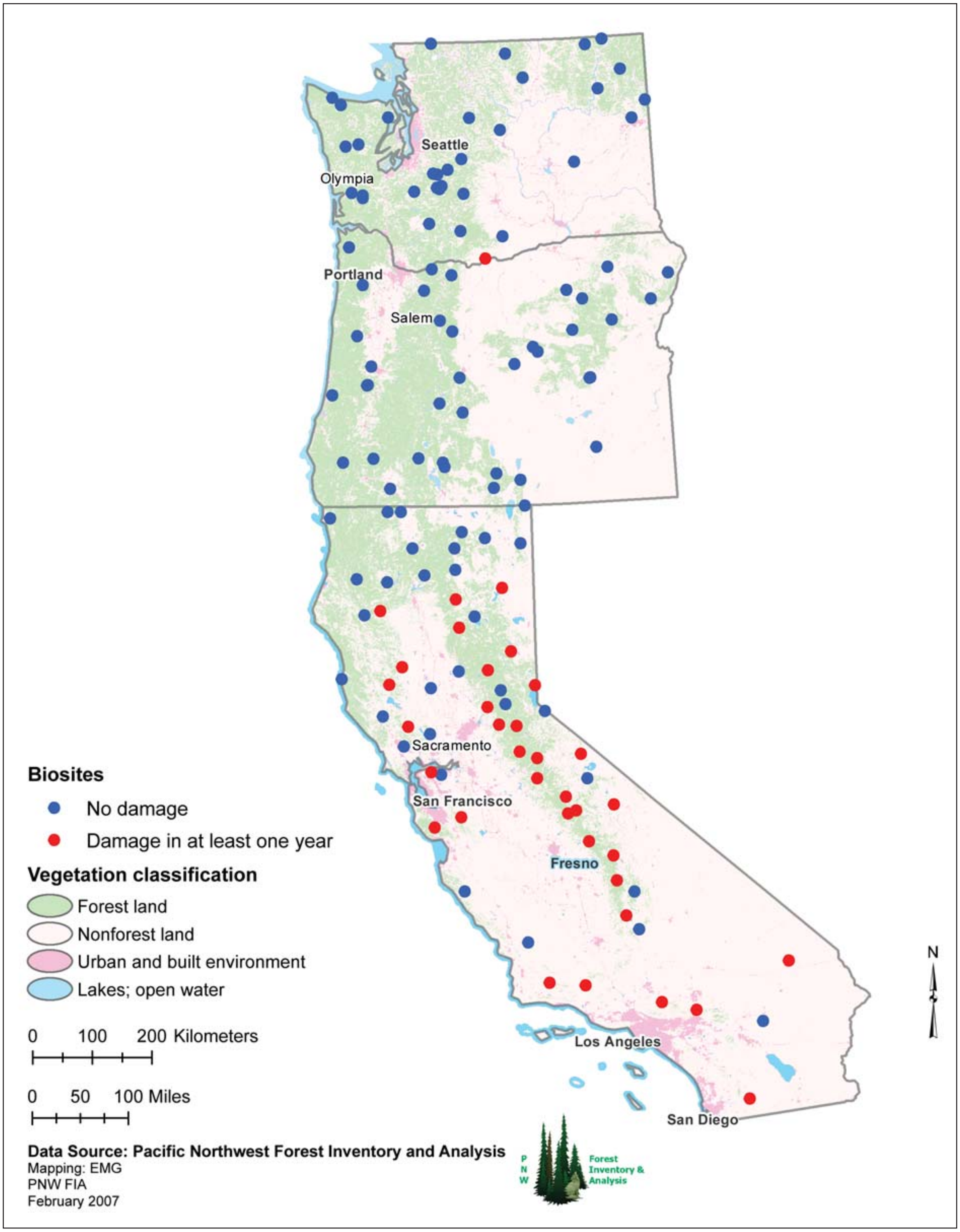
Ozone Injury Interpretation

Washington has no ozone nonattainment areas and, with the exception of one location near Enumclaw (southeast of Seattle) where the national standard for 1-hour and 8-hour average concentrations of O_3 was exceeded in 2006, ambient monitoring between 2000 and 2006 indicates that Washington currently meets the national standards for O_3 (U.S. EPA 2008). Consistent injury of Jeffrey pine at the Columbia Gorge biosite, however, shows that although measured O_3 concentrations are not exceeding national standards, phytotoxic O_3 levels are present there (Campbell et al. 2007). Although population increases are expected in Washington, it is hoped that continued efforts and innovations to abate vehicular and industrial emissions will sustain low O_3 levels. Because the entire biosite network is fully resampled each year, the FIA O_3 indicator will allow us to easily track temporal and geographic fluctuations in O_3 injury.

Lichen Community Background

For the lichen community indicator, surveyors determine the abundance and diversity of epiphytic lichens on phase 3 plots. The FIA Program uses these data for monitoring air quality as well as forest biodiversity (see "Lichen and Plant Biodiversity" section in chapter 3) and climate change (Jovan 2008). With the help of multivariate models, FIA lichen data are used to score air quality at each plot. Two models are used to monitor Washington's forests: one each for the west and east sides of the Cascades. The west-side model, as reported here, was developed by Geiser and Neitlich (2007) in collaboration with FIA and the Forest Service's PNW Region, Air Resource Program. The model needed for evaluation of east-side air quality is currently under development.

Low air pollution scores suggest lower levels of pollutants and vice versa. Geiser and Neitlich (2007) made their assessment by (1) examining the distribution of lichen indicator species across plots, (2) conducting laboratory analysis of nitrogen (N) and sulfur (S) accumulation in collected lichens, (3) correlating scores to pollutant measurements collected at a subset of plots, and (4) examining land use patterns. Air quality scores are used to delineate six air quality zones: best, good, fair, degraded, poor, and worst.



Elaina Graham

Figure 68—Forest Inventory and Analysis ozone biosites and injury status for forests in Washington, Oregon, and California, 2000-2005 (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

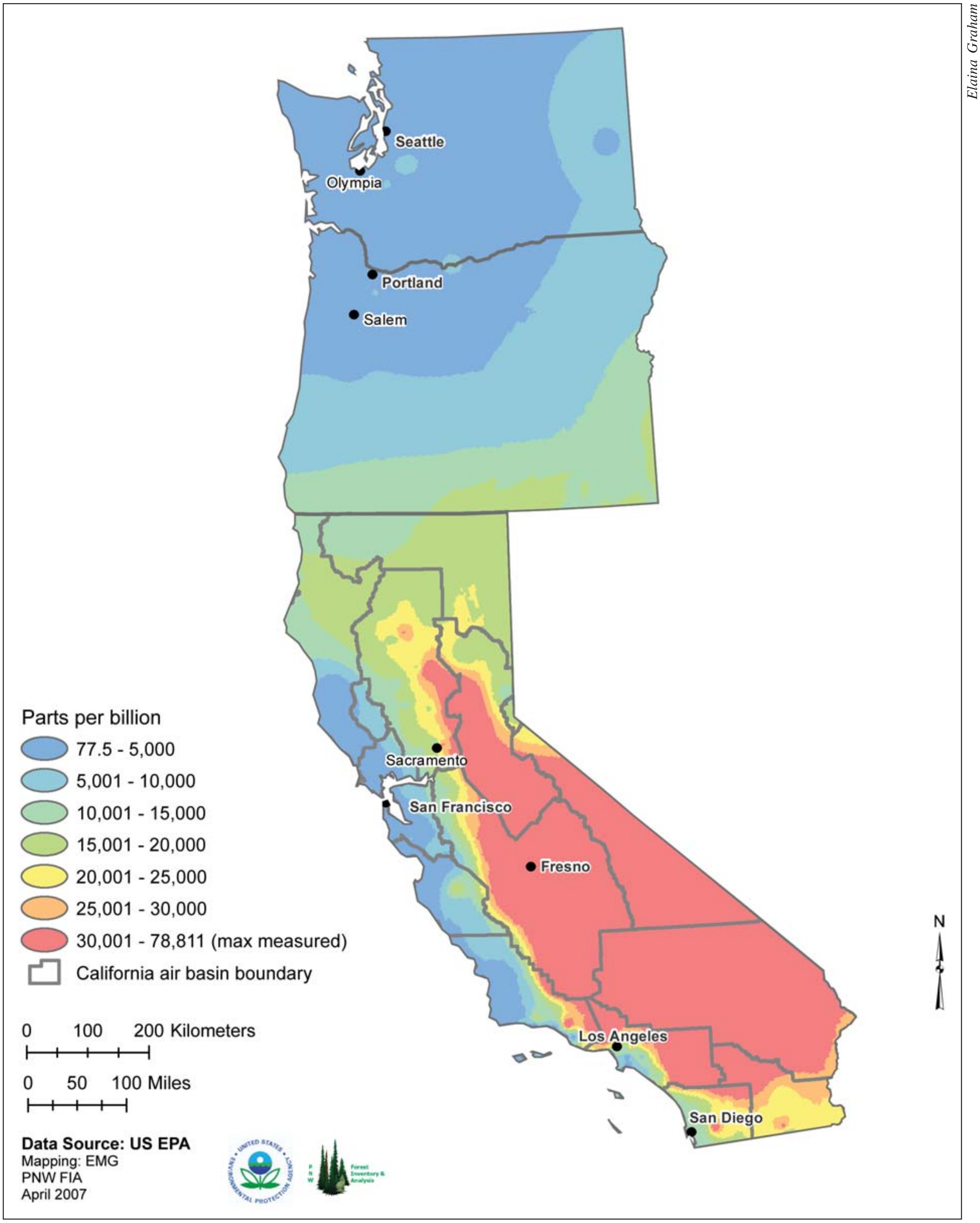


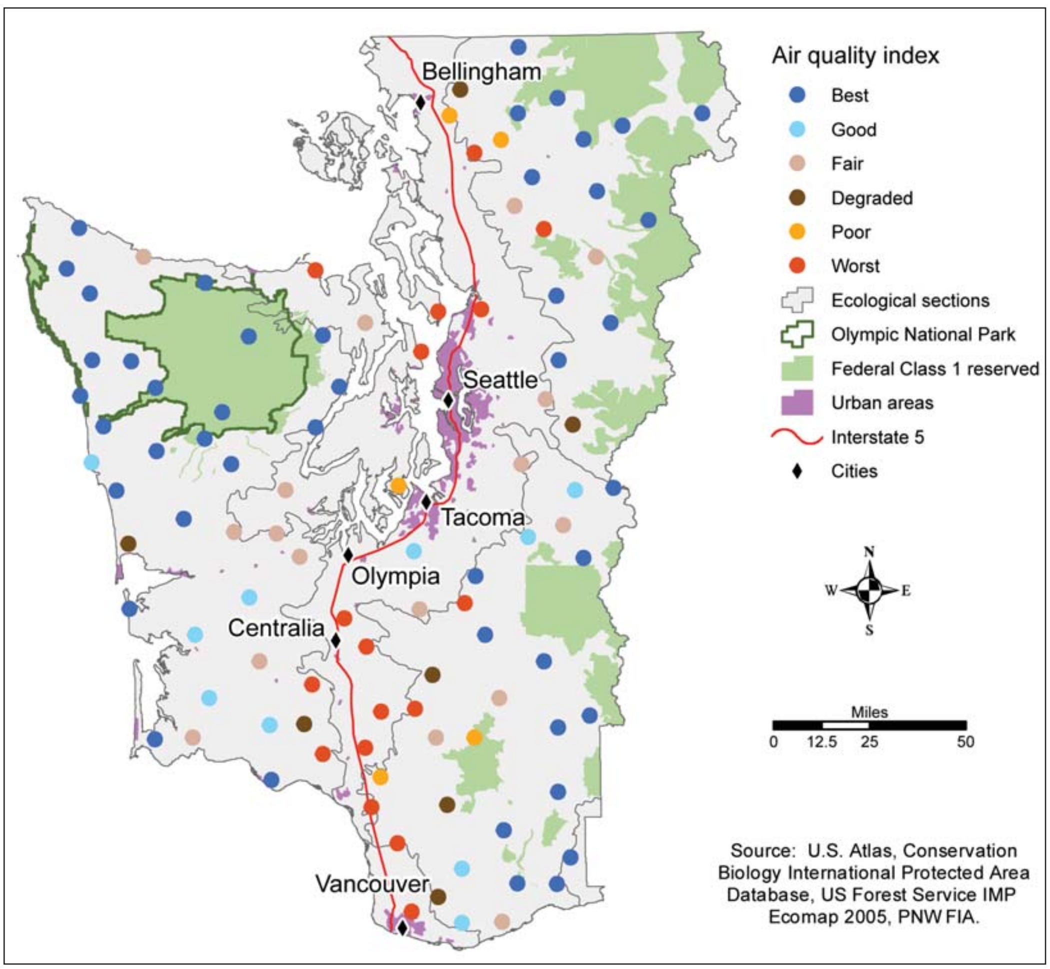
Figure 69—Average ozone exposure in Washington, Oregon, and California, based on cumulative hourly ozone concentrations exceeding 60 parts per billion (SUM60) June 1 to August 31, 8 a.m. to 8 p.m., 2001 to 2005 average (SUM60 ozone data: U.S. Environmental Protection Agency 2006).

Lichen Community Findings

Results from 5 years of surveys (1998-2001 and 2003) in west-side forests provide strong evidence that N pollution is having a heavy impact on some stands. Diverse assemblages of pollution-sensitive lichens characterized low-scoring plots, and species that indicate high N levels, known as nitrophytes (fig. 70), were relatively abundant at high-scoring plots (fig. 71). The presence of these lichen communities suggests that the Puget Trough ecoregion, where much of western Washington's agriculture and metropolitan areas lie, is part of a major N hotspot that extends into foothill forests of the Coast and Cascade ranges.

Sarah Jovan

Figure 70—Nitrophytes (eutrophs) grow prolifically on bark surfaces enriched by nitrogen.



John Chase

Figure 71—Air quality scores (Geiser and Neitlich 2007) on forest land plots in western Washington, 1998-2001, 2003 (ecosection geographic information system [GIS] layer: Cleland et al. 2005, urban GIS layer: U.S. Geological Survey 2001).

On the other hand, nearly all lichen communities sampled near Federal Class 1 areas suggested excellent air quality. Federal Class 1 areas (i.e., national parks, national wilderness areas, and national monuments) receive special air quality protection under section 162(a) of the Clean Air Act. The only exception was Mount St. Helens National Monument where some degradation was detected, although it's unclear whether pollution is of local origin or a result of lying downwind of the Puget Trough.

Lichen Community Interpretation

Beyond degrading air quality, the ecological and economic impacts of excessive N pose an increasing concern for terrestrial and aquatic ecosystems in the Pacific Northwest. In addition to promoting a nitrophytic lichen flora, N pollution can cause accelerated accumulation of fuels, soil acidification, shifts in plant communities, and a decline in mycorrhizal fungi (Fenn et al. 2003). Remeasurement of lichen communities beginning in 2011 will allow FIA to track changes in N as well as the proliferation of other ecologically harmful pollutants. More elaborate discussion of lichens and Washington's air quality may be found in Geiser and Neitlich (2007) and Jovan (2008), and at the Forest Service PNW Region lichen-air quality Web page: http://www.fs.fed.us/r6/aq/lichen/.

Air Quality Tables and Maps in Appendix B

Table 43—Forest Inventory and Analysis plots sampled for lichen community, air quality index information, western Pacific Northwest and western Washington, 1998-2001, 2003

Table 44—Forest Inventory and Analysis plots sampled for lichen community, climate index information, western Pacific Northwest and western Washington, 1998-2001, 2003

Table 45—Ozone injury by year, Washington, 2000-2006

Fire Incidence[19]

Background

All forest types in Washington have the potential to experience crown or surface fire, although fire incidence differs considerably by region and forest type. State and federal agencies estimate the size of all wildland fires and some prescribed fires, map the perimeters of larger fires, and calculate statistics on fire incidence for the lands for which they have protection responsibility. Agencies' fire incidence reports seldom specify the vegetation type that was burned, and different agencies use different reporting thresholds. Moreover, data on some fires appear in both federal and state databases, but without common identifiers that would facilitate identifying and accounting for duplicate reporting. Therefore, reliable and consistent estimates of forest area burned per year across all ownership classes are lacking. The FIA field crews record evidence of surface and crown fire that occurred within the 5 years preceding the plot visit[20] making it possible to estimate the expected forest area burned per year and the fraction of the forest this represents.

Findings

We estimate that over the period 1998-2005, more than 86,000 acres of forest burned statewide per year (range 24,000 to 155,000 acres), with nearly 83 percent of this total burning east of the Cascade crest. No clear temporal trends in area burned were observed. This average represents 0.39 percent (SE = 0.07) of the total forest land area in Washington, but year-to-year variability was considerable (fig. 72), ranging from 0.11 percent of forest area burned in 2005 to 0.70 percent in 2001. Regional variability also was high; the average annual fraction of the forest that burned for the three survey units on the

[19] Author: Jeremy S. Fried.

[20] Because plot visits occur throughout the year and could occur before or after a fire in a given year, it was necessary to exclude from analysis observations of fire evidence in the same year as the plot visit.

west side of the Cascade Range crest (fig. 8) was 0.12 percent (SE = 0.08) versus 0.72 percent (SE = 0.11) for the two east-side survey units.

The estimate of 86,000 acres per year of forest burned over the period 1998 through 2005 compares favorably with data derived from databases of fire incidents maintained by the Washington Department of Natural Resources (covering primarily nonfederal lands) and the Northwest Interagency Coordination Center (NWCC) (covering primarily federal lands) (fig. 72). Annual burned area totals from all sources (agency databases and estimates from FIA field visits) are extremely variable, and the WDNR data include some (but not all) federal fires in its data series after 2003. Comparing the average area burned per year as represented by WDNR data for nonfederal lands in 1998–2005 (25,777 acres) with the estimate from FIA field plots for the same land base and period (23,515 acres) suggests promising correspondence. The average annual area burned on all lands in Washington as represented in the NWCC database (104,010 acres) also corresponds quite favorably with the FIA estimate of 86,000 acres on forest lands. In both comparisons, the FIA estimates are lower, but this is not surprising given that these and other interagency fire databases tend to be concerned with fire causes and sometimes (in the case of federal data) the location of the fire perimeter of larger fires, but do not account for the kinds of vegetation within the fires. Thus some of the area accounted for in

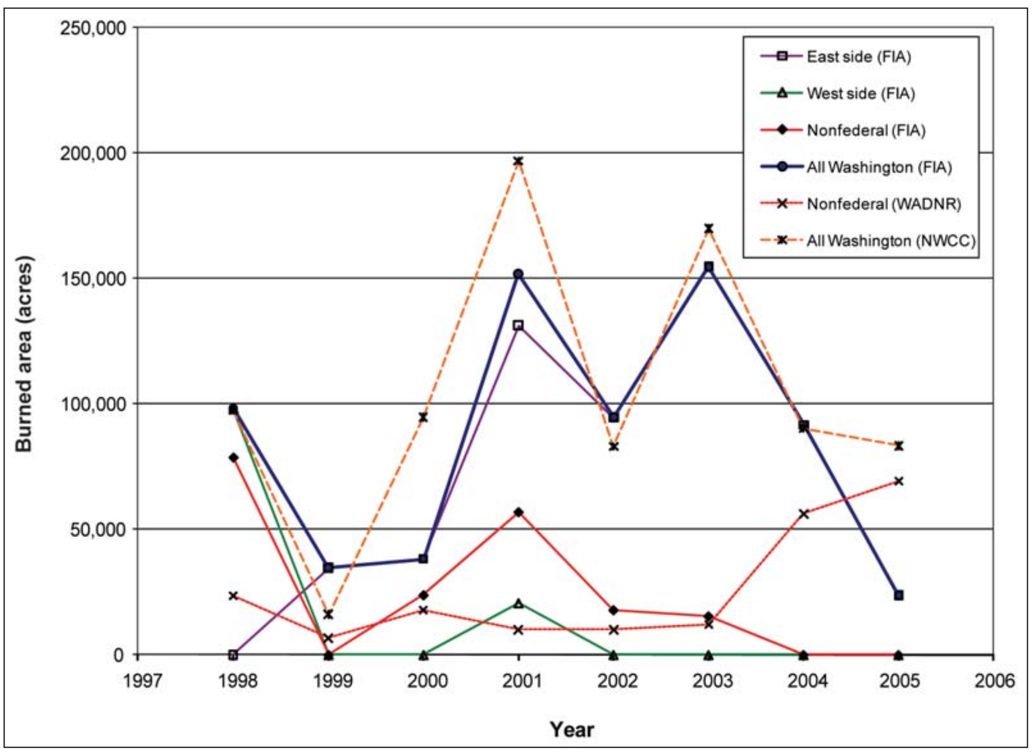


Figure 72—Annual area burned by fire as estimated from observations on Forest Inventory and Analysis plots collected between 2002 and 2006 (east side, west side, nonfederal, all Washington), summarization of the Washington Department of Natural Resources (WADNR) fire incident database (nonfederal [WADNR lands], although some fires on federal lands are included), and compilation of federal geographic information system data sets (Northwest Interagency Coordination Center data available only for 2004 and later).

agency databases is covered in flammable vegetation not classified as forest (e.g., grass and shrubs). Because FIA does not collect a complete ground-based sample of nonforest lands, it is not possible to estimate directly from FIA plot data the area burned in nonforest vegetation types. Moreover, some of the area within recorded perimeters of large fires is, in fact, entirely unburned, so relying on fire perimeters tends to generate overestimates of burned area.

Caveats

Because fire is a relatively rare event, the number of plots where recent fire is observed is very small, and therefore, standard errors on estimates of area burned, even at a state and half-state scale, are comparatively large. Generating estimates for subsets of the forest land base (e.g., ownership classes, particular forest types, ecoregions) is impractical because of the small sample, inconsistent differentiation of fire type (e.g., surface vs. crown) and origin (e.g., prescribed vs. wildfire), and because field crews were not universally able to assess fire type. For those reasons, all acres observed to have been burned were pooled for this analysis.

However, we have no reason to believe that these estimates are any less accurate than those based on available agency databases. Most fire incident databases have numerous fire reports that do not record the area burned, some have discrepancies between reported sizes and the geographic information system (GIS)-calculated area, and they differ in the size thresholds of fires included. They also generally do not track acres by vegetation type, rendering the data unsuitable for assessing the area of burned forest. These common problems suggest that users who rely on such databases may unknowingly under- or overestimate actual area burned.

Interpretation

Clearly, fire incidence on the west side of the state during the period sampled is comparatively low. Most of Washington's recently burned forest can be found on federal lands east of the Cascade Crest. The high year-to-year variability in wildfire incidence and extent makes it impossible to identify any trend in forest area burned over the past 8 years. Unlike agency fire incident databases, the FIA data enable estimation of forest area burned by region and owner class (agency databases report area within fire perimeters, some of which is not burned and some of which is not forest, and contain no information as to owners of burned land). Over time, as additional panels are installed, it is possible that trends may become observable.

This analysis is but one example of what can be explored using the disturbance information recorded as condition attributes (and thus linked to area, not trees) on FIA plots by field crews. Other kinds of disturbance routinely recorded, and with a greater frequency than fire, include insects, disease, animals, and weather.

Fire Incidence Tables in Appendix B

Table 46—Forest land area on which evidence of fire was observed, by year and geographic location, Washington, 1998-2005

Crown Fire Hazard[21]

Background

Reduction of wildfire hazard has emerged as a priority issue in Washington, where fuel treatments are proposed on an unprecedented scale. Characterization of fire hazard typically focuses on crown fire potential—the tendency of a forest stand to experience crown rather than surface fire—because crown fires are typically stand-replacing events and often are regarded as highly destructive. Before an effective fuel treatment program can be developed, it is essential to know initial hazard levels and identify where hazard reduction is most technically, economically, and socially feasible (see, e.g., Barbour et al. 2008, Vogt et al. 2005). The FIA inventory provides a unique opportunity to assess the extent of

[21] Authors: Jeremy S. Fried and Glenn Christensen.

Tom Iraci

Figure 73—Fire has changed the composition of forests across large areas in Washington.

crown fire hazard across all land ownerships, survey units, and forest types (fig. 73). Examining these statistics on a proportional basis, by forest type and geographic distribution, provides key insights into factors associated with high crown fire hazard.

All plots with forest were simulated with the Forest Vegetation Simulator (FVS) and its Fire and Fuels Extension (FFE) (Reinhardt and Crookston 2003) to calculate indices of crown fire potential and fire type under severe fire weather.[22] Each inventory plot was assigned to the appropriate FVS variant by GIS overlay with the FVS variant map (USDA Forest Service 2007b). Other than the tree height, canopy bulk density, and canopy base height crown fuel parameters, which were derived from the tree-level data collected by FIA and the crown uncompaction model of Monleon et al. (2004), fuel (e.g., surface fuel model) and weather (e.g., windspeed 20 feet above the ground) parameters were assigned default values.[23] Fire type was modeled using FFE as one of four classes (see tabulation below), and results were analyzed and mapped.[24]

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[22] The FVS-FFE was applied to all conditions classified as forested on the ground. Although classified as forested, sometimes by field crews considering areas of the condition outside of the plot footprint, some conditions contained few or no trees on the plot, such that stand attributes the model uses to estimate crown fire potential (e.g., canopy bulk density, height to canopy base) cannot be calculated reliably. The FFE model assumes that sparsely forested conditions have a surface fire regime, which may or may not be true depending on stand structure in the remainder of the condition (outside the plot footprint).

[23] Surface fuels were determined via lookup tables based on stand structure and forest type. For the fire weather scenario, FFE default parameters were used such that 20-foot windspeed was set at 20 miles per hour, temperature at 70 degrees F; 1-, 10-, 100-, and 1,000-hour fuel moisture at 4, 4, 5, and 10 percent, respectively; duff fuel moisture at 15 percent, and live fuel moisture at 70 percent.

[24] To better visualize the broad-scale geographic distribution of fire regimes, local kriging interpolation was performed on the ordinal variable, fire type, as if it were a ratio (continuous) variable. This produces a surface of crown fire potential from the plot data, with values ranging from 1 (surface fire) to 4 (active crown fire).

Fire type	Fire characteristics
Surface	Only surface fuels on the forest floor burn
Conditional crown	Existing crown fire will continue as a crown fire, but if canopy gaps interrupt its spread, it will convert to a surface fire and not reinitiate as a crown fire
Passive	Some crowns will burn as individual trees or groups of trees "torch," with fire climbing from the surface via ladders of dead branches and lesser vegetation
Active	Fire moves through the tree crowns and reinitiates as a crown fire if canopy gaps interrupt its progress

Findings

Patterns for the crown fire potential indices and fire type were similar; thus, for simplicity, only the fire type results are reported here. Under the modeled weather conditions, fire would likely occur as a surface fire on 37 percent of the forest statewide. Passive crown fire would likely occur on 34 percent of the forest, and active crown fire would be expected on 20 percent. However, there is substantial regional variation—for example, given FVS-FFE default severe weather, active crown fires would be expected on about 33 percent of forests in the Puget Sound survey unit (fig. 8), and significantly less (8 percent) on forests in eastern Washington's Inland Empire (fig. 74). It is difficult to predict how these differences in potential hazard translate to events on the ground, because incidence of both fires and severe fire weather also varies among these regions. As was seen in the "Fire Incidence" section in this chapter, much more forest burns in areas like the Inland Empire on the state's east side than on the west side.

Moreover, potential for crown fire appears to differ by forest type. Among the six most prevalent coniferous forest type groups, spruce/cedar, true fir, and miscellaneous softwoods (e.g., mountain hemlock) have the highest potential for active and passive crown fire, and ponderosa

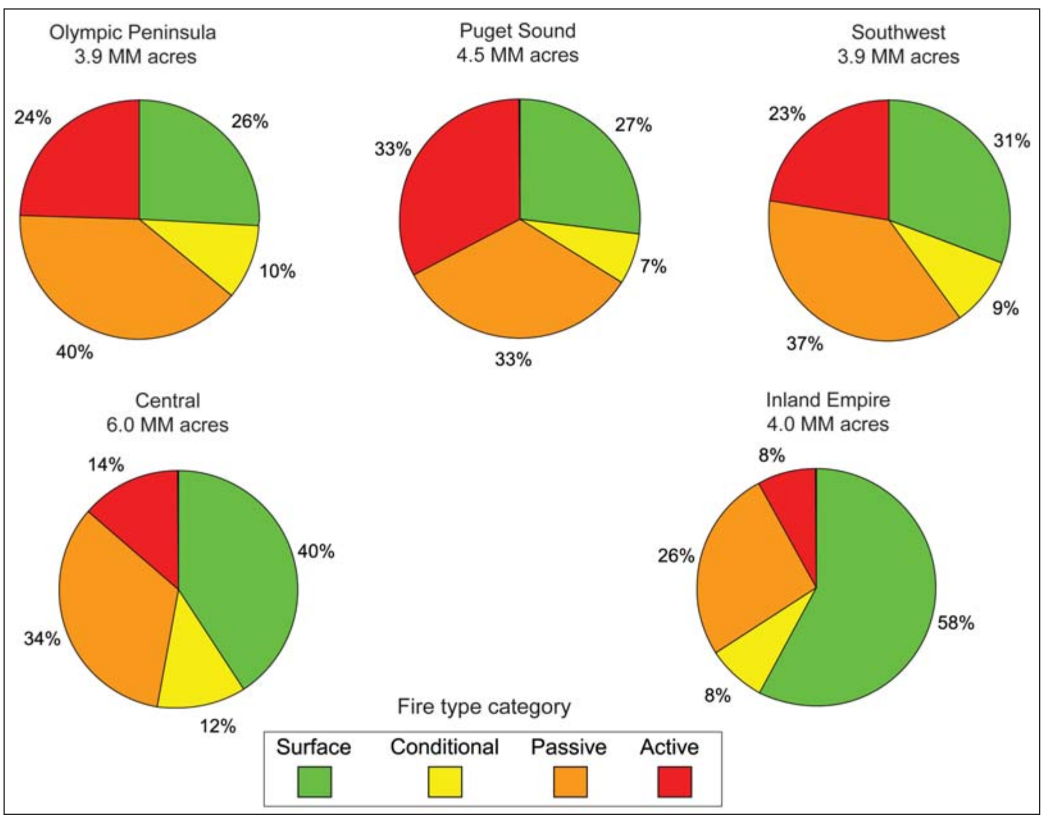

Figure 74—Percentage of forest land in Washington in each modeled fire type category, by survey unit, 2002–2006.

pine the lowest (fig. 75). However, passive crown fire is more common than active crown fire in all forest type groups considered except true fir, and does not appear to differ much among forest types. Fire regime also appears to differ by ownership (fig. 76, and app. B table 47), with lands in the noncorporate-private ownership and state and local government ownership categories predicted to have the highest percentage of forests in which surface or conditional crown fires (55 percent) are likely to occur and other federal lands to have the least (33 percent). Such differences could be due to differences in management, but may also be traced to differences in age class structure, forest type, and stand history. Interestingly, the two forest types with the highest predicted proportion in surface fire regimes, ponderosa pine and hardwoods, account for only 8 percent of private forest lands versus 11 percent of public lands.

The geographic distribution of likely fire type consistently indicates a concentration of elevated crown fire potential in forests near the Cascade crest, in the Olympic National Park, and in the extreme northeast part of the state (fig. 77). Note that crown fire potential does not necessarily relate closely to fire incidence. As shown in the section on fire incidence, the vast majority of the area burned by fire is in eastern Washington despite our finding that crown fire hazard is greater in western Washington. This is most likely due to the rarity on the west side of Washington of the severe fire weather conditions used to model crown fire potential as well as a comparatively greater rate of lightning-originated ignitions on the east side.

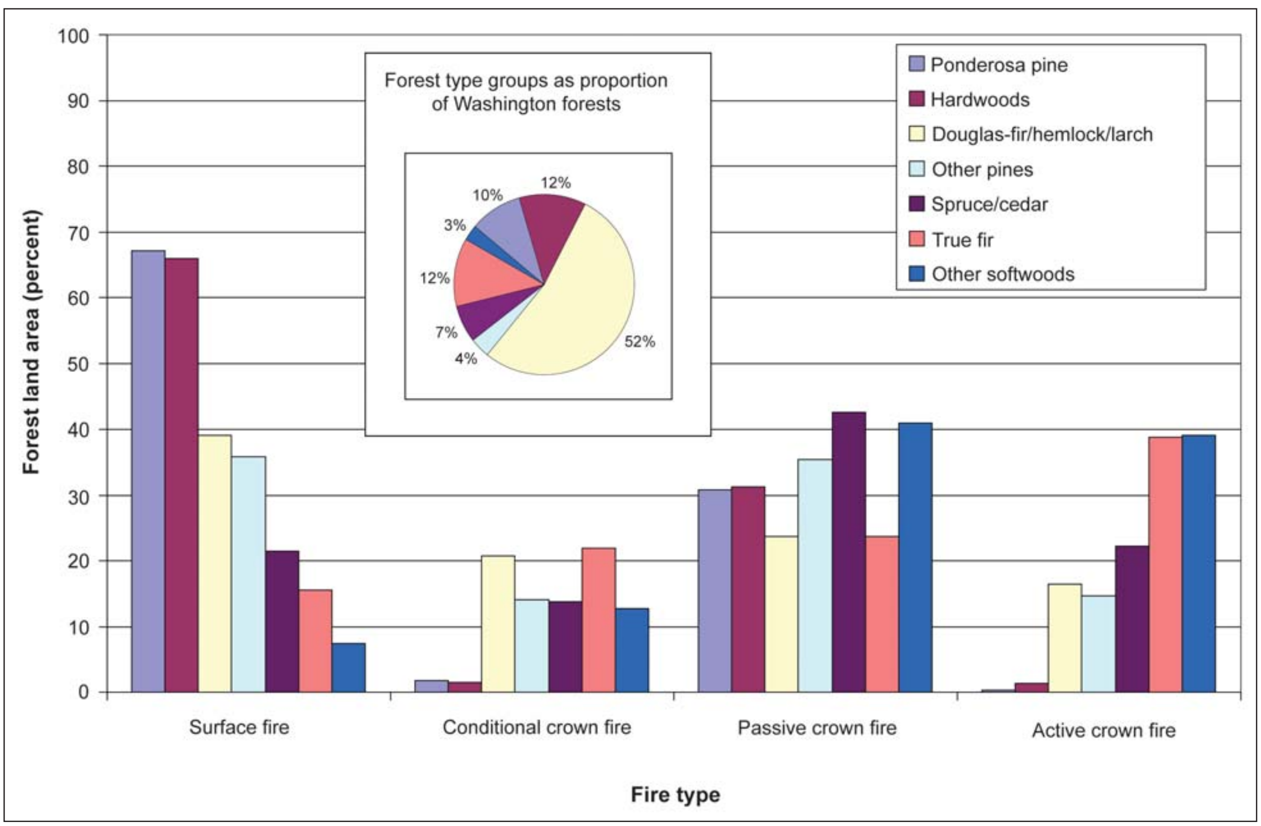

Figure 75—Percentage of Washington forest land area in each modeled fire type category for the seven most prevalent forest type groups, 2002-2006, and percentage of Washington forest land area, by forest type group, 2002-2006 (inset).

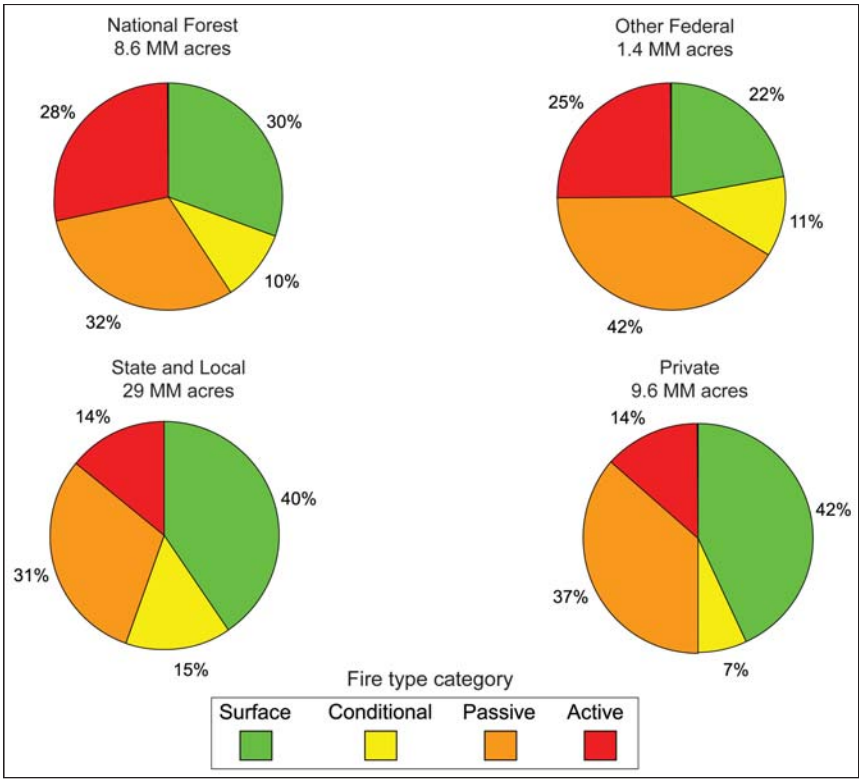

Figure 76— Percentage of Washington forest land area in each modeled fire type category, by owner group, 2002-2006.

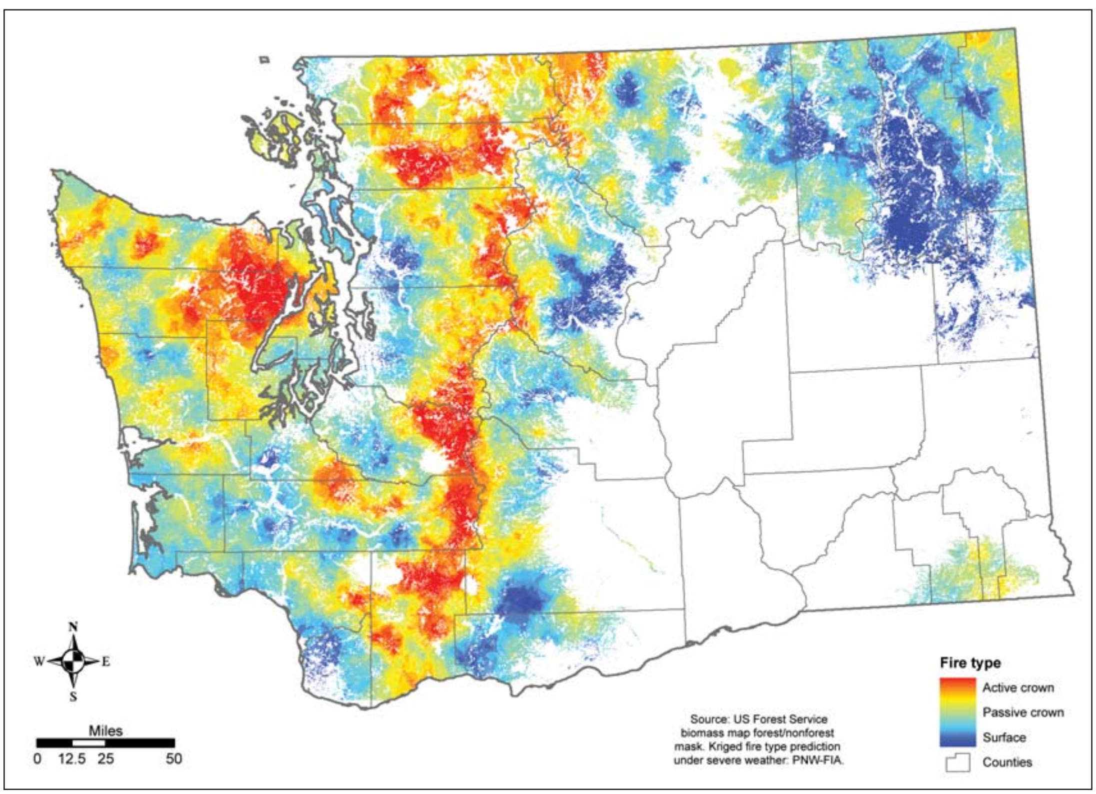

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Figure 77—Statewide distribution of fire types predicted by the Forest Vegetation Simulator Fire and Fuels Extension, under severe weather using data generated via kriging interpolation of forested Forest Inventory and Analysis plots.

Interpretation

These data paint a different picture of fire hazard and fuel treatment opportunity than is often conjured by people interpreting maps of fire regime condition class (Hardy et al. 1999, Schmidt et al. 2002). These maps depict most of the area in at least some parts of Washington (notably much of western Washington) as having significantly departed from historical fire regimes (thus becoming "out-of-whack," in the resource management vernacular) and, by implication, meriting intervention to reduce fire hazard. Under the fire weather assumed for this analysis, just over half the forested lands are predicted to develop crown fires, and an even smaller fraction, less than a quarter, can be expected to develop active crown fire. Although crown-fire potential models such as FFE have yet to be vigorously validated against behavior of actual fires, many fire managers regard them as suitable for "ballpark" predictions of what is likely to occur.

These results have implications both for the scope of fuel treatment programs and for the challenges that firefighters will face. In the context of firefighting, building a fire line that disrupts the continuity of surface fuels can be effective in stopping fire spread in areas prone to surface fires. In areas where crown fire, if it occurs, is likely to be passive, trees will torch individually, and most trees may die. On those more limited areas where active crown fire is likely to occur, a far more labor- and time-intensive job of line-building to remove standing trees would be required for fire containment efforts to be successful.

From the standpoint of implementing fuel treatments, these results and results from simulating fuel treatments at the landscape scale (Daugherty and Fried 2007) suggest that much less than half of the forested landscape is likely to benefit from fuel treatment if the objective is to reduce crown fire hazard. Given that spatial analyses of fuel treatments have demonstrated that treating a small percentage of the landscape can reduce landscape-scale fire hazard significantly and sometimes cost-effectively (Finney 2001), these results suggest that the fuels management challenge may be more easily managed than has been assumed.

Crown Fire Tables in Appendix B

Table 47—Percentage of forest land area by owner group, survey unit, and fire type, and the total forest land area by owner group and survey unit, Washington, 2002-2006

The Fawn Peak Fire[25]

The Fawn Peak fire burned 81,277 acres in 2003 and represented one of Washington's largest fires during the period of this inventory. The fire burned in relatively high-elevation forest land in the Okanogan-Wenatchee National Forest. From a sample of 15 FIA plots located within the burn, the average plot elevation was over 5,000 feet; only 1 plot was under 3,000 feet. The dominant species composition of these plots was subalpine fir, Engelmann spruce, lodgepole pine, Douglas-fir, whitebark pine, and ponderosa pine in decreasing order of abundance. All plots were classified as either pole timber size (5.0 to 8.9 inches d.b.h.) or small sawtimber (9 to 19.9 inches d.b.h.). The average crown ratio of these trees was relatively high, around 60 percent.

As part of a larger fire effects study, we remeasured 15 national forest inventory plots that fell within the Fawn Peak burn perimeter a year after the fire to evaluate the ability of predicting burn effects based on preburn characteristics. These plots were originally measured in the mid-to-late 1990s. The remeasurement captured the prior five-subplot national forest inventory (current vegetation survey) design (Max et al. 1996). A 6.8-foot-radius circle was used to evaluate the effects of the fire at the ground layer on each of the five subplots. Tree burn parameters including the percentage of stem that was blackened, height and direction of both low and high scorch locations, cause of death, and others were measured in addition to the regular phase 2 FIA plot measurements.

High-elevation stands, with smaller trees and lower crowns, are more susceptible to crown fires leading to high mortality rates and stand-replacing events. The Fawn Peak fire showed evidence of this stand replacement with over 75 percent fire-caused mortality for the remeasured trees:

Species	Remeasured trees	Fire-caused mortality	Trees ≥5 inches d.b.h. with crown ratio > 50 percent	Fire-caused mortality (trees ≥5 inches d.b.h.)
		Percent		
Subalpine fir	404	85	77	85
Engelmann spruce	206	78	89	75
Lodgepole pine	198	88	21	88
Douglas-fir	198	55	55	36
Whitebark pine	99	87	53	87
Ponderosa pine	76	48	38	27

[25] Author: Dave Azuma.

Of the 75 subplots scheduled to be remeasured, a majority had greater than 70 percent of the 6.8-foot circle burned at the ground surface. Two subplots were not measured, 13 had minor burn effects (less than 30 percent of the subplot burned), and 11 were moderately burned (30 to 70 percent of the subplot area burned). As shown in the tabulation below, the percentage of prefire crown that was burned was related to the amount of the subplot ground surface burned, the amount of mortality, and the percentage of spruce and fir on the subplot.

The ground-measured evidence shows that for the Fawn Peak Fire, a combination of a hot fire in smaller trees with lower crowns resulted in stand replacement across most of the remeasured plots. High mortality in the spruce and fir stands is generally related to the amount of the ground surface with burn effects.

Percentage of subplot surface burned	Number of subplots	Fire-caused mortality	Spruce/fir	Prefire crown burned
		Percent		
High (>70 percent)	49	84	48	70
Moderate (30-70 percent)	11	60	51	30
Low (<30 percent)	13	24	24	10

Forest products being transported to the mill.

Forests are harvested throughout Washington.

Chapter 5: Products

Washington's forests are an essential source of raw material for timber and nontimber forest products, and they provide many other amenities and services to the people of Washington. The forest products industry has historically been a mainstay of Washington's economy and culture. Its contributions continue today in the form of wood products, employment and income, tax revenue, and maintenance of forest lands across the landscape. The aim of the following chapters is to examine the productive capacity of Washington's forests and its contribution to the state's economy and environment.

Washington's Primary Forest Products Industry[26]

Background

Until World War II, the forest products industry was the leading component of Washington state's economic base. Although the software and aerospace industries now surpass it, the forests products industry still sells billions of dollars in products annually and provides living wage jobs for 19,900 workers in the solid wood products sector and 12,200 in the pulp and paper sector. The industry also serves as stewards of the state's forests, supporting ecological as well as economic sustainability for rural communities around the state. Healthy working forests are good for business and preserve the outdoor recreation and natural environments for the priceless "Northwest lifestyle."

Forestry and forest products are big business in Washington (fig. 78). Washington's forests provide more than 10 percent of the softwood timber harvested in the United States, and Washington sawmills provide 13 percent of softwood lumber produced in the United States. Forest management activities in the state generate nearly

Dorian Smith

Figure 78—Veneer is one of the many timber products that Washington mills produce.

[26] Author: Dorian Smith.

$2 billion in gross business income annually, according to the state's Department of Revenue. The wood products manufacturing sector is much larger. Wood products made in Washington exceeded $5 billion in value in 2006.

The Washington State Department of Natural Resources conducts a biennial census of Washington's primary forest products industry (i.e., timber processors). This census, *The Washington Mill Survey* (Smith and Hiserote 2007), provided statistics for most of the information presented below and some details on timber harvest and flow, as well as comprehensive information about the state's timber processing sectors, product volumes, and mill residue.

Findings

Log sources and ownership—
Washington forests provided nearly 85 percent of the wood processed by in-state mills or exported from Washington ports during 2006. Logs from Oregon made up nearly 8 percent of the logs processed in or exported from Washington–much of that exported through Washington's largest port in Longview on the Columbia River. British Columbia supplied 5 percent of the wood processed in Washington, and smaller volumes were imported from Montana, Alaska, and Idaho. More than half of the log volume processed in or exported from Washington came from large, privately owned forests. The remainder came in equal shares from small, private forest landowners, public agencies (primarily state), and tribal landowners.

In 2006, Grays Harbor County contributed the largest volume of logs to in-state mills–364 million board feet (MMBF) Scribner, followed by Clallam (244 MMBF) and Lewis (239 MMBF) Counties. The top eastern Washington timber-supplying counties to in-state mills were Yakima (112 MMBF) and Stevens (91 MMBF). More than one-third of the timber volume processed by Washington mills came from the Olympic Peninsula economic area (fig. 79). Softwoods accounted for 92.5

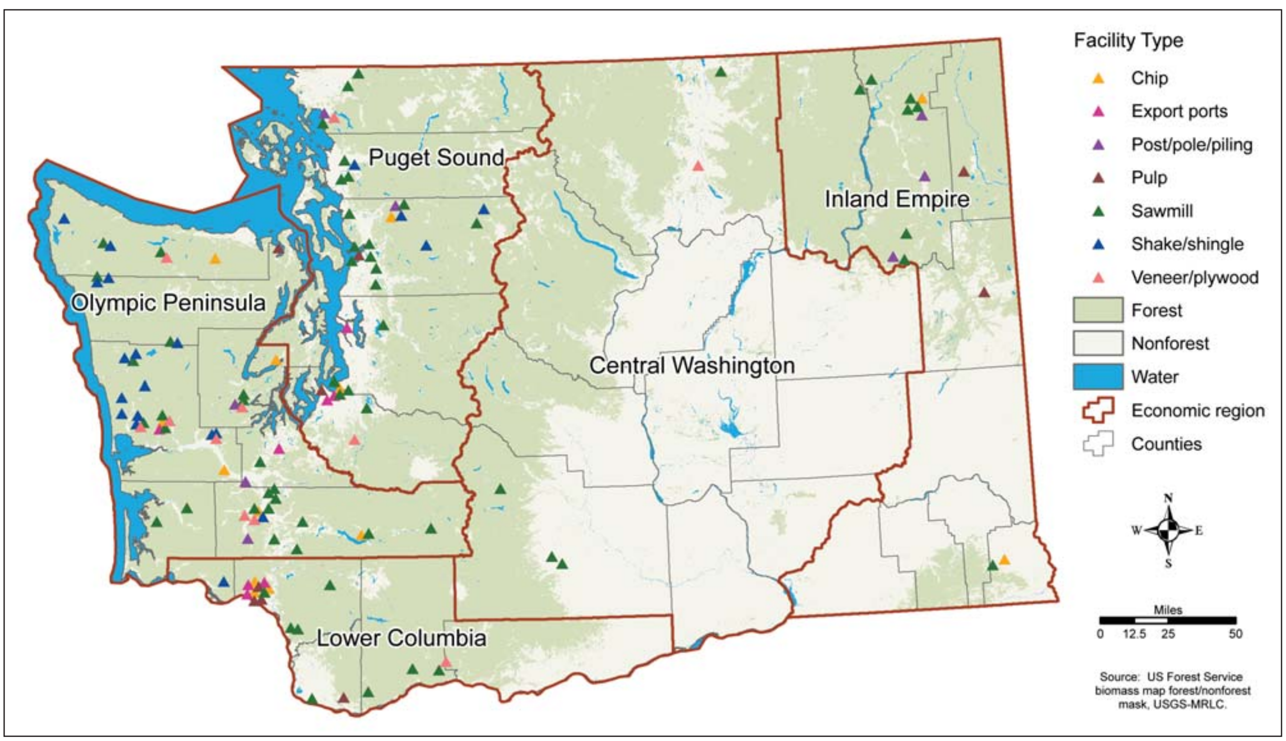

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Figure 79—Active Washington primary forest products facilities by county and economic area, 2003 (forest/nonforest geographic information system [GIS] layer: Blackard et al. 2008; urban/water GIS layer: Homer et al. 2004).

percent of the volume processed in Washington mills. Hardwoods (primarily red alder) are also sought by sawmills, chipping facilities, veneer and plywood manufacturers, and pulp mills.

Fewer, larger mills—
In 2006, *The Washington Mill Survey* identified 136 active facilities (fig. 79), a decline of 42 percent of all mill types since 1992. The shake and shingle sector was reduced from 50 to 16 mills owing to the decline of available western redcedar (see "Common and Scientific Plant Names" section). The consumption of redcedar by shake and shingle mills was down 26 percent between 1992 and 2006. The surviving sawmills were larger and more efficient operations than their predecessors. Although lumber production increased by 39 percent between 1996 and 2006, the net number of sawmills declined from 94 to 68, so the average output per mill increased by 54 percent. Sawmills received approximately 2,500 MMBF Scribner (68 percent) of the timber delivered to Washington timber processors in 2006. The statewide average overrun in 2006 was 2.0 (board feet of lumber produced per board foot Scribner of timber). In 1998, overrun was 1.8, indicating that the mills remaining in 2006 were larger and more efficient. Total production capacity in Washington increased by more than 10 percent while the average sawmill capacity leaped 53 percent during that 14-year period.

Product sales values—
In the sawmill sector, the total lumber production in 2006 was 4.95 billion board feet lumber tally with an estimated value of more than $1.7 billion. Most of the lumber was kiln-dried (56 percent) and surfaced or planed (82 percent), creating higher value lumber.

Pulp mills generate a significant share of gross business income in Washington. In 2006, the pulp sector produced 910,000 tons of bleached paper, 992,000 tons of unbleached paper, 433,000 tons of newsprint, 548,421 tons of other paper, and 257,570 tons of market pulp. Total market value of these products was more than $2.7 billion.

Rounding out Washington's wood products manufacturers for 2006, shake and shingle operations produced 3,306 shake squares; 85,725 shingle squares; and 45,943 other squares worth over $25 million. Chipping operations ground out 1.75 million bone-dry tons (BDT) of chips with an estimated value of $122 million. Post, pole, and piling manufacturers produced 29.4 MMBF worth $44 million.

Log exports have declined from the late 1980s when 2,800 MMBF left Washington ports for foreign destinations. In 2006, slightly more than 541 MMBF of logs worth $395 million were exported through Washington's ports. That volume includes nearly all of Oregon's exported logs, which were embarked from the Port of Longview.

Mill residues—
While producing lumber, shakes, and plywood, the mills generate a mountain of mill residue: 6.04 million BDT of chips, bark, sawdust, and shavings in 2006. The residues were sold for pulp (41.6 percent); as fuel (31.6 percent) for boilers and wood pellet manufacturers; as furnish for manufacturing reconstituted boards (6.8 percent); and for landscaping, garden mulch, and livestock bedding (20 percent). Fifty-seven percent (788,818 BDT) of bark residue was used for fuel, and the remainder was used for other purposes. Less than 1 percent of mill residue generated by Washington mills was reported as not used.

Interpretation

The responses to this major period of transition were mixed among Washington's forest products industries. Between 2000 and 2006, the total number of operations dropped from 228 to 136. The shake and export sectors fell significantly in total production. But in that 10-year period, total lumber production increased 18 percent while per-mill log production grew 30 percent. Improved milling technology has increased product recovery (e.g., overrun) by 10 percent while allowing increased utilization of smaller diameter trees. Washington will likely continue to be one of the top three softwood-lumber-producing states.

Growth, Removals, and Mortality[27]

Background

Increases or decreases in timber volume (growing stock) can be explained by examining growth, removals, and mortality of trees. Comparing removals and mortality to growth addresses one aspect of forest sustainability; when removals and mortality exceed growth, total growing stock volume in the stand declines. In localized areas, removing trees to reduce risk from fire or insect outbreaks can cause removals to exceed growth, but may benefit the health of the stand. Widespread mortality from some agent of disturbance such as bark beetles may also offset growth gains and thus slow stand development (fig. 80).

The most comprehensive data for estimating change in growing-stock volume on private land and unreserved public land outside national forests are from the periodic FIA inventory of 1988-1990 and the periodic closeout inventory of 2000-2001 (Gray et al. 2005, 2006). During remeasurement on 978 forested plots, all trees present at the previous inventory and any new trees were accounted for and new measurements taken; analysis is provided for the 911 plots that remained timberland in both inventories. The most comprehensive data for national forest lands are from the Current Vegetation Survey (Max et al. 1996) conducted by the Pacific Northwest Region (Region 6) of the U.S. Forest Service. Plots were installed in Washington in 1993-1997, and 2,431 plots were remeasured in 1999-2006 with previous and new trees accounted for.

Findings

Private and public timberland outside national forests—
Between 1990 and 2001-02, removals plus mortality exceeded growth volume significantly on corporate private timberland at the state level (95-percent confidence interval [CI] is -4,008 to -500 million cubic feet of net change). The same pattern was true in eastern Washington (95-percent CI is -996 to -170 million cubic feet net change), where the volume of removals plus mortality was more than 1.8 times as high as growth volume (standard error [SE] = 0.30). In contrast, the volume of removals plus mortality did not significantly exceed growth volume in western Washington (95-percent CI is -3,377 to +29 million cubic feet of net change), where removals plus mortality was about 1.2 times as high as growth (SE = 0.11) (fig. 81).

On noncorporate private timberland, periodic removals and mortality did not exceed periodic growth significantly at the state level (95-percent CI is -1,911 to +355 million cubic feet of net change) and also did not significantly exceed it in either eastern or western Washington. The ratio of removals and mortality to growth was similar in eastern (1.10, SE = 0.11) and western Washington (1.19, SE = 0.17).

On public timberland (mainly state land, excluding national forests), the trend was different. Here, removals and mortality were significantly lower than growth in both eastern (95-percent CI is 65 to 417 million cubic feet of net change) and western Washington (95-percent CI is 1,207 to 2,799 million cubic feet of net change). In eastern Washington, removals and mortality were only about 60 percent of current growth (SE = 13 percent) and only about 48 percent in western Washington (SE = 10 percent). At the state level, removals and mortality were significantly lower than growth (95-percent CI is 1,429 to 3,059 million cubic feet of net change).

National forest land—
Between the mid-1990s and 2006, volume growth on unreserved forest land on national forests significantly exceeded loss from mortality and removals (95-percent confidence interval is 314 to 550 million cubic feet of net change for eastern Washington and 1,169 to 1,467 for western Washington). On reserved forest lands, however, the net change in volume was not significantly different from zero (95-percent CI is -163 to 103 and -26 to 370 million cubic feet for eastern and western Washington, respectively). For all lands combined, most

[27] Authors: Olaf Kuegler and Andrew Gray.

Figure 80—Growth of trees is offset by harvesting and mortality.

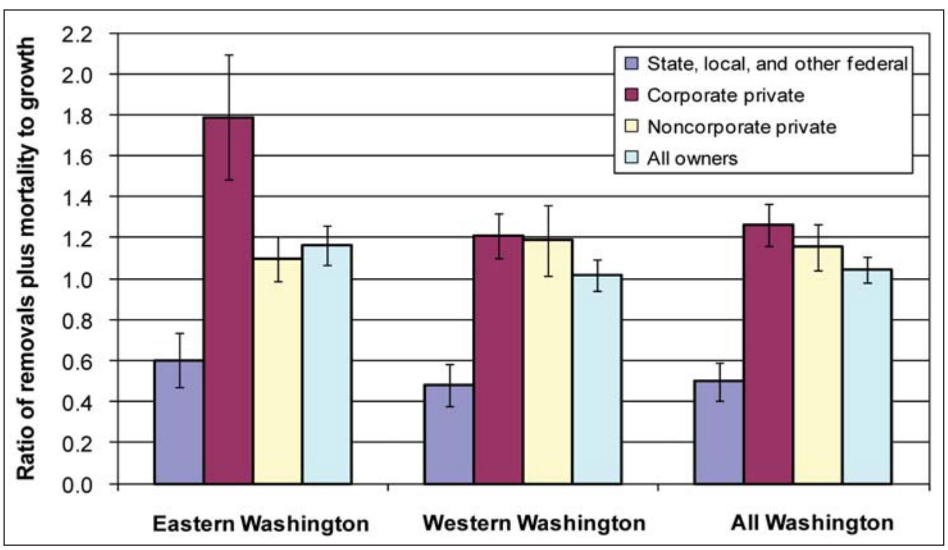

Figure 81—Ratios of removals plus mortality to growth for cubic-foot volume of growing stock on non-national-forest timberland in Washington, by owner group. Lines at end of bars represent ± standard error.

of the volume loss was attributed to natural mortality events, with an estimated 9 percent (SE = 1.5 percent) attributed to harvest (removal).

These changes in volume resulted in a net increase of 5.4 percent (SE = 0.4 percent) on national forests across the state as a whole, with the greatest relative losses in volume from mortality seen in eastern Washington (fig. 82a) and the greatest net increases seen in western Washington (fig. 82b). Timber harvest removed an estimated 1.0 percent (SE = 0.2 percent) of the growing stock volume present in the mid-1990s on unreserved forest land.

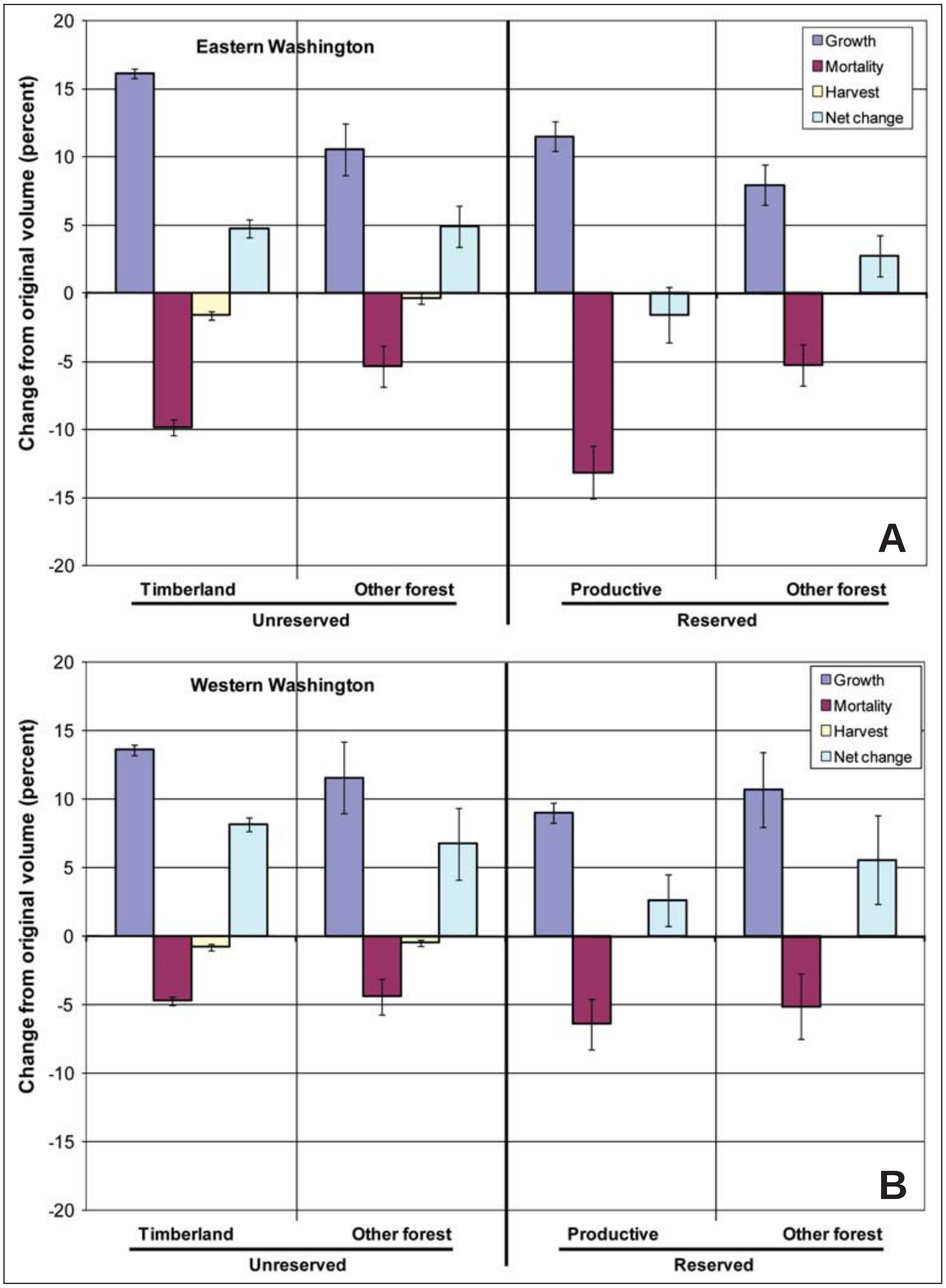

Figure 82—Growth, removals, and mortality on national forests as a percentage of standing growing-stock volume in the mid-1990s, by land status, for eastern Washington (top) and western Washington (bottom). Lines at end of bars represent ± standard error.

Interpretation

The current trends observed on private and unreserved public timberland outside national forests are similar to historical trends. Figure 83 shows the historical development of average growing stock volume, growth, removals, and mortality on timberland between 1968 and 2000.[28] Average standing growing-stock volume per acre decreased steadily between 1968 and 2000 on corporate private timberland (fig. 83a). In 1968, public timberland (excluding national forests) and corporate private timberland had about the same amount of standing growing-stock volume per acre. By 2000, the growing-stock volume on public timberland (other public) had increased from 3,850 cubic feet per acre in 1968 to 5,140 cubic feet per acre while the volume on corporate private timberland decreased from 3,920 cubic feet to 2,800 cubic feet per acre. On noncorporate private timberland (other private), volume increased between 1968 and 1979 from 2,130 cubic feet per acre to 2,790 cubic feet and remained at about this level through 2000 (fig. 83b). These opposing trends on private corporate, private noncorporate and other public timberland (excluding national forests) had the effect that the average amount of growing stock (standing timber) per acre on timberland in Washington remained about the same between 1968 and 2000 (fig. 83d).

Comparable data are not available for prior decades on national forest lands, but the change in growing stock volume between the mid-1990s and 2006 is likely a substantial departure from prior years. The greatest difference would be the decline in removal volume since the early 1990s (see "Removals for Timber Products" section in this chapter). With less harvest taking place, it is possible that growth and mortality were somewhat higher in the period covered here. Given current management approaches on national forests in Washington, it is likely that growth will remain comparable in the future, and harvest may increase as planned tree density and fuel reduction approaches are implemented. Mortality is much harder to predict, especially if insect infestations intensify (e.g., mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in lodgepole pine) or a severe wildfire season occurs.

Growth, Removals, and Mortality Tables in Appendix B

Table 48—Estimated ratio of periodic mortality and removals volume to growth volume of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990-1991 to 2000-2001

Table 49—Estimated periodic gross cubic-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990-1991 to 2000-2001

Table 50—Estimated periodic gross board-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990-1991 to 2000-2001

Table 51—Estimated periodic gross cubic-foot growth, mortality, and removals of growing stock on national forest land, by location, type of forest land, and reserved status, Washington, 1993-1997 to 1999-2006

Table 52—Estimated periodic gross board-foot growth, mortality, and removals of sawtimber on national forest land, by location, type of forest land, and reserved status, Washington, 1993-1997 to 1999-2006

Removals for Timber Products[29]

Background

Volume removed from forest inventory during the harvesting of timber is known as removals. Removals are an important indicator of the sustainability of timber harvest. Removals that exceed net growth volume could indicate overharvesting and decreasing forest inventory

[28] Estimates of sampling error are not consistently available for the data between 1968 and 1989.

[29] Author: Todd A. Morgan,

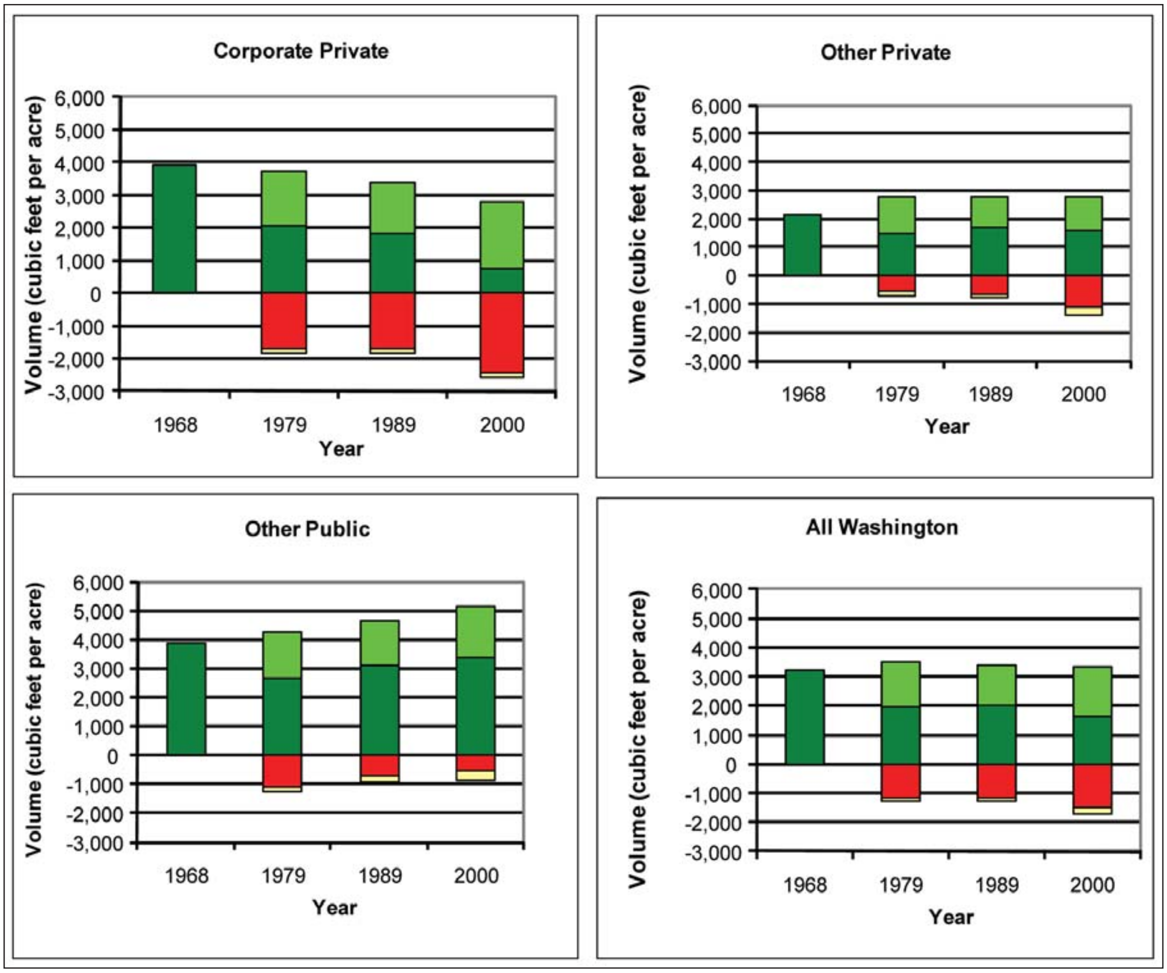

Figure 83—Average growing stock volume, growth, removals, and mortality volume for (a) corporate private (forest industry), (b) other (noncorporate) private, (c) other public (excluding national forest), and (d) all owners. To read the graph, start with the leftmost bar, representing standing volume in 1968. The negative values in the next bar (red and yellow for removals and mortality, respectively) reduce the growing stock volume from the previous period (dark green), while growth (light green) adds to the growing stock volume. The result is an estimate of the average standing growing stock volume per acre for each time period, by reading the value at the top of the bar.

(standing volume), whereas growth greatly exceeding removals could signal a need for increased vegetation management to decrease risks of tree mortality, insect outbreaks, or wildfire.

Removals can come from two sources: the growing-stock portion of live trees (live trees of commercial species meeting specified standards of quality or vigor), or dead trees and other non-growing-stock sources. The two general types of removals are timber products harvested for processing by mills and logging residue (i.e., volume cut or killed but not utilized) (fig. 84). Removals, as reported here, are based on a 2004 survey of Washington's primary forest products industry (Smith and Hiserote 2007).

Findings

Washington's 2004 timber harvest for industrial wood products was approximately 3.8 billion board feet Scribner; dead trees accounted for about 116.5 million

Figure 84—Removals are stacked on log decks, waiting to be transported to local mills.

board feet (3 percent). The 2004 harvest was roughly 94 percent of the average annual harvest for the previous 10 years, but just 66 percent of the 40-year average (fig. 85).

Removals for timber products totaled 1,057 million cubic feet (MMCF) during 2004 (fig. 86). Growing stock accounted for 972 MMCF (87 percent) of removals for products, with the remainder coming from other sources, including dead trees and other non-growing-stock sources. Saw logs[30] were the leading product harvested, accounting for 74 percent of removals for products. Fuelwood, including residential firewood, accounted for 10 percent, logs chipped for pulpwood accounted for 9 percent, and veneer logs accounted for 6 percent. Posts, poles, pilings, and cedar products accounted for the remaining 1 percent of removals for timber products. Softwoods accounted for approximately 94 percent (989 MMCF) of removals for products. The largest volumes of hardwoods were used for saw logs and chipped for pulp and composite products, with smaller quantities used for fuelwood and veneer.

Total removals from Washington's timberlands during 2004 were 1,334 MMCF. This included the 1,057 MMCF used for timber products and 277 MMCF of logging residue left in the forest as slash. Growing-stock removals were 972 MMCF. Slightly over 94 percent (915 MMCF) of growing-stock removals were used to produce wood products, and just under 6 percent (57 MMCF) were not utilized. Sawlogs were the largest component (77 percent) of growing-stock removals, followed by pulpwood (10 percent), and veneer logs (6 percent).

About 52 percent (510 MMCF) of growing-stock removals came from corporate timberlands, and 33 percent (317 MMCF) came from other private and tribal lands. Less than 2 percent of the volume removed from growing stock was from national forests. Slightly more than 13 percent of growing-stock removals came from other public lands, primarily Washington Department of

[30] Log volume exported from Washington to other states and countries is included in the saw-log timber product category.

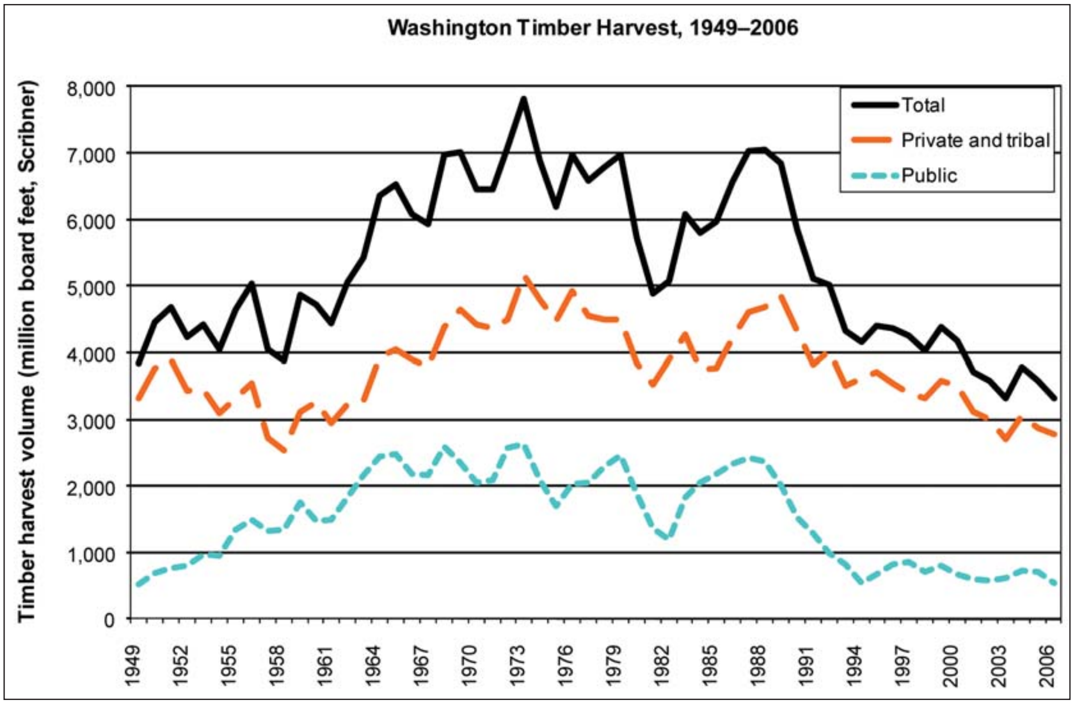

Figure 85—Timber harvest in Washington, by ownership, 1949-2006 (harvest data: Washington Department of Natural Resources 2006; Washington Department of Revenue 2006).

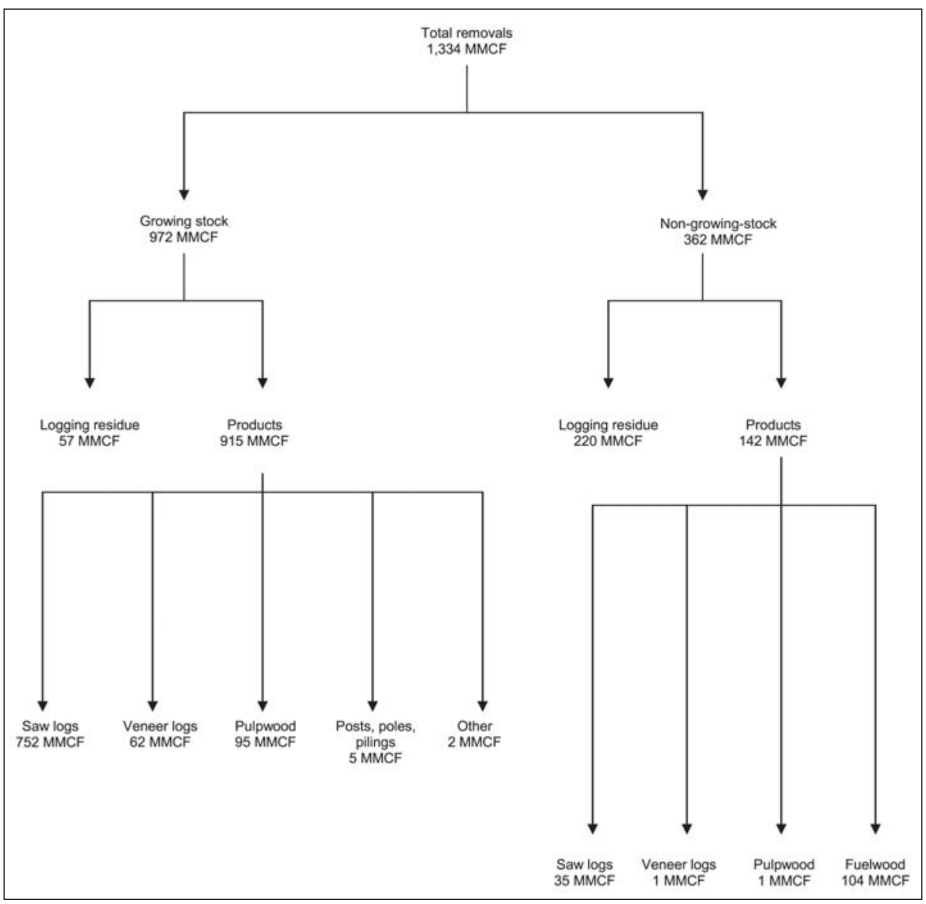

Figure 86—Trees harvested from Washington's forests in 2004 were used for a variety of forest products including saw logs, veneer, pulp, posts, and poles.

Natural Resources, and other state agencies, counties, municipal watersheds, city-owned timberlands, the U.S. Department of Defense, Fish and Wildlife Service, and the Bureau of Land Management.

Douglas-fir was the leading species harvested, accounting for 46 percent (445 MMCF) of growing-stock removals. Western hemlock represented about 27 percent, and true firs represented about 8 percent. Hardwoods, predominantly red alder, accounted for slightly less than 7 percent of growing-stock removals. Ponderosa pine, cedars, spruces, lodgepole pine, larch, and other softwoods together accounted for 12 percent. Douglas-fir was the leading species harvested for most products, with 35 percent of pulpwood volume, 45 percent of sawlog volume, 63 percent of veneer log volume, and 87 percent of post, pole, and piling volume coming from Douglas-fir. Cedar was the leading species harvested for other products, including shakes and shingles. Red alder accounted for 27 percent of sawlog volume, 28 percent of veneer log volume, and 35 percent of log volume chipped for pulp or composite products.

Interpretation

Sustainability of Washington's forests depends on sustainable harvest levels, a forest products industry capable of utilizing harvested material, and a suitable land base available for timber production. Fortunately, growth exceeds removals statewide. But Washington's timber harvest volume has been declining since 1989, and the state's forest products industry is currently facing mill closures and curtailments as a result of the severe downturn in the U.S. housing market since 2005, corresponding drops in lumber prices, and fall-out from subprime mortgage issues. However, in the long run, loss of timberland to developed or residential uses may prove to be more challenging to forest sustainability, as well as to Washington's forest products industry. To ensure sustainable harvests for future generations, careful consideration should be given not only to growth and removals across Washington's available timberlands, but also to the amount of land and timber being converted to nonforest uses.

Removals Tables in Appendix B

Table 53—Total roundwood output by product, species group, and source of material, Washington, 2004
Table 54—Volume of timber removals by type of removal, source of material, and species group, Washington, 2004

Nontimber Forest Products[31]

Background

Nontimber forest products (NTFP) are harvested from forests for reasons other than production of timber commodities. Vascular plants, lichens, and fungi are the primary organisms included in NTFPs (Jones 1999) and are collected for subsistence, recreational, educational, or commercial purposes (Vance et al. 2001). Examples of NTFPs include boughs, bark, moss, and mushrooms and can be broadly defined to include even water and livestock. The NTFPs are fundamental to many botanical, floral, and woodcraft industries and are important to medicinal and natural food industries as well. Permits are required to collect NTFPs on national forests in Washington, and the number of permits provides a useful indicator of the economic importance of NTFPs (Duran 2007).

Although harvest of NTFPs is prevalent in Pacific coast forests, relatively little is known about their overall abundance or how they are affected by different land management practices. It is also not clear whether current levels of harvesting are sustainable or whether they are negatively affecting the resources (Everett 1997). Because PNW-FIA crews record the cover of the most abundant and readily identifiable vascular plant species found on each phase 2 plot, the inventory can provide useful baseline information on the status and trends of many NTFP species (Vance et al. 2002). Crews also collect samples of epiphytic lichens found on phase 3 plots, allowing assessment of selected lichen NTFPs (note: collection of lichens and most mosses is prohibited on national forest lands).

[31] Authors: Andrew Gray and Sarah Jovan.

Lists of vascular plant and lichen NTFPs were compiled from the literature (Everett 1997, Jones 1999, Vance et al. 2001) and compared with species recorded on FIA plots. Plant species that were readily identifiable by most crews (i.e., common shrubs or common and distinctive herbs) were included in the analyses, as well as seedlings and saplings of selected tree species (under the assumption that most boughs are harvested from small trees). Mean cover of each species across all sampled subplots was calculated, and the area covered on each plot extrapolated to all forest land with standard inventory statistics. The frequency of plots on which NTFP lichen species were collected and identified was summarized. The value of permits sold on national forests primarily in Washington (not including the Umatilla National Forest) was summarized for type of NTFP.

Findings

The NTFP plant species with the greatest cover was swordfern (fig. 87), which covered 1.1 million acres. Brackenfern was the next most widespread herb, covering 258,000 acres. The shrubs covering the most acreage were salal (842,000 acres), vine maple (725,000 acres), and salmonberry (603,000 acres). In comparison, the cover of NTFP tree seedlings and saplings was quite low except for Douglas-fir, which covered 158,000 acres. Plant NTFPs were more prevalent in western than in eastern Washington ecosections; and the Puget Trough ecosection had the most cover (fig. 88). Lichen NTFPs were common, with beard lichens recorded on 63 percent of the forested plots and witch's hair lichen recorded on 48 percent:

Scientific name	Common name	Plots[a]
		Percent
Alectoria sarmentosa	Witch's hair lichen	48.3
Bryoria fremontii	Old man's beard	30.0
Letharia vulpina	Wolf lichen	45.4
Lobaria pulmonaria	Lungwort	3.4
Parmelia saxatilis	Crottle	3.9
Usnea	Beard lichens	63.3
Usnea hirta	Beard lichen	1.0

[a] 207 forested plots were sampled; data subject to sampling error.

National forests in Washington sold permits to collect NTFPs for $1.7 million in 2007, with an estimated market value of $17 million (Duran 2008). The greatest value


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Figure 87—Swordfern is the nontimber forest product that covers the greatest area of Washington forest lands.

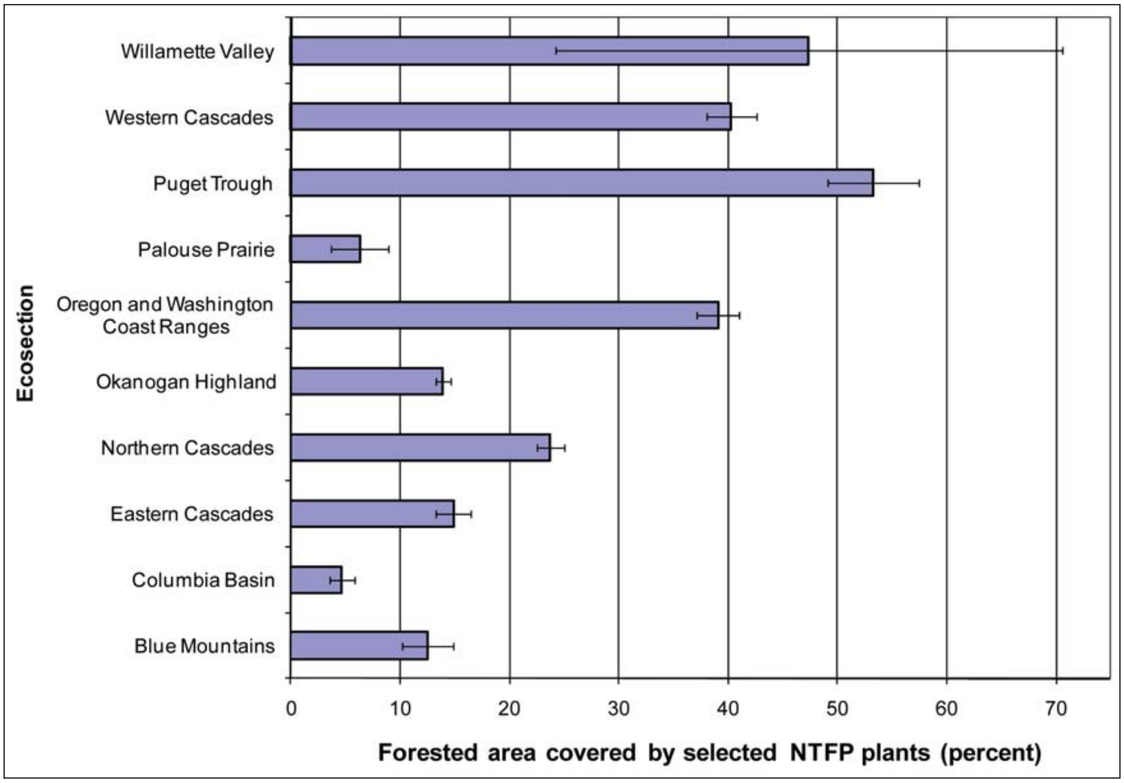

Figure 88—Forested area covered by selected vascular plant nontimber forest products (NTFPs) on forest land in Washington, by ecosection, 2002-2006. Lines at end of bars represent ± standard error.

by far was in the sale of permits for boughs, which are primarily used in the floral industry, as shown below:

NTFP product	Income from permits
	Dollars
Bark	2,660
Cones	760
Foliage	78,480
Fruit	20,080
Grass	174,250
Boughs	1,206,862
Mushrooms	111,308
Miscellaneous	39,210
Transplants	25,912
Christmas trees	39,441
Total	1,698,963

Interpretation

Washington's forests appear to have abundant resources of vascular plant species used as NTFPs, including those used for floral, medicinal, and woodcraft businesses and those important for subsistence and recreation (e.g., swordfern, St. Johnswort, Pacific yew, Oregon grape, and thinleaf huckleberry). Within a given species, not all plants will produce the desired quality of greens or fruits, so the actual resource is likely less than that reported here. Nevertheless, NTFPs collected on national forests clearly make a substantial contribution to the economy of the state; the total from all landowners may be double that recorded on national forests (Schlosser et al. 1991). The figures on species abundance will provide an important baseline for changes over time and could be used for more detailed analyses by ownership or geography.

Nontimber Forest Products Tables in Appendix B

Table 55—Estimated area of forest land covered by vascular plant nontimber forest products, by plant group and species, Washington, 2002-2006

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Washington forests contain a mixture of live and dead trees and open spaces.

Cub Lake, Glacier Peak Wilderness.

Chapter 6: Conclusions

We hope this report provides a better understanding of Washington's forest resources, highlighting information that is new as well as confirming things you may already know from personal experience or from other data and publications. Because this report is an overview, touching briefly on many relevant topics, we expect some readers will be eager to see more indepth research and analysis on selected topics to fully understand current status, change, and relationships in Washington forests. Some possible areas of future work may include more comprehensive analysis and reporting of forest fuels and indepth work on forest health issues, carbon dynamics, and forest productivity.

We expect that our own Pacific Northwest (PNW) Forest Inventory and Analysis (FIA) research staff as well as researchers and analysts from other programs and institutes will investigate many of the questions that can be addressed with the annual inventory data, especially once a full cycle of data has been collected.

The annual FIA inventory, as currently designed, will continue into the future, provided funding and support for it are maintained. As directed by the 1998 Farm Bill (section 253(c) of the Agricultural Research, Extension, and Education Reform Act of 1998), findings from the inventory will be published every 5 years. For Washington, the next report will be written in about 2013, after all FIA plots have been visited and the first full cycle of data collection is completed.

Common and Scientific Plant Names

Life form	Common name	Scientific name
Trees:		
	Alaska yellow-cedar	*Chamaecyparis nootkatensis* (D. Don) Spach
	Alder	*Alnus* spp.
	Ash	*Fraxinus* spp.
	Bigleaf maple	*Acer macrophyllum* Pursh
	Birch	*Betula* spp.
	Bitter cherry	*Prunus emarginata* (Dougl. ex Hook.) D. Dietr.
	Black cottonwood	*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw
	Boxelder	*Acer negundo* L.
	California black oak	*Quercus kelloggii* Newberry
	California-laurel	*Umbellularia californica* (Hook. & Arn.) Nutt.
	Canyon live oak	*Quercus chrysolepis* Liebm.
	Cedar	*Thuja* spp.
	Chokecherry	*Prunus virginiana* L.
	Cottonwood	*Populus* spp.
	Curl-leaf mountain mahogany	*Cercocarpus ledifolius* Nutt.
	Douglas-fir	*Pseudotsuga menziesii* (Mirbel) Franco
	Elm	*Ulmus* spp.
	Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
	Giant chinquapin, golden chinquapin	*Chrysolepis chrysophylla* (Dougl. ex Hook.) Hjelmqvist
	Grand fir	*Abies grandis* (Dougl. ex D. Don) Lindl.
	Hawthorn	*Crataegus* spp.
	Hemlock	*Tsuga* spp.
	Jeffrey pine	*Pinus jeffreyi* Grev. & Balf.
	Juniper, redcedar	*Juniperus* spp.
	Knobcone pine	*Pinus attenuata* Lemmon
	Larch	*Larix* spp.
	Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
	Maple	*Acer* spp.
	Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
	Noble fir	*Abies procera* Rehd.
	Oak	*Quercus* spp.
	Oregon ash	*Fraxinus latifolia* Benth.
	Oregon crabapple	*Malus fusca* (Raf.) Schneid.
	Oregon white oak	*Quercus garryana* Dougl. ex Hook.
	Pacific dogwood	*Cornus nuttallii* Audubon ex Torr. & Gray
	Pacific madrone	*Arbutus menziesii* Pursh
	Pacific silver fir	*Abies amabilis* (Dougl. ex Loud.) Dougl. ex Forbes
	Pacific yew	*Taxus brevifolia* Nutt.
	Paper birch	*Betula papyrifera* Marsh.
	Pine	*Pinus* spp.
	Ponderosa pine	*Pinus ponderosa* P.&C. Lawson
	Port-Orford-cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
	Quaking aspen, aspen	*Populus tremuloides* Michx.
	Red alder	*Alnus rubra* Bong.

Life form	Common name	Scientific name
	Rocky Mountain maple, intermountain maple	*Acer glabrum* Torr.
	Sitka spruce	*Picea sitchensis* (Bong.) Carr.
	Spruce	*Picea* spp.
	Subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
	Sugar pine	*Pinus lambertiana* Dougl.
	Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
	True fir species	*Abies* spp.
	Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
	Western juniper	*Juniperus occidentalis* Hook.
	Western larch	*Larix occidentalis* Nutt.
	Western oaks	*Quercus* (spp.)
	Western redcedar	*Thuja plicata* Donn ex D. Don
	Western white pine	*Pinus monticola* Dougl. ex D. Don
	White alder	*Alnus rhombifolia* Nutt.
	White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
	Whitebark pine	*Pinus albicaulis* Engelm.
Shrubs:		
	Blue elderberry	*Sambucus nigra* L. ssp. *cerulea* (Raf.) R. Bolli
	Creeping barberry	*Mahonia repens* (Lindl.) G. Don
	Currant	*Ribes* spp.
	Cutleaf blackberry	*Rubus laciniatus* Willd.
	Devils club	*Oplopanax horridus* Miq.
	Dwarf mistletoe	*Arceuthobium* spp.
	Dwarf Oregon grape, cascade barberry	*Mahonia nervosa* (Pursh) Nutt.
	English holly	*Ilex aquifolium* L.
	English ivy	*Hedera helix* L.
	Himalayan blackberry	*Rubus discolor* Weihe & Nees
	Kinnikinnick	*Arctostaphylos uva-ursi* (L.) Spreng.
	Manzanita	*Arctostaphylos* spp.
	Ninebark	*Physocarpus* spp.
	Oregon boxleaf	*Paxistima myrsinites* (Pursh) Raf.
	Oregon grape, hollyleaved barberry	*Mahonia aquifolium* (Pursh) Nutt.
	Oval-leaf blueberry	*Vaccinium ovalifolium* Sm.
	Pinemat manzanita	*Arctostaphylos nevadensis* Gray
	Pipsissewa	*Chimaphila umbellata* (L.) W. Bart.
	Pursh's buckthorn	*Frangula purshiana* (DC.) Cooper
	Red elderberry	*Sambucus racemosa* L.
	Red huckleberry	*Vaccinium parvifolium* Sm.
	Rose	*Rosa* spp.
	Salal	*Gaultheria shallon* Pursh
	Salmonberry	*Rubus spectabilis* Pursh
	Scotch broom	*Cytisus scoparius* (L.) Link
	Scouler's willow	*Salix scouleriana* Barratt ex Hook.
	Snowberry	*Symphoricarpos* spp.
	Snowbrush ceanothus	*Ceanothus velutinus* Dougl. ex Hook.
	Thimbleberry	*Rubus parviflorus* Nutt.
	Thinleaf huckleberry	*Vaccinium membranaceum* Dougl. ex Torr.

Life form	Common name	Scientific name
	Vine maple	*Acer circinatum* Pursh
	Willow	*Salix* spp.
Forbs:		
	Brackenfern, western brackenfern	*Pteridium aquilinum* (L.) Kuhn
	Broadleaf arnica	*Arnica latifolia* Bong.
	British Columbia wildginger	*Asarum caudatum* Lindl.
	Bull thistle	*Cirsium vulgare* (Savi) Ten.
	Canada thistle	*Cirsium arvense* (L.) Scop.
	Common beargrass	*Xerophyllum tenax* (Pursh) Nutt.
	Common mullein	*Verbascum thapsus* L.
	Common yarrow	*Achillea millefolium* L.
	Dalmatian toadflax	*Linaria dalmatica* (L.) P. Mill.
	Garlic mustard	*Alliaria petiolata* (Bleb.) Cavara & Grande.
	Hairy cat's ear	*Hypochaeris radicata* L.
	Heartleaf arnica	*Arnica cordifolia* Hook.
	Oxeye daisy	*Leucanthemum vulgare* Lam.
	Pacific trillium	*Trillium ovatum* Pursh
	Purple foxglove	*Digitalis purpurea* L.
	Sitka valerian	*Valeriana sitchensis* Bong.
	Spotted knapweed	*Centaurea biebersteinii* DC.
	St. Johnswort	*Hypericum perforatum* L.
	Stinging nettle	*Urtica dioica* L.
	Stinking willie, tansy ragweed	*Scenecio jacobaea* L.
	Swordfern, western swordfern	*Polystichum munitum* (Kaulfuss) K. Presl
	Thistle	*Cirsium* spp.
	Wall-lettuce	*Mycelis muralis* (L.) Dumort.
	Western pearly everlasting	*Anaphalis margaritacea* (L.) Benth.
	White knapweed	*Centaurea diffusa* Lam.
Graminoids:		
	Cheatgrass	*Bromus tectorum* L.
	Common velvetgrass	*Holcus lanatus* L.
	Orchardgrass	*Dactylis glomerata* L.
Lichens:		
	Beard lichen	*Usnea hirta* (L.) F.H. Wigg.
	Beard lichens	*Usnea* spp.
	Crottle	*Parmelia saxatilis* (L.) Ach.
	Lungwort lichen	*Lobaria pulmonaria* (L.) Hoffm.
	Lungwort lichens	*Lobaria* spp.
	Old man's beard	*Bryoria fremontii* (Tuck.) Brodo & D. Hawksw.
	Orange wall lichen	*Xanthoria polycarpa* (Hoffm.) Rieber
	Oregon lung lichen	*Lobaria oregana* (Tuck.) Mull. Arg.
	Witch's hair lichen	*Alectoria sarmentosa* (Ach.) Ach.
	Wolf lichen	*Letharia vulpina* (L.) Hue

Acknowledgments

First and foremost, we want to acknowledge the FIA field crews and National Forest System contracting companies for collecting the high-quality field data on which this report is based: Julie Andersen, Brett Anderson, Dale Baer, Jerry Bednarczyk, Gabe Bellante, Joe Berry, Andrew Black, Mike Boldt, Matthew Brown, Chuck Brushwood, Will Bunten, Jon Burgbacher, Whitney Burgess, Glenn Burkhart, Sarah Butler, Janelle Cossey, James Cox, Donna Crone, Don Dahlman, Brian Daum, Jessica Deans, Paul Deignan, Joseph Digranes, Summer Dunn, Ruth Epling, Matthew Ferrante, Walter Foss, Ben Fricke, Brian Gasper, Thomas Glose, Ryan Glynn, Maria Gonzalez-Abad, Walter Grabowiecki, Colleen Grenz, Michael Griffin, John Hall, Jamie Halperin, Jake Hawkins, Heather Hayden, Drew Hedesh, Andy Hoff, Mike Hogan, Tristan Kelley, Nicci Lambert, Marc LaPine, Jesper Lesch, Brian Lewis, J.D. Lloyd, Jamie Ludwig, Chris Moltzau, Brance Morefield, Marc Much, Eric Murphy, Dell Needham, Adam Neff, Yhtt Nighthawk, Melissa Patterson, Jessica Pijoan, Peter Rahn, Scott Rash, Erin Riggs, Amanda Rollwage, Tyler Ross, David Rutledge, Jeremy Sapp, Barry Skolout, Samuel Solano, Adrianna Sutton, Bruce Stevens, Brent Stroud, Rylee Sweeney, Zack Taylor, Andrew Tasler, Lydia Wedge, James Weiser, Misha Yatskov, Biometrics Forestry, Boateng and Associates, Bolin Construction, Buffalo Jump, Camp II Forest Management, Crownwood Forestry, Duck Creek Associates, Logsden Forestry, Merlin Biological, Steve Holmes Forestry, Raven Forestry, Ruth Johnson.

In addition to the chapter authors, many other individuals contributed significantly to this report. Our thanks to Joel Thompson for assistance with data tables; to Dale Weyermann for GIS support; to Elaina Graham and John Chase for preparing the maps displayed in this report; to Brett Butler for providing National Woodland Owner Survey data; to Chuck Veneklase for field data recorder programming and support; to Alison Nimura, Ron Wanek, and Kurt Campbell for compiling the data that are the foundation of this report; to Bruce Hiserote, Erica Hanson, and Adrianna Sutton for data correction assistance; to Khakie Jones for assistance with photographs; and to Steve Fairweather, Karen Ripley, Dave Marshall, Frank Duran, Louisa Evers, Shawna Bautista, Kim Mellen-Mclean, Mike Daugherty, Brian Staab, Melinda Moeur, Rick Graw, Kathy Sheehan, and Alison Nelson for their thoughtful and helpful reviews of the draft manuscript. Finally, we want to acknowledge our PNW-FIA Program manager, Sue Willits, and the PNW-FIA team leaders, Tara Barrett, George Breazeale, Jeremy Fried, Ray Koleser, Bob Rhoads, and Jeff Reis for their unflagging support of this project.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	0.3048	Meters
Miles	1.609	Kilometers
Acres	0.405	Hectares
Board feet	0.0024	Cubic meters
Cubic feet	0.0283	Cubic meters
Cubic feet per acre	0.06997	Cubic meters per hectare
Square feet	0.0929	Square meters
Square feet per acre	0.229	Square meters per hectare
Ounce	28349.5	Milligrams
Pounds	0.453	Kilograms
Pounds per cubic foot	16.018	Kilograms per cubic meter
Tons per acre	2.24	Megagrams per hectare
Degrees Fahrenheit	0.55 (F-32)	Degrees Celsius
British thermal units (Btu)	0.000293	Kilowatt hours
Pounds per cubic foot	0.016	Grams per cubic centimeter

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Appendix A: Methods and Design

Field Design and Sampling Method

The Pacific Northwest Research Station's Forest Inventory and Analysis unit (PNW-FIA) implemented the new annual inventory across all ownerships in Washington in 2002. The overall sampling design is a significant change from that of previous periodic inventories; the differences will be discussed more fully below.

In the annual inventory system for the Pacific Northwest (Alaska, Washington, Oregon, and California), the objective is to measure approximately 10 percent of the annual plots across an entire state each year. This annual subsample is referred to as a panel. The plots measured in a single panel are selected to ensure systematic coverage within each county, spanning both public and privately owned forests, and including lands reserved from industrial wood production such as national parks, wilderness areas, and natural areas. Estimates of forest attributes can be derived from measurements of a single panel for areas as small as a survey unit or ecosection; however, such estimates are often imprecise because one panel represents only 10 percent of the full inventory sample. More precise statistics are obtained by combining data from multiple panels. Estimates from sampled plots in the five panels measured 2002-2006 were combined to produce the statistics in this report. Once all panels have been measured (2011), we will remeasure each one approximately every 10 years.

The FIA program collects information in three phases. In phase 1, a sample of points is interpreted from remotely sensed imagery, either aerial photos or satellite data, and the landscape is stratified into meaningful groupings, such as forested and nonforested areas, ecologically similar regions, and forest types. In phase 2, field plots are measured for a variety of indicators that describe forest composition, structure, and the physical geography of the landscape. Phase 2 plots are spaced at approximate 3-mile intervals on a hexagonal grid throughout the forest. In phase 3, a 1/16 sample of phase 2 plots is measured to assess forest health indicators.

Phase 1

The goal of phase 1 is to reduce the variance associated with estimates of forest land area and volume by stratifying samples. Digital imagery collected by remote-sensing satellites is classed into a few similar strata (such as forest or nonforest) by means of standard techniques for image classification, and the total area of each of these strata is used to assign a representative acreage to each sample plot. Source data were derived from Landsat Thematic Mapper (30-m resolution) imagery collected between 1991 and 1993 (Blackard et al. 2008, Vogelman et al. 1996). An image-filtering technique is used to classify individual plots by a summary of the 5- by 5-pixel region that surrounds the pixel containing a sample plot. The resulting 26 classes, or strata (ranging from entirely forested to entirely nonforested, for example), are combined with other forest attributes likely to improve stratification effectiveness, such as owner class. For this report, separate strata are defined for national forest lands outside wilderness that were sampled at a greater density of plots than the FIA standard of 1 plot per 6,000 acres. The resulting strata are evaluated for each estimation unit (county or combination of small counties) and collapsed as necessary to ensure that at least four plots are in each stratum. Stratified estimation is applied by assigning each plot to one of these collapsed strata and by calculating the area of each collapsed stratum in each estimation unit. The estimates from stratified data are usually more precise than those from unstratified estimates.

Phase 2

The nationally standardized plot installed at each forested phase 2 location is a cluster of four subplots spaced 120 feet apart (fig. 89). Subplot 1 is in the center, with

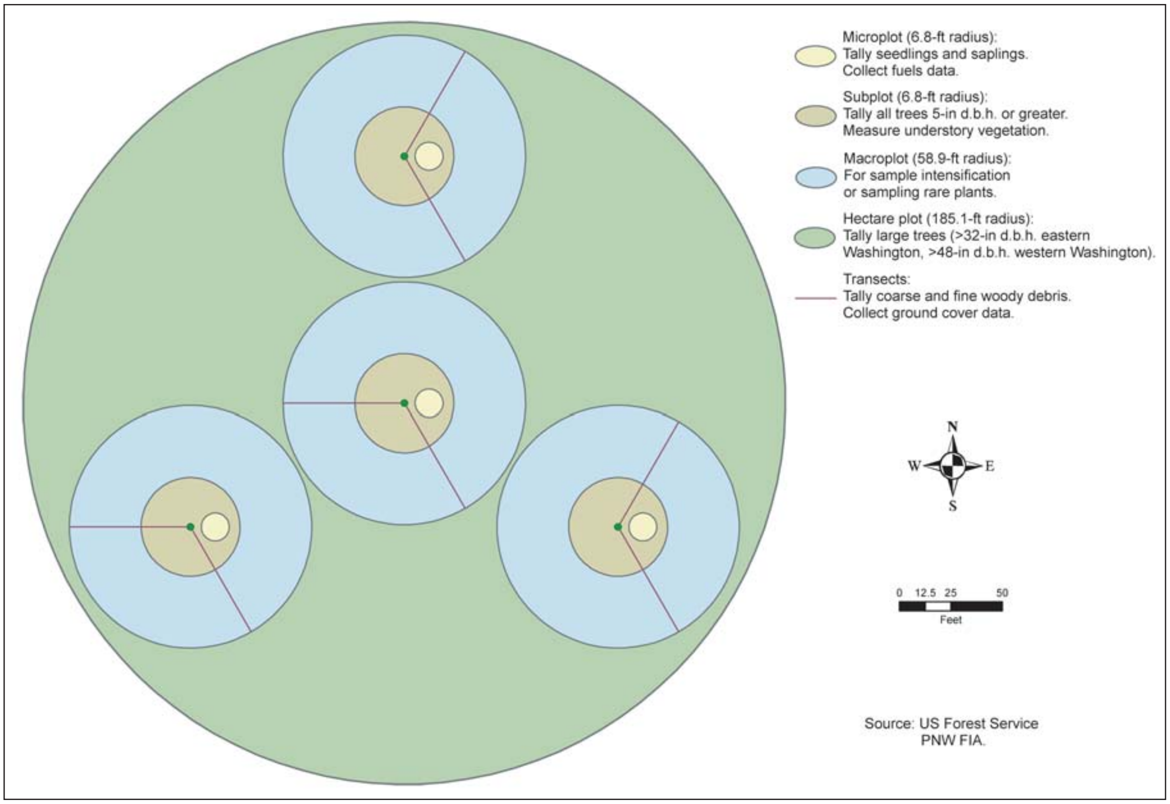

Figure 89—The Forest Inventory and Analysis plot design used in the Washington annual inventory, 2002-2006; d.b.h. = diameter at breast height.

subplots 2 through 4 uniformly distributed radially around it. Each point serves as the center of a 1/24-acre circular subplot used to sample all trees at least 5.0 inches in diameter at breast height (d.b.h.). A 1/300-acre microplot, with its center located just east of each subplot center, is used to sample trees 1.0 to 4.9 inches d.b.h., as well as seedlings (trees less than 1.0 inch d.b.h.). On all lands in Washington, a ¼-acre "macroplot" (58.9-foot radius) around each subplot center is used to tally trees larger than 24 inches d.b.h. in eastern Washington and 30 inches d.b.h. in western Washington. In addition, a hectare plot (a 185.1-foot fixed-radius plot centered on subplot 1) is also established on national forests in Washington to tally trees larger than 32 inches d.b.h. in eastern Washington and 48 inches d.b.h. in western Washington.

All phase 2 plots classified through aerial photography as possibly being forested are established in the field without regard to land use or land cover. Field crews delineate areas within the plot that are comparatively less heterogeneous than the plot as a whole with regard to reserved status, owner group, forest type, stand size class, regeneration status, and tree density; these areas are described as condition classes. The process of delineating these condition classes on a fixed-radius plot is called mapping. All measured trees are assigned to the mapped condition class in which they are located.

On phase 2 plots, crews assess physical characteristics such as slope, aspect, and elevation; stand characteristics such as age, size class, forest type, disturbance, site productivity, and regeneration status; and tree characteristics such as tree species, diameter, height, damages, decay, and vertical crown dimensions. They also collect general descriptive information such as soil depth, proximity to water and roads, and the geographic position of the plot in the larger landscape. In Washington, crews also assess regional variables: height and cover of understory species, the structure of live and dead fuels, and the structure and composition of downed wood (see "Core, Core-Optional, and Regional Variables" section below).

The FIA Program sampled 1,884 forested phase 2 plots in Washington between 2002 and 2006 on the standard national plot grid. In addition, the Pacific Northwest Region (Region 6) sampled 1,094 forested plots on national forest lands outside wilderness using identical phase 2 protocols. Estimates of timber volume and other forest attributes were derived from tree measurements and classifications made at each plot. Volumes for individual tally trees were computed with equations for each of the major species in Washington. Estimates of growth, removals, and mortality for non-national-forest timberland were determined from the closeout remeasurement of 911 forested sample plots established in previous inventories (Gray et al. 2005, 2006). Estimates of growth, removals, and mortality for national forest land were determined from the remeasurement of 2,431 forested sample plots established for the Region 6 Current Vegetation Survey (CVS) (Max et al. 1996). The first two years of remeasurement data (CVS "Panel C") were not used owing to an inability to determine whether some trees were not remeasured because of a change in the subplot radius, or because they had fallen.

Phase 3

More extensive forest health measurements are collected in a 16-week period during the growing season (when most plants are in full leaf and many are flowering) on a subset (1/16) of phase 2 sample locations. At these phase 3 plots, measurements are taken on tree crowns, soils, lichens, down woody material, and (in some years) understory vegetation in addition to the phase 2 variables. One forest health measurement, ozone injury, is conducted on a separate grid with all 32 ozone plots measured annually.

The FIA program sampled 232 forested phase 3 plots in Washington between 2002 and 2006. The relatively small number of phase 3 samples is intended to serve as a broad-scale detection monitoring system for forest health problems.

Core, Core-Optional, and Regional Variables

The majority of FIA variables collected in Washington are identical to those collected by FIA elsewhere in the United States—these are national "core" or "core optional" variables (as the name suggests, collection of core-optional variables is optional but, if collected, they must be collected the same way everywhere). A number of other variables are unique to PNW-FIA—these are "regional" variables and include such items as down woody material and understory vegetation on phase 2 plots (not to be confused with down woody and understory vegetation on phase 3 plots, which are measured using a slightly different protocol), as well as insect and disease damage, a record of previous disturbance on the plot, and measurements for special studies (such as nesting habitat assessment for the marbled murrelet (*Brachyramphus marmoratus*).

Data Processing

The data used for this report are stored in the FIA National Information Management System (NIMS). The NIMS provides a means to input, edit, process, manage, and distribute FIA data. It includes a process for data loading, a national set of edit checks to ensure data consistency, an error-correction process, approved equations and algorithms, code to compile and calculate attributes, a table report generator, and routines to populate the presentation database. It applies numerous algorithms and equations to calculate, for example, stocking, forest type, stand size, volume, and biomass. The NIMS also generates estimates and associated statistics based on county areas and stratum weights developed outside of NIMS. Additional FIA statistical design and estimation techniques are further reviewed in Bechtold and Patterson (2005).

Statistical Estimates

Throughout this report we have published standard errors (SE) for most of our estimates. These standard errors account for the fact that we measured only a small sample of the forest (thereby producing a sample-based estimate) and not the entire forest (which is the population parameter of interest). Because of small sample sizes or high variability within the population, some estimates can be very imprecise. The reader is encouraged to take the standard error into account when drawing any inference. One way to consider this type of uncertainty is to construct confidence intervals. Customarily, 66- or 95-percent confidence intervals are used. A 95-percent confidence interval means that one can be 95 percent confident that the interval contains the true population parameter of interest. For more details about confidence intervals, please consult Moore and McCabe (1989) or other statistical literature.

It is relatively easy to construct approximate 66- or 95-percent confidence intervals by multiplying the SE by 1.0 (for 66-percent confidence intervals) or 1.96 (for 95-percent confidence intervals) and subtracting and adding this to the estimate itself. For example, in table 2 of appendix B we estimated the total timberland in Washington to be 18,303,000 acres with a standard error of 174,000. A 95-percent confidence interval for the total timberland area ranges from 17,962,000 to 18,644,000 acres.

The reader may want to assess whether or not two estimates are significantly different from each other. The statistically correct way to address this is to estimate the SE of the difference of two estimates, and either construct a confidence interval or use the equivalent z-test. However, this requires the original inventory data. It is often reasonable to assume that two estimates are nearly uncorrelated. For example, plots usually belong to one and only one owner. The correlation between estimates for different owners will be very small. If both estimates can be assumed to be nearly uncorrelated, the SE of the difference can be estimated by:

$$SE_{Difference} = \sqrt{SE^2_{\text{Estimate 1}} + SE^2_{\text{Estimate 2}}}$$

Using the SE of the difference, a confidence of the difference can be constructed with this method.

If two estimates are based on data that occur on the same plot at the same time, the above equation should not be used. For example, app. B table 17 contains estimates of tree volume by diameter class. If the reader wants to compare the volume of trees in the diameter class 9.0 to 10.9 d.b.h. (21.6 billion board feet) with that of trees in the diameter class 21.0 to 22.9 d.b.h. (33.15 billion board feet), the covariance between the estimates is not zero and this equation should not be used.

There are two other approaches the reader could possibly consider, but we do not recommend them. The first is to construct a confidence interval for **one** estimate and evaluate whether the other estimate falls within the interval. The problem is that unless both estimates are highly **positively** correlated, this approach will lead to a too-small confidence interval. The second approach is to construct confidence intervals for **both** estimates and determine whether or not they overlap. The problem here is that unless both estimates are highly **negatively** correlated, this approach will be very conservative. For more complex and indepth analysis, the reader may contact the PNW-FIA unit.

All estimates—means, totals and their associated SE—are based on the poststratification methods described by Bechtold and Patterson (2005).

Access Denied, Hazardous, or Inaccessible Plots

Although every effort was made to visit all field plots that were entirely or partially forested, some were not sampled for a variety of reasons. Field crews may have been unable to obtain permission from the landowner to access the plot (“denied access”), and there were some plots that were impossible for crews to safely reach or access (“hazardous/inaccessible”). Some private landowners deny access to their land, but privately owned plots usually are not as hazardous or inaccessible as plots on public lands. Although permission to visit public lands is almost always granted, some public land lies in higher elevation areas that can be very dangerous or impossible to reach.

This kind of missing data can introduce bias into the estimates if the nonsampled plots tend to be different from the entire population. Plots that are obviously nonforested (based on aerial photos) are rarely visited, and therefore the proportion of denied-access, hazardous, or inaccessible plots is significantly smaller than it is for forested plots.

The poststratification approach outlined in Bechtold and Patterson (2005) removes nonsampled plots from the sample. Estimates are adjusted for plots that are partially nonsampled by increasing the estimates by the non-sampled proportion within each stratum. To reduce the possible bias introduced by nonsampled plots, we delineated five broad strata groups: census water, forested public land, nonforested public land, forested private land, and nonforested private land. Some of these five broad strata groups were further divided into smaller strata to reduce the variance. Percentage of denied-access and hazardous/inaccessible plots for each of the five broad strata groups for Washington, 2002-2006, are shown in the following tabulation:

Strata group	Total plots	Denied access	Hazardous/ inaccessible
		Percent	
Census water	147	0.68	0.17
Private forest	1,189	10.04	0.42
Private nonforest	1,133	3.00	0.03
Public forest	1,701	0.57	0.90
Public nonforest	1,111	0.29	0.40
Total	5,281	3.17	0.48

Timber Products Output Survey

The Washington State Department of Natural Resources conducts a biennial census of Washington's primary forest products industry (i.e., sawmills, pulp mills, and log exports). This census, *The Washington Mill Survey* (Smith and Hiserote 2007), provides information on production capacity, county of operation, ownership, volume of raw material, timber size and species, and types and volumes of finished product. The survey is designed to determine the size and composition of Washington's timber and forest products industry and its use of forest resources.

National Woodland Owner Survey

This survey of private forest owners (Butler et al. 2005) is conducted annually by the USDA Forest Service FIA Program to increase our understanding of private wood-land owners. Questionnaires are mailed to individuals and private groups who own woodlands in which FIA has established forest inventory plots. Nationally, 20 percent of these owners (about 50,000) are contacted each year, and questionnaires with more detail are sent to coincide with national census, inventory, and assessment pro-grams. For Washington, 268 private noncorporate wood-land owners were sent questionnaires, and the 130 that were returned provide the data that were summarized and presented in this report.

Periodic Versus Annual Inventories

The PNW-FIA Program began fieldwork for the fifth sample-based inventory of Washington in 2002. This was the first inventory that used the annual inventory system, in which one-tenth of all forested plots (referred to as one panel) were visited each year. The first statewide panel of field plots was completed in 2002, and half of all field plots in the state were measured by 2006, prompting pro-duction of this congressionally mandated 5-year analysis of Washington's forest resources.

Data from new inventories are often compared with those from earlier inventories to determine trends in for-est resources. However, for the comparisons to be valid, the procedures used in the two inventories must be similar. Before the 1960s, Washington inventories were based on forest type maps and were inventoried in 1931-35 (Andrews and Cowlin 1940, Cowlin et al. 1942), 1937-41 (various Forest Survey Reports by county), and 1948-61 (various Forest Survey Reports by county). Subsequent inventories were based on a spatially systematic sample of plot locations and were conducted in 1963-68 (Arbogast 1974; Bolsinger 1969, 1971; Hazard 1965; Howard 1975), 1978-1980 (Bassett and Oswald 1981a, 1981b, 1982, 1983), 1988-90 (MacLean et al. 1991a, 1991b, 1991c, 1992; McKay et al. 1995), and 2000-2001 (Gray et al. 2005, 2006). These were periodic inventories in which all forested plots outside of national forests and national parks in the state were visited within a 2- or 3-year window.

As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have been made since the last periodic Washington inventory in 2001. These changes included an increase in plot density of about 18 percent, a new plot footprint (changing from a five-subplot configuration distributed over a 6-acre area, to a four-subplot configuration over a 2.5 acre area) (fig. 89), a new set of nationally consistent measurement protocols, and a plot visitation schedule that calls for sampling of 10 percent of all forested plots in the state each year. Although these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass, they may significantly affect plot classification variables such as forest type and stand size class (especially county-level estimates).

Estimates of growth, removals, and mortality (GRM) are particularly dependant on comparisons between inventories, and thus are most likely to be valid when based on remeasurements of the same plots and trees. Only half of the field plots (5 out of 10 panels) have been visited under the annual system as of 2006, and the increase in plot density means about 18 percent of the plots are new and were not visited during a previous inventory. Unlike the five-subplot, variable-radius design used in the 2001 periodic inventory (fig. 90), the annual inventory uses fixed-radius sampling on four subplots with only one subplot center coinciding with that of a periodic subplot. Thus, relatively few of the trees sampled at the periodic inventory were or will be remeasured in the annual inventory. Estimates of GRM will improve as the annual inventory becomes fully implemented and several panels of plots are remeasured.

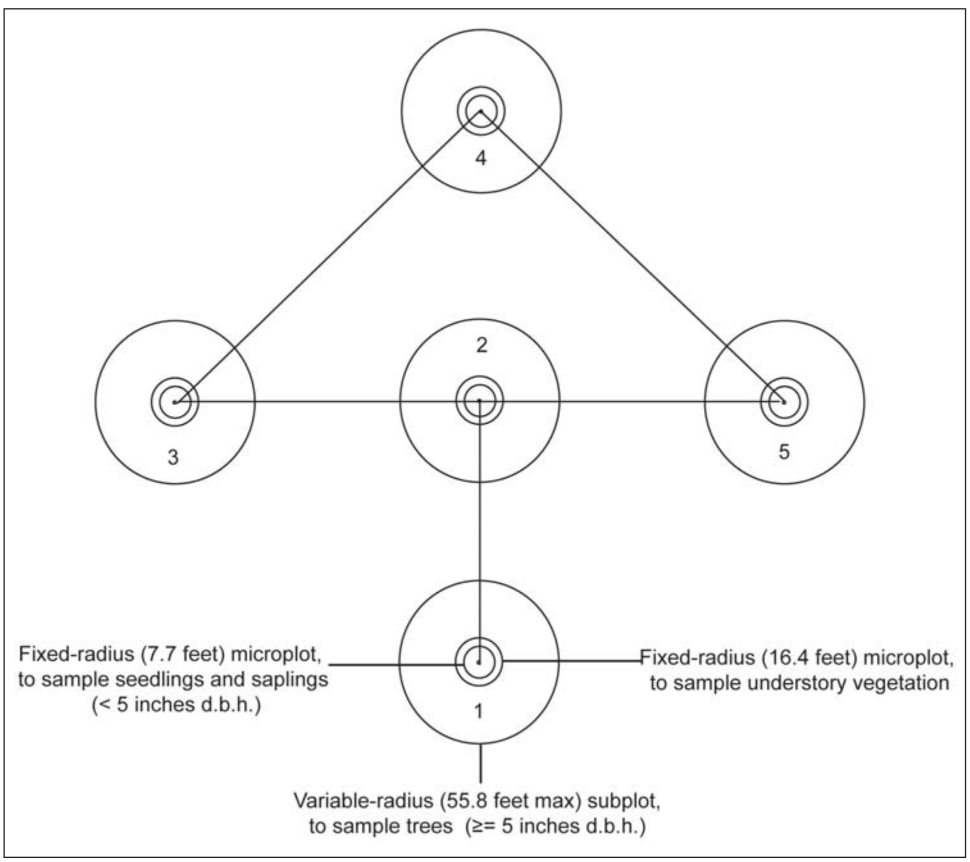

Figure 90—Typical plot design used in Washington periodic inventories, 1978–2001.

Appendix B: Summary Data Tables

The following tables contain basic information about the forest resources of Washington as they relate to the discussions of current forest issues and basic resource information presented in this report. These tables aggregate data to a variety of levels, including county (fig. 5), ecosection (fig. 6), owner group (fig. 7), survey unit (fig. 8), and forest type, allowing Forest Inventory and Analysis (FIA) inventory results to be applied at various scales and used for various analyses. Many other tables could be generated from the Washington annual data, but space limits us to a few (60+) key ones. Data are also available for download in nonsummarized form at www.fia.fs.fed.us.

The national FIA Web site contains a tool for querying the Washington annual data and generating custom tables or maps (http://www.fia.fs.fed.us/tools-data/). Some of the tables below contain summaries of regional variables; data for regional variables currently are not included in the national FIA database. Additional information on regional variables can be requested from our office by emailing Karen Waddell (kwaddell@fs.fed.us).

Please note that information in tables presented here and in those generated from the national FIA database (FIADB) may differ. As new data are added each year to FIADB, any tables generated from it will be based on the current full set of data in FIADB (e.g., 2002–2007, 2002–2008, etc.), whereas tables in this publication contain data from only 2002–2006. The user can take a snapshot of data from FIADB by selecting the desired years and generating tables that are similar, but probably not identical, to those presented here.

Table 1—Number of Forest Inventory and Analysis plots measured in Washington 2002–2006, by land class, sample status, and owner group[a]

Land class and sample status	National forest	Other public	Private	Total
Forest land plots:				
Softwood types	1,706	339	669	2,695
Hardwood types	71	49	187	307
Nonstocked	81	10	32	123
All	1,793	377	827	2,972
Nonforest land plots:	325	237	1,056	2,147
Unsampled plots:				
Denied access	16	11	89	116
Hazardous	194	57	23	274
All	211	70	118	399
All plots	1,911	599	1,716	4,694

[a] Each cell in this table includes a count of the number of plots that had at least one condition in each category. Because there can be multiple conditions on a plot, the total row or column will not be the sum of the preceding rows or columns. For example, there were 1,706 plots that had at least one forest land condition present, which was a softwood forest type and owned by the national forest system. One of these plots might also have a nonforest condition present, which would be counted again in the nonforest plot category.

Table 2—Estimated area of forest land, by owner class and forest land status, Washington 2002–2006

	Unreserved forests						Reserved forests						All forest land	
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total			
Owner class	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres													
USDA Forest Service:														
National forest	6,011	68	217	28	6,228	63	1,910	90	275	57	2,184	80	8,412	74
Total	6,011	68	217	28	6,228	63	1,910	90	275	57	2,184	80	8,412	74
Other federal government:														
National Park Service	—	—	—	—	—	—	1,134	60	118	38	1,252	56	1,252	56
Bureau of Land Management	52	25	20	15	71	29	—	—	—	—	—	—	71	29
U.S. Fish and Wildlife Service	—	—	—	—	—	—	54	25	—	—	54	25	54	25
Departments of Defense and Energy	32	20	—	—	32	20	—	—	—	—	—	—	32	20
Other federal	64	28	—	—	64	28	23	16	—	—	23	16	87	32
Total	148	42	20	15	168	44	1,211	67	118	38	1,329	63	1,497	76
State and local government:														
State	2,270	103	48	25	2,319	102	144	43	—	—	144	43	2,462	101
Local	279	58	13	13	292	59	42	23	—	—	42	23	334	64
Other public	15	14	—	—	15	14	—	—	—	—	—	—	15	14
Total	2,565	113	61	28	2,625	113	186	49	—	—	186	49	2,811	114
Corporate private	4,794	175	35	21	4,829	175	—	—	—	—	—	—	4,829	175
Noncorporate private:														
Nongovernmental conservation or natural resource organizations	235	54	—	—	235	54	—	—	—	—	—	—	235	54
Unincorporated partnerships, associations, or clubs	17	12	—	—	17	12	—	—	—	—	—	—	17	12
Native American	1,851	125	43	22	1,893	125	—	—	—	—	—	—	1,893	125
Individual	2,683	152	9	9	2,693	153	—	—	—	—	—	—	2,693	153
Total	4,786	181	52	24	4,838	181	—	—	—	—	—	—	4,838	181
All owners	18,303	174	385	53	18,688	171	3,306	121	392	68	3,699	112	22,387	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 3—Estimated area of forest land, by forest type group and productivity class, Washington 2002–2006

	Site productivity class[a]														All productivity classes	
	0-19		20-49		50-84		85-119		120-164		165-224		225+			
Forest type group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres															
Softwoods:																
Douglas-fir	173	38	1,263	95	1,950	125	1,245	102	2,434	145	1,424	115	169	43	8,658	223
Fir/spruce/mountain hemlock	367	62	884	94	1,148	104	806	82	672	77	111	32	4	4	3,992	165
Western hemlock/Sitka spruce	37	19	131	35	291	52	427	64	942	91	814	90	659	85	3,300	161
Lodgepole pine	3	4	179	38	262	50	181	38	20	13	5	4	—	—	651	74
Ponderosa pine	52	21	537	71	993	99	372	62	107	33	8	6	—	—	2,069	131
Western larch	4	4	25	17	142	32	58	16	70	21	12	9	8	5	318	45
Western white pine	—	—	—	—	4	4	7	5	—	—	—	—	—	—	11	7
Other western softwoods	77	33	59	29	20	13	9	5	20	16	—	—	—	—	186	48
Total	714	83	3,078	154	4,809	188	3,106	156	4,265	184	2,374	144	839	94	19,184	201
Hardwoods:																
Alder/maple	11	11	14	12	76	27	305	58	916	91	458	69	124	34	1,905	123
Aspen/birch	—	—	—	—	40	20	26	16	62	26	11	10	—	—	138	38
Elm/ash/cottonwood	9	9	11	12	8	6	58	22	65	23	30	19	—	—	182	40
Western oak	26	16	35	19	36	21	14	12	15	12	—	—	—	—	126	36
Woodland hardwoods	—	—	35	23	45	21	19	14	4	4	12	12	—	—	114	37
Other hardwoods	—	—	4	4	36	18	27	17	32	18	—	—	12	12	112	33
Total	46	21	99	35	242	49	449	69	1,094	99	511	72	137	36	2,578	144
Nonstocked	17	8	163	39	178	39	76	30	123	35	38	16	30	19	625	75
All forest types	777	86	3,339	161	5,228	194	3,631	171	5,482	204	2,923	158	1,006	102	22,387	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Site productivity class refers to the potential productivity of forest land expressed as the mean annual increment (in cubic feet/acre/year) at culmination in fully stocked stands.

Table 4—Estimated area of forest land, by forest type group, owner group, and land status, Washington 2002–2006

	USDA Forest Service				Other federal				State and local government				Corporate private				Noncorporate private					
	Timberland[a]		Other forest land		Timberland		Other forest land		Timberland		Other forest land		Timberland		Other forest land		Timberland		Other forest land		All owners	
Forest type group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres																					
Softwoods:																						
Douglas-fir	2,545	81	404	64	87	33	269	55	1,172	96	148	44	2,476	145	3	3	1,554	122	—	—	8,658	223
Fir/spruce/mountain hemlock	1,391	71	1,277	100	17	13	443	66	156	42	5	5	284	57	13	13	392	65	12	12	3,992	165
Western hemlock/Sitka spruce	800	49	190	50	25	17	541	64	548	73	20	15	774	90	11	11	389	67	—	—	3,300	161
Lodgepole pine	313	34	148	46	—	—	—	—	21	14	10	12	14	13	—	—	146	41	—	—	651	74
Ponderosa pine	392	36	43	21	8	9	34	19	172	44	26	18	331	62	7	8	1,043	102	13	13	2,069	131
Western larch	191	26	19	16	—	—	6	7	26	17	—	—	33	17	—	—	42	22	—	—	318	45
Western white pine	11	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	7
Other western softwoods	21	9	162	47	—	—	—	—	—	—	—	—	3	2	—	—	—	—	—	—	186	48
Total	5,665	73	2,242	90	138	40	1,294	64	2,095	105	209	51	3,915	166	35	21	3,566	160	25	18	19,184	201
Hardwoods:																						
Alder/maple	111	19	24	14	—	—	30	17	339	60	29	19	598	78	—	—	775	85	—	—	1,905	123
Aspen/birch	12	6	—	—	—	—	—	—	10	9	9	8	36	21	—	—	72	28	—	—	138	38
Elm/ash/cottonwood	18	7	4	4	—	—	17	12	37	20	—	—	36	19	—	—	62	23	9	9	182	40
Western oak	—	—	—	—	—	—	8	9	—	—	—	—	76	29	—	—	24	14	18	13	126	36
Woodland hardwoods	15	7	22	20	—	—	—	—	8	8	—	—	—	—	—	—	69	29	—	—	114	37
Other hardwoods	18	8	—	—	—	—	—	—	—	—	—	—	36	21	—	—	58	25	—	—	112	33
Total	175	24	49	24	—	—	54	23	394	65	37	21	782	90	—	—	1,060	100	27	16	2,578	144
Nonstocked	171	24	110	38	10	11	—	—	75	29	—	—	98	30	—	—	160	43	—	—	625	75
All forest types	6,011	68	2,401	85	148	42	1,348	65	2,565	113	247	56	4,794	175	35	21	4,786	181	52	24	22,387	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Unreserved forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 5—Estimated area of forest land, by forest type group and stand size class, Washington 2002–2006

	Large-diameter stands[a]		Medium-diameter stands[b]		Small-diameter stands[c]		All size classes	
Forest type group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
				Thousand acres				
Softwoods:								
Douglas-fir	6,188	203	1,026	97	1,444	113	8,658	223
Fir/spruce/mountain hemlock	2,874	144	345	57	773	85	3,992	165
Western hemlock/Sitka spruce	2,685	146	248	48	367	60	3,300	161
Lodgepole pine	337	56	227	44	87	20	651	74
Ponderosa pine	1,650	118	82	29	329	61	2,069	131
Western larch	215	35	69	25	34	14	318	45
Western white pine	8	6	—	—	3	4	11	7
Other western softwoods	73	28	67	32	46	23	186	48
Total	14,030	226	2,064	135	3,083	160	19,184	201
Hardwoods:								
Alder/maple	924	88	522	71	460	70	1,905	123
Aspen/birch	28	15	60	26	51	23	138	38
Elm/ash/cottonwood	114	32	14	9	54	23	182	40
Western oak	29	17	70	28	26	16	126	36
Woodland hardwoods	49	26	7	5	58	26	114	37
Other hardwoods	27	18	17	12	68	26	112	33
Total	1,171	101	690	81	718	86	2,578	144
Nonstocked	—	—	—	—	—	—	625	75
All forest types	15,201	231	2,754	154	3,800	176	22,387	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Stands in which the majority of trees are at least 11.0 inches diameter at breast height for hardwoods and 9.0 inches diameter at breast height for softwoods.

[b] Stands in which the majority of trees are at least 5.0 inches diameter at breast height but not as large as large-diameter trees.

[c] Stands in which the majority of trees are less than 5.0 inches diameter at breast height.

Table 6—Estimated area of forest land, by forest type group and stand age class, Washington 2002–2006

	Stand age class (years)																						All forest land	
	1-20		21-40		41-60		61-80		81-100		101-120		121-140		141-160		161-180		181-200		201+			
Forest type group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres																							
Softwoods:																								
Douglas-fir	1,812	124	1,524	117	932	91	1,472	112	1,103	98	506	62	297	44	300	50	125	33	92	24	471	61	8,658	223
Fir/spruce/mountain hemlock	349	54	366	55	319	60	517	72	394	59	261	48	213	44	242	43	191	45	212	47	924	96	3,992	165
Western hemlock/Sitka spruce	283	51	599	79	621	82	395	61	152	36	83	25	55	21	102	31	35	16	85	29	864	83	3,300	161
Lodgepole pine	38	14	54	20	157	39	180	35	130	36	27	17	14	10	17	8	16	17	14	14	4	4	651	74
Ponderosa pine	142	39	213	48	278	56	479	70	515	73	193	46	45	18	74	23	28	10	47	22	50	13	2,069	131
Western larch	14	7	30	13	62	21	135	31	36	11	4	4	12	7	—	—	4	4	4	3	19	16	318	45
Western white pine	3	4	—	—	4	4	—	—	—	—	4	4	—	—	—	—	—	—	—	—	—	—	11	7
Other western softwoods	—	—	17	12	14	16	9	6	10	6	67	34	4	3	23	17	1	1	—	—	41	23	186	48
Total	2,641	143	2,804	152	2,387	147	3,188	159	2,340	140	1,145	100	640	68	756	77	400	60	453	65	2,372	125	19,184	202
Hardwoods:																								
Alder/maple	601	79	420	64	437	63	348	60	63	27	19	11	—	—	4	4	4	4	—	—	—	—	1,905	123
Aspen/birch	39	21	11	12	19	12	45	22	24	16	—	—	—	—	—	—	—	—	—	—	—	—	138	38
Elm/ash/cottonwood	52	23	8	6	23	15	56	24	40	18	2	2	—	—	1	1	—	—	—	—	—	—	182	40
Western oak	—	—	9	10	18	13	56	25	22	14	15	14	—	—	6	6	—	—	—	—	—	—	126	36
Woodland hardwoods	15	13	24	17	—	—	20	14	39	24	4	4	—	—	13	13	—	—	—	—	—	—	115	37
Other hardwoods	30	18	5	4	38	21	14	13	26	15	—	—	—	—	—	—	—	—	—	—	—	—	112	34
Total	736	87	477	68	535	70	539	74	214	47	39	18	—	—	25	15	4	4	—	—	—	—	2,578	144
Nonstocked	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	625	75
All forest types	3,377	157	3,281	162	2,922	162	3,727	173	2,553	146	1,184	102	640	68	781	78	404	61	453	65	2,372	125	22,387	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

Table 7—Estimated area of timberland, by forest type group and stand size class, Washington 2002–2006

Forest type group	Large-diameter stands[a] Total	Large-diameter stands[a] SE	Medium-diameter stands[b] Total	Medium-diameter stands[b] SE	Small-diameter stands[c] Total	Small-diameter stands[c] SE	All size classes Total	All size classes SE
	Thousand acres							
Softwoods:								
Douglas-fir	5,402	187	1,002	97	1,429	113	7,834	209
Fir/spruce/mountain hemlock	1,567	98	239	43	436	60	2,241	119
Western hemlock/Sitka spruce	1,968	122	224	45	344	58	2,537	137
Lodgepole pine	251	43	159	31	83	20	493	56
Ponderosa pine	1,550	115	82	29	308	57	1,946	127
Western larch	190	31	69	25	34	14	293	42
Western white pine	8	6	—	—	3	4	11	7
Other western softwoods	16	8	3	3	4	4	24	9
Total	10,951	211	1,779	121	2,642	146	15,378	195
Hardwoods:								
Alder/maple	865	86	499	70	460	70	1,823	121
Aspen/birch	28	15	60	26	42	21	129	37
Elm/ash/cottonwood	85	28	14	9	54	23	152	37
Western oak	25	16	49	23	26	16	100	33
Woodland hardwoods	27	17	7	5	58	26	93	31
Other hardwoods	27	18	17	12	68	26	112	33
Total	1,056	95	646	79	709	86	2,410	139
Nonstocked	—	—	—	—	—	—	515	65
All forest types	12,007	217	2,424	141	3,351	163	18,303	174

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Stands in which the majority of trees are at least 11.0 inches diameter at breast height for hardwoods and 9.0 inches diameter at breast height for softwoods.

[b] Stands in which the majority of trees are at least 5.0 inches diameter at breast height but not as large as large-diameter trees.

[c] Stands in which the majority of trees are less than 5.0 inches diameter at breast height.

Table 8—Estimated number of live trees on forest land, by species group and diameter class, Washington, 2002–2006

	Diameter class (inches)													
	1.0-2.9		3.0-4.9		5.0-6.9		7.0-8.9		9.0-10.9		11.0-12.9		13.0-14.9	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand trees													
Softwoods:														
Douglas-fir	568,287	36,066	313,718	22,369	257,128	12,215	217,873	10,386	165,684	7,963	119,484	5,661	86,751	4,161
Engelmann and other spruces	59,439	11,533	28,111	6,791	14,056	1,581	10,231	1,235	8,679	1,199	6,704	945	5,109	852
Lodgepole pine	98,818	19,916	69,747	15,695	71,173	11,491	55,736	6,481	29,399	3,189	17,296	2,286	8,187	1,379
Ponderosa and Jeffrey pines	137,162	25,940	65,582	10,546	37,716	3,374	27,722	2,404	24,815	2,358	19,161	1,867	12,732	1,289
Sitka spruce	15,897	4,724	6,519	2,795	4,258	1,045	2,833	792	3,507	1,201	2,018	587	1,049	336
True fir	947,239	68,507	350,232	24,440	207,786	9,880	133,853	6,821	82,671	4,395	56,792	2,996	40,455	2,531
Western hemlock	690,770	61,458	264,959	23,699	187,624	11,082	128,184	7,593	95,265	5,568	69,190	4,421	49,383	3,504
Western larch	27,891	7,471	18,703	4,133	22,994	3,356	17,367	2,430	13,051	1,656	8,959	859	5,061	610
Western redcedar	378,448	55,727	119,661	16,114	60,332	4,958	39,251	3,053	23,548	2,091	16,342	1,434	12,378	1,203
Western white pine	18,574	4,333	4,120	1,738	2,316	567	1,388	397	940	269	522	176	520	188
Other western softwoods	210,946	32,043	72,768	12,332	45,269	4,652	36,509	3,712	20,841	2,483	13,728	1,732	10,809	1,448
Total	3,153,473	133,860	1,314,121	52,015	910,653	24,991	670,946	17,315	468,399	12,079	330,195	8,854	232,434	6,724
Hardwoods:														
Cottonwood and aspen	14,857	9,623	4,927	2,484	5,016	1,465	3,922	1,063	2,464	668	1,378	362	1,125	342
Oak	14,607	6,453	19,228	8,121	12,915	4,430	5,192	1,889	1,831	608	1,262	468	651	246
Red alder	239,607	34,324	105,663	16,392	65,725	6,762	48,397	4,279	33,525	3,349	23,833	2,467	14,480	1,581
Western woodland hardwoods	66,186	22,396	21,089	4,815	5,996	908	2,450	457	1,761	463	1,239	431	474	169
Other hardwoods	229,369	50,855	48,900	9,177	33,182	3,662	21,026	2,696	13,022	1,771	8,683	1,154	6,557	1,122
Total	564,626	69,044	199,808	21,095	122,834	9,121	80,987	5,612	52,602	3,965	36,395	2,886	23,287	2,054
All species groups	3,718,099	152,641	1,513,929	56,400	1,033,487	26,370	751,934	18,112	521,001	12,599	366,590	9,248	255,720	7,005

Table 8—Estimated number of live trees on forest land, by species group and diameter class, Washington, 2002–2006 (continued)

	Diameter class (inches)																	
	15.0-16.9		17.0-18.9		19.0-20.9		21.0-24.9		25.0-28.9		29.0-32.9		33.0-36.9		37.0+		All classes	
Species group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Thousand trees																	
Softwoods:																		
Douglas-fir	59,370	2,939	41,844	2,268	31,655	1,844	37,955	2,182	19,946	1,550	9,215	683	5,374	392	8,592	692	1,942,876	62,122
Engelmann and other spruces	3,578	628	2,652	505	2,098	460	2,941	783	1,364	319	811	188	249	67	229	72	146,252	18,526
Lodgepole pine	3,523	799	1,394	355	241	103	176	107	114	88	15	14	15	14	9	11	355,843	41,961
Ponderosa and Jeffrey pines	10,198	1,135	7,196	870	5,323	698	6,022	818	2,977	256	1,422	156	638	106	539	84	359,206	35,314
Sitka spruce	1,082	323	531	223	856	280	755	280	1,194	391	307	138	107	37	329	96	41,243	7,281
True fir	27,543	1,834	19,318	1,444	15,791	1,332	18,255	1,565	9,199	946	4,476	487	2,704	275	3,841	512	1,920,155	99,059
Western hemlock	34,236	2,552	22,252	1,694	15,085	1,340	18,781	1,616	11,884	1,384	5,608	566	3,123	287	7,230	748	1,603,572	88,787
Western larch	3,614	504	1,947	332	1,228	257	1,940	431	894	186	412	86	129	47	137	44	124,327	13,255
Western redcedar	8,741	975	6,398	756	6,215	826	6,993	1,020	5,391	935	2,131	383	916	125	3,985	509	690,731	74,010
Western white pine	376	136	140	58	205	154	204	108	76	39	26	16	12	9	13	13	29,435	5,449
Other western softwoods	6,959	1,141	5,039	1,143	4,982	854	5,661	1,000	2,348	449	1,640	378	1,224	258	1,445	321	440,169	47,548
Total	159,222	4,926	108,711	3,764	83,680	3,057	99,684	3,653	55,389	2,705	26,062	1,213	14,491	656	26,349	1,379	7,653,809	192,739
Hardwoods:																		
Cottonwood and aspen	884	319	914	316	1,091	332	911	338	1,008	371	447	170	229	71	224	70	39,397	11,287
Oak	684	297	364	226	153	107	89	77	15	14	—	—	12	12	—	—	57,004	15,276
Red alder	10,309	1,327	6,741	1,115	3,354	703	1,585	375	585	234	174	112	11	12	11	12	553,999	48,257
Western woodland hardwoods	298	143	149	99	—	—	70	71	11	12	—	—	—	—	—	—	99,723	23,842
Other hardwoods	3,506	732	2,866	536	2,173	468	1,888	474	1,435	380	608	184	164	57	228	76	373,608	56,901
Total	15,681	1,630	11,035	1,304	6,770	926	4,544	694	3,053	619	1,230	279	416	94	463	132	1,123,730	83,065
All species groups	174,902	5,196	119,745	3,979	90,450	3,222	104,228	3,719	58,441	2,790	27,292	1,252	14,908	667	26,812	1,385	8,777,539	209,620

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = fewer than 500 trees were estimated.

Table 9—Estimated number of growing-stock trees[a] on timberland, by species group and diameter class, Washington, 2002–2006

	Diameter class (inches)															
	1.0-2.9		3.0-4.9		5.0-6.9		7.0-8.9		9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	S
	Thousand trees															
Softwoods:																
Douglas-fir	532,668	34,529	294,861	21,603	243,591	12,073	205,789	10,253	153,742	7,732	110,495	5,430	78,915	3,976	52,877	2,7
Engelmann and other spruces	45,667	8,651	21,063	4,584	11,042	1,376	8,072	1,098	6,973	1,008	4,629	721	3,241	587	2,135	3
Lodgepole pine	82,441	17,197	47,124	11,771	45,743	6,477	39,187	4,165	22,015	2,189	12,087	1,405	5,452	872	2,720	6
Ponderosa and Jeffrey pines	134,543	25,917	62,962	10,447	35,851	3,309	26,810	2,368	23,489	2,310	18,005	1,801	12,102	1,251	9,225	1,0
Sitka spruce	14,950	4,628	6,519	2,795	3,930	1,027	2,499	768	3,265	1,193	1,860	576	978	328	865	2
True fir	650,587	56,033	242,416	20,180	135,752	7,848	82,170	4,681	53,623	3,398	34,101	2,015	23,012	1,639	14,927	1,0
Western hemlock	567,699	57,370	228,710	22,302	157,798	10,223	111,579	7,288	80,659	5,245	57,565	4,115	39,990	2,986	27,601	2,2
Western larch	27,891	7,471	18,703	4,133	22,462	3,336	16,728	2,382	11,989	1,493	8,304	819	4,851	569	3,136	4[illegible]
Western redcedar	336,934	51,871	106,650	15,044	52,701	4,554	34,084	2,832	20,748	1,954	14,137	1,314	10,581	1,081	7,011	832
Western white pine	16,802	4,095	4,120	1,738	1,810	510	1,273	389	786	250	500	175	405	156	351	134
Other western softwoods	61,014	10,402	23,011	5,271	16,677	2,516	11,723	1,705	8,013	1,337	4,999	971	3,735	871	2,521	727
Total	2,471,196	117,648	1,056,140	45,526	727,357	21,611	539,914	15,246	385,302	11,028	266,681	7,972	183,262	5,845	123,367	4,268
Hardwoods:																
Cottonwood and aspen	14,857	9,623	4,927	2,484	4,837	1,457	3,651	1,049	2,388	663	1,355	361	1,004	330	861	318
Oak	14,607	6,453	19,228	8,121	11,758	4,364	4,772	1,827	1,439	528	998	422	451	214	548	259
Red alder	227,138	33,389	102,978	16,314	62,850	6,604	46,729	4,251	31,915	3,295	23,164	2,454	13,500	1,545	9,703	1,310
Other hardwoods	221,372	50,687	46,977	9,053	30,636	3,500	18,855	2,546	11,316	1,611	7,718	1,103	5,531	1,023	3,248	709
Total	477,974	64,698	174,111	20,442	110,081	8,867	74,007	5,468	47,057	3,824	33,235	2,816	20,485	1,975	14,361	1,598
All species groups	2,949,170	136,789	1,230,251	50,199	837,439	23,170	613,920	16,163	432,360	11,606	299,917	8,398	203,747	6,160	137,728	4,577

Table 9—Estimated number of growing-stock trees[a] on timberland, by species group and diameter class, Washington, 2002–2006 (continued)

Species group	Diameter class (inches) 17.0-18.9 Total	17.0-18.9 SE	19.0-20.9 Total	19.0-20.9 SE	21.0-24.9 Total	21.0-24.9 SE	25.0-28.9 Total	25.0-28.9 SE	29.0-32.9 Total	29.0-32.9 SE	33.0-36.9 Total	33.0-36.9 SE	37.0+ Total	37.0+ SE	All classes Total	All classes SE
	Thousand trees															
Softwoods:																
Douglas-fir	35,993	2,061	26,977	1,669	32,688	2,043	16,217	1,398	7,423	587	4,042	336	5,413	442	1,801,690	59,507
Engelmann and other spruces	1,632	340	1,032	248	1,196	378	485	106	380	116	116	30	89	35	107,752	13,339
Lodgepole pine	1,061	280	241	103	176	107	18	14	15	14	15	14	9	11	258,305	30,874
Ponderosa and Jeffrey pines	6,598	790	4,728	666	5,644	795	2,726	244	1,333	148	531	85	497	81	345,045	35,112
Sitka spruce	390	167	856	280	564	252	1,107	382	276	136	75	31	194	79	38,329	7,121
True fir	11,147	1,058	8,379	773	8,831	903	4,890	545	1,970	271	1,216	143	1,287	161	1,274,308	80,111
Western hemlock	16,815	1,489	11,356	1,168	12,593	1,266	6,853	966	3,114	388	1,389	136	2,615	288	1,326,336	82,116
Western larch	1,827	315	1,140	239	1,706	399	679	123	314	72	129	47	93	27	119,951	13,105
Western redcedar	5,558	705	5,028	726	5,760	944	3,719	769	1,624	318	734	102	2,041	251	607,310	68,307
Western white pine	116	53	205	154	95	48	76	39	8	6	12	9	13	13	26,574	5,256
Other western softwoods	2,104	979	1,378	333	1,959	677	648	212	428	103	318	80	377	84	138,903	19,171
Total	83,242	3,358	61,320	2,536	71,212	3,058	37,420	2,152	16,884	914	8,577	447	12,628	685	6,044,502	168,671
Hardwoods:																
Cottonwood and aspen	799	304	856	305	778	287	961	370	433	170	229	71	198	68	38,135	11,266
Oak	276	174	153	107	76	77	15	14	—	—	12	12	—	—	54,332	15,133
Red alder	6,475	1,103	3,267	698	1,440	360	497	185	174	112	11	12	11	12	529,853	47,351
Other hardwoods	2,608	513	2,087	462	1,461	392	1,154	333	565	182	150	56	202	72	353,878	56,480
Total	10,158	1,269	6,363	911	3,756	604	2,625	573	1,172	276	402	93	412	127	976,199	78,688
All species groups	93,400	3,599	67,682	2,725	74,968	3,123	40,046	2,243	18,057	965	8,979	463	13,040	697	7,020,701	186,564

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = fewer than 500 trees were estimated.

[a] Growing-stock trees are live trees of commercial species that meet certain merchantability standards; excludes trees that are entirely cull (rough or rotten tree classes).

Table 10—Estimated net volume of all live trees, by owner class and forest land status, Washington 2002–2006

	Unreserved forests						Reserved forests							
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total		All forest land	
Owner class	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
USDA Forest Service:														
National forest	29,562	735	435	100	29,998	731	10,193	815	360	119	10,553	809	40,551	976
Other federal government:														
National Park Service	—	—	—	—	—	—	12,660	803	347	145	13,007	763	13,007	763
Bureau of Land Management	138	71	21	18	159	73	—	—	—	—	—	—	159	73
U.S. Fish and Wildlife Service	—	—	—	—	—	—	241	123	—	—	241	123	241	123
Departments of Defense and Energy	254	163	—	—	254	163	—	—	—	—	—	—	254	163
Other federal	439	249	—	—	439	249	117	85	—	—	117	85	556	263
Total	830	297	21	18	851	298	13,018	815	347	145	13,365	776	14,216	830
State and local government:														
State	11,583	951	90	48	11,673	950	668	229	—	—	668	229	12,342	945
Local	1,373	370	24	24	1,397	370	314	173	—	—	314	173	1,711	409
Other public	116	109	—	—	116	109	—	—	—	—	—	—	116	109
Total	13,072	1,004	115	54	13,187	1,003	982	287	—	—	982	287	14,169	1,012
Corporate private	12,555	848	36	27	12,591	848	—	—	—	—	—	—	12,591	848
Noncorporate private:														
Nongovernmental conservation or natural resource organizations	665	220	—	—	665	220	—	—	—	—	—	—	665	220
Unincorporated partnerships, associations, or clubs	47	44	—	—	47	44	—	—	—	—	—	—	47	44
Native American	4,472	457	26	15	4,498	456	—	—	—	—	—	—	4,498	456
Individual	8,091	741	7	7	8,098	741	—	—	—	—	—	—	8,098	741
Total	13,274	869	33	16	13,307	869	—	—	—	—	—	—	13,307	869
All owners	69,294	1,567	640	119	69,934	1,563	24,193	1,187	707	187	24,900	1,156	94,834	1,843

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 11—Estimated net volume of all live trees on forest land, by forest type group and stand size class, Washington 2002–2006

	Large-diameter stands[a]		Medium-diameter stands[b]		Small-diameter stands[c]		All size classes	
Forest type group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
				Million cubic feet				
Softwoods:								
Douglas-fir	33,257	1,440	1,366	153	394	60	35,017	1,434
Fir/spruce/mountain hemlock	18,403	1,166	545	105	252	47	19,200	1,162
Western hemlock/Sitka spruce	25,893	1,604	556	123	85	24	26,534	1,606
Lodgepole pine	1,399	291	530	107	21	7	1,950	308
Ponderosa pine	3,059	261	64	33	137	49	3,261	266
Western larch	851	190	171	69	14	6	1,036	201
Western white pine	20	15	—	—	—	—	20	15
Other western softwoods	78	29	57	26	9	7	144	39
Total	82,960	1,857	3,289	254	913	92	87,165	1,815
Hardwoods:								
Alder/maple	5,313	602	982	165	133	39	6,428	609
Aspen/birch	116	61	93	44	5	4	215	75
Elm/ash/cottonwood	580	189	17	10	6	3	603	189
Western oak	64	58	71	32	9	6	144	66
Woodland hardwoods	48	30	4	3	33	16	85	34
Other hardwoods	104	74	9	6	27	13	140	76
Total	6,226	637	1,175	173	213	45	7,614	643
Nonstocked	—	—	—	—	—	—	55	13
All forest types	89,186	1,900	4,465	304	1,126	102	94,834	1,843

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

[a] Stands in which the majority of trees are at least 11.0 inches diameter at breast height for hardwoods and 9.0 inches diameter at breast height for softwoods.

[b] Stands in which the majority of trees are at least 5.0 inches diameter at breast height but not as large as large-diameter trees.

[c] Stands in which the majority of trees are less than 5.0 inches diameter at breast height.

Table 12—Estimated net volume of all live trees on forest land, by species group and owner group, Washington 2002–2006

Species group	USDA Forest Service		Other federal		State and local government		Corporate private		Noncorporate private		All owners	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet											
Softwoods:												
Douglas-fir	12,708	508	3,028	465	6,042	601	5,451	463	4,641	497	31,870	1,073
Engelmann and other spruces	1,442	234	12	10	180	100	30	17	219	68	1,883	264
Lodgepole pine	1,375	178	37	19	119	47	99	60	387	94	2,016	215
Ponderosa and Jeffrey pines	1,097	89	138	61	372	79	402	77	1,643	180	3,652	229
Sitka spruce	103	79	165	64	266	108	184	53	154	64	871	169
True fir	10,395	572	3,576	472	680	192	456	83	914	152	16,022	784
Western hemlock	7,183	429	5,394	614	3,911	585	3,354	421	1,295	246	21,137	1,053
Western larch	929	98	26	18	149	51	146	35	354	76	1,605	137
Western redcedar	2,130	251	1,085	290	709	135	797	175	1,025	194	5,747	479
Western white pine	87	17	8	4	19	15	12	6	36	15	162	28
Other western softwoods	2,444	317	601	191	47	49	81	44	123	54	3,296	380
Total	39,892	972	14,070	829	12,493	951	11,013	773	10,791	749	88,260	1,771
Hardwoods:												
Cottonwood and aspen	134	32	22	16	260	122	80	28	386	111	882	170
Oak	—	—	6	6	5	3	63	27	47	19	120	34
Red alder	358	51	39	18	986	176	1,124	203	1,150	170	3,656	307
Western woodland hardwoods	19	4	4	2	10	5	4	2	13	4	50	8
Other hardwoods	148	27	76	63	415	116	306	92	920	165	1,866	223
Total	658	71	146	74	1,676	269	1,577	233	2,516	321	6,573	455
All species groups	40,551	976	14,216	830	14,169	1,012	12,591	848	13,307	869	94,834	1,843

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

Table 13—Estimated net volume of all live trees on forest land, by species group and diameter class, Washington 2002–2006

	Diameter class (inches)													
	5.0-6.9		7.0-8.9		9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9		17.0-18.9	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
Softwoods:														
Douglas-fir	609	30	1,405	69	2,056	102	2,498	126	2,695	138	2,602	139	2,503	151
Engelmann and other spruces	34	4	67	9	113	16	139	20	158	28	161	30	159	31
Lodgepole pine	222	35	431	49	411	45	391	54	263	48	160	37	82	22
Ponderosa and Jeffrey pines	56	5	117	10	225	23	294	30	312	33	353	40	345	44
Sitka spruce	9	2	15	5	39	17	45	14	29	10	42	13	23	9
True fir	447	23	816	43	1,015	54	1,164	63	1,245	78	1,218	83	1,178	90
Western hemlock	486	32	945	61	1,397	87	1,698	116	1,797	133	1,808	138	1,515	120
Western larch	67	10	133	20	181	23	200	19	162	20	156	22	118	20
Western redcedar	139	12	241	20	258	23	294	27	310	31	300	37	286	36
Western white pine	5	1	9	2	12	3	14	5	18	7	22	8	10	4
Other western softwoods	61	7	139	15	171	23	189	26	231	33	212	37	226	54
Total	2,136	67	4,319	122	5,878	162	6,926	204	7,219	226	7,034	235	6,445	239
Hardwoods:														
Cottonwood and aspen	15	4	28	8	35	10	35	10	46	15	44	14	55	17
Oak	24	9	22	8	13	5	15	6	10	4	14	6	8	7
Red alder	189	21	389	35	507	55	571	62	517	59	505	72	437	78
Western woodland hardwoods	10	2	8	2	9	2	7	2	6	2	5	3	3	2
Other hardwoods	91	11	160	22	183	26	197	29	222	41	166	35	172	34
Total	329	25	607	44	748	62	827	71	801	76	734	83	676	88
All species groups	2,464	71	4,926	129	6,626	172	7,752	214	8,020	238	7,768	251	7,121	254

Table 13—Estimated net volume of all live trees on forest land, by species group and diameter class, Washington 2002–2006 (continued)

	Diameter class (inches)													
	19.0-20.9		21.0-24.9		25.0-28.9		29.0-32.9		33.0-36.9		37.0+		All classes	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
Softwoods:														
Douglas-fir	2,480	154	4,079	258	3,227	277	1,932	149	1,471	113	4,314	396	31,870	1,073
Engelmann and other spruces	165	37	327	94	213	51	171	37	74	22	102	34	1,883	264
Lodgepole pine	20	9	17	10	11	8	3	3	3	3	3	3	2,016	215
Ponderosa and Jeffrey pines	345	47	539	72	400	35	273	31	173	30	220	38	3,652	229
Sitka spruce	54	18	86	34	181	65	61	28	28	10	260	96	871	169
True fir	1,235	105	2,032	184	1,630	177	1,082	118	899	98	2,061	282	16,022	784
Western hemlock	1,327	124	2,389	222	2,115	253	1,300	135	949	91	3,409	386	21,137	1,053
Western larch	93	20	202	45	131	28	77	16	35	12	51	16	1,605	137
Western redcedar	355	51	533	89	590	102	318	58	185	26	1,937	321	5,747	479
Western white pine	20	16	18	8	12	6	7	4	4	3	11	11	162	28
Other western softwoods	271	46	442	80	281	57	295	68	287	67	491	118	3,296	380
Total	6,365	244	10,663	424	8,790	456	5,519	266	4,108	196	12,858	771	88,260	1,771
Hardwoods:														
Cottonwood and aspen	77	27	102	37	197	78	106	40	65	21	75	25	882	170
Oak	7	5	4	4	1	1	—	—	2	2	—	—	120	34
Red alder	290	61	155	38	58	23	30	19	2	3	4	4	3,656	307
Western woodland hardwoods	—	—	1	1	—	—	—	—	—	—	—	—	50	8
Other hardwoods	145	31	175	45	177	50	99	30	30	11	49	17	1,866	223
Total	519	73	438	69	433	98	236	54	99	24	128	39	6,573	455
All species groups	6,884	257	11,101	430	9,223	468	5,754	272	4,208	198	12,986	772	94,834	1,843

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

Table 14—Estimated net volume of growing-stock trees[a] on timberland, by species group and diameter class, Washington 2002–2006

	Diameter class (inches)																					
	5.0-6.9		7.0-8.9		9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9		17.0-18.9		19.0-20.9		21.0-28.9		29.0+		All classes	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet																					
Softwoods:																						
Douglas-fir	581	30	1,337	68	1,915	99	2,322	121	2,463	132	2,348	133	2,207	143	2,161	144	6,279	420	5,464	384	27,076	970
Engelmann and other spruces	28	4	56	8	95	14	103	18	108	21	102	19	101	22	82	20	211	50	148	37	1,033	133
Lodgepole pine	151	22	317	35	325	35	282	33	179	28	125	30	63	16	20	9	19	11	9	7	1,489	143
Ponderosa and Jeffrey pines	54	5	114	10	214	22	277	29	294	31	316	36	312	40	312	46	869	88	602	69	3,362	217
Sitka spruce	8	2	13	5	36	17	42	14	27	10	35	12	17	7	54	18	232	84	238	92	703	156
True fir	303	18	510	29	677	43	705	42	733	52	678	50	690	68	685	67	1,906	193	1,525	170	8,412	478
Western hemlock	420	30	838	59	1,208	83	1,422	108	1,469	117	1,470	122	1,183	108	1,018	110	2,809	297	2,325	213	14,162	792
Western larch	65	10	128	20	167	21	185	18	155	19	139	20	112	19	85	19	281	50	130	27	1,447	115
Western redcedar	124	11	213	19	235	22	259	25	270	28	253	33	260	35	293	45	882	150	1,313	161	4,101	331
Western white pine	4	1	8	2	10	3	13	5	15	6	21	8	9	4	20	16	21	8	17	12	138	27
Other western softwoods	27	4	53	8	73	14	80	17	83	19	87	27	97	45	86	20	247	62	337	69	1,169	197
Total	1,767	58	3,586	109	4,955	150	5,688	185	5,797	200	5,572	207	5,049	217	4,815	212	13,757	620	12,109	571	63,093	1,480
Hardwoods:																						
Cottonwood and aspen	14	4	27	8	34	10	35	10	42	14	42	14	47	16	65	26	286	92	239	64	832	168
Oak	22	9	20	8	11	4	13	6	8	4	12	6	8	7	7	5	5	4	2	2	108	33
Red alder	183	21	380	35	489	55	558	62	495	59	491	71	430	78	282	60	208	50	36	20	3,553	307
Other hardwoods	86	10	144	21	165	24	175	27	186	35	152	34	154	32	137	30	278	66	167	41	1,645	201
Total	305	25	572	43	699	61	781	70	731	73	697	83	639	87	491	72	777	131	445	86	6,137	443
All species groups	2,072	63	4,158	118	5,654	161	6,469	197	6,527	212	6,269	225	5,688	234	5,305	227	14,533	637	12,554	581	69,230	1,566

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

[a] Growing-stock trees are trees of commercial species that meet certain merchantability standards; excludes trees that are entirely cull (rough or rotten tree classes).

Table 15—Estimated net volume of growing-stock[a] trees on timberland, by species group and owner group, Washington 2002–2006

Species group	USDA Forest Service		Other federal		State and local government		Corporate private		Noncorporate private		All owners	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet											
Softwoods:												
Douglas-fir	11,029	443	545	238	5,415	592	5,446	463	4,641	497	27,076	970
Engelmann and other spruces	649	68	3	3	133	91	30	17	219	68	1,033	133
Lodgepole pine	919	84	9	8	76	33	99	60	387	94	1,489	143
Ponderosa and Jeffrey pines	994	82	26	15	307	70	402	77	1,632	180	3,362	217
Sitka spruce	103	79	—	—	262	108	184	53	154	64	703	156
True fir	6,365	404	17	15	673	192	446	82	911	152	8,412	478
Western hemlock	5,532	271	116	116	3,870	586	3,349	421	1,295	246	14,162	792
Western larch	788	63	10	7	149	51	146	35	354	76	1,447	115
Western redcedar	1,566	135	100	107	618	125	793	175	1,024	194	4,101	331
Western white pine	68	15	3	2	19	15	12	6	36	15	138	27
Other western softwoods	938	179	—	—	47	49	67	41	117	54	1,169	197
Total	28,951	729	828	297	11,569	949	10,974	773	10,771	749	63,093	1,480
Hardwoods:												
Cottonwood and aspen	112	23	—	—	260	122	80	28	379	111	832	168
Oak	—	—	1	1	5	3	63	27	39	19	108	33
Red alder	339	49	—	—	941	175	1,123	203	1,149	170	3,553	307
Other hardwoods	137	25	1	1	282	84	306	92	918	165	1,645	201
Total	588	66	3	2	1,488	252	1,572	233	2,487	320	6,137	443
All species groups	29,539	735	830	297	13,057	1,004	12,546	847	13,257	869	69,230	1,566

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

[a] Growing-stock trees are trees of commercial species that meet certain merchantability standards; excludes trees that are entirely cull (rough or rotten tree classes).

Table 16—Estimated net volume (International 1/4-inch rule) of sawtimber trees[a] on timberland, by species group and diameter class, Washington 2002–2006

	Diameter class (inches)													
	9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9		17.0-18.9		19.0-20.9		21.0-22.9	
Species group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million board feet (International 1/4-inch rule)													
Softwoods:														
Douglas-fir	8,462	442	12,071	637	13,858	756	13,908	807	13,592	908	13,647	926	12,750	1,020
Engelmann and other spruces	431	66	542	97	618	123	610	117	618	137	515	126	401	141
Lodgepole pine	1,494	167	1,501	175	1,020	158	747	179	382	98	124	57	85	63
Ponderosa and Jeffrey pines	866	91	1,327	141	1,550	165	1,761	202	1,809	233	1,891	280	1,587	295
Sitka spruce	155	77	221	74	150	54	205	67	98	44	329	109	79	57
True fir	3,004	191	3,665	221	4,152	298	4,047	298	4,273	425	4,365	433	3,651	458
Western hemlock	5,598	390	7,684	595	8,574	697	9,029	755	7,483	689	6,597	723	5,555	65 7
Western larch	759	97	976	98	880	107	824	119	687	118	535	117	661	217
Western redcedar	1,012	97	1,308	125	1,463	154	1,436	197	1,514	203	1,748	273	1,317	259
Western white pine	41	14	74	28	89	34	129	50	57	26	131	104	57	32
Other western softwoods	296	58	388	85	428	100	485	155	559	262	519	119	620	256
Total	22,119	684	29,756	992	32,782	1,158	33,181	1,258	31,072	1,362	30,403	1,363	26,762	1,405
Hardwoods:														
Cottonwood and aspen	—	—	168	46	242	85	251	85	288	93	412	170	299	139
Oak	—	—	50	23	38	19	59	29	45	36	36	26	24	24
Red alder	—	—	2,655	300	2,790	334	2,953	434	2,672	490	1,788	383	620	198
Other hardwoods	—	—	781	121	994	190	863	200	935	199	837	187	392	141
Total	—	—	3,655	335	4,064	410	4,127	498	3,940	542	3,074	455	1,334	276
All species groups	22,119	684	33,411	1,042	36,846	1,226	37,308	1,366	35,012	1,467	33,476	1,452	28,095	1,427

Table 16—Estimated net volume (International 1/4-inch rule) of sawtimber trees[a] on timberland, by species group and diameter class, Washington, 2001–2005 (continued)

	Diameter class (inches)									
	23.0-24.9		25.0-26.9		27.0-28.9		29.0+		All classes	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (International 1/4-inch rule)									
Softwoods:										
Douglas-fir	10,626	914	9,596	1,006	8,396	987	37,659	2,687	154,564	6,205
Engelmann and other spruces	469	152	278	65	234	60	1,017	251	5,733	792
Lodgepole pine	25	16	12	10	—	—	57	43	5,448	633
Ponderosa and Jeffrey pines	1,536	235	1,387	147	987	113	4,095	476	18,796	1,277
Sitka spruce	352	204	531	209	562	269	1,678	675	4,359	1,046
True fir	3,129	419	3,173	416	2,850	403	10,819	1,211	47,128	3,014
Western hemlock	5,052	696	5,011	883	3,301	497	16,274	1,498	80,158	4,870
Western larch	498	148	357	73	316	82	864	177	7,355	630
Western redcedar	1,579	346	1,361	329	1,208	315	8,742	1,073	22,688	2,003
Western white pine	—	—	70	41	12	10	124	85	785	171
Other western softwoods	431	119	277	97	220	84	2,337	482	6,561	1,148
Total	23,697	1,335	22,051	1,552	18,085	1,286	83,666	3,994	353,573	9,412
Hardwoods:										
Cottonwood and aspen	328	153	841	324	462	294	1,616	437	4,907	1,108
Oak	—	—	3	3	—	—	14	14	270	103
Red alder	356	149	264	132	110	67	246	133	14,453	1,640
Other hardwoods	417	149	562	198	311	143	1,072	264	7,164	1,019
Total	1,101	256	1,670	427	883	333	2,947	570	26,793	2,445
All species groups	24,797	1,368	23,722	1,609	18,968	1,338	86,613	4,054	380,367	9,873

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 board feet was estimated.

[a] Sawtimber trees have merchantability limits that differ for softwood and hardwood species as follows: ≥9 inches diameter at breast height for softwoods and ≥11 inches diameter at breast height for hardwoods.

Table 17—Estimated net volume (Scribner rule)[a] of sawtimber trees[b] on timberland, by species group and diameter class, Washington, 2002–2006

	Diameter class (inches)													
	9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9		17.0-18.9		19.0-20.9		21.0-22.9	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (Scribner rule)													
Softwoods:														
Douglas-fir	5,194	260	8,039	414	9,768	520	10,202	583	10,306	686	10,489	710	9,863	787
Engelmann and other spruces	320	50	429	78	504	101	517	99	530	118	449	110	354	126
Lodgepole pine	1,110	126	1,173	136	823	125	598	135	309	78	107	50	75	56
Ponderosa and Jeffrey pines	644	68	1,037	111	1,254	135	1,458	168	1,521	198	1,629	242	1,374	256
Sitka spruce	83	45	136	47	97	37	132	44	62	29	221	74	53	40
True fir	1,969	122	2,556	152	3,048	217	3,116	231	3,342	330	3,495	347	2,968	375
Western hemlock	3,348	237	4,957	391	5,825	483	6,414	542	5,458	509	4,958	550	4,251	508
Western larch	571	73	777	78	726	88	694	100	593	102	467	103	586	193
Western redcedar	609	59	845	84	942	100	963	135	1,039	147	1,217	192	894	174
Western white pine	27	9	56	22	70	27	111	43	50	23	102	80	50	28
Other western softwoods	179	38	255	60	272	62	326	100	384	168	391	91	444	175
Total	14,055	425	20,261	660	23,331	808	24,531	915	23,594	1,021	23,524	1,049	20,914	1,094
Hardwoods:														
Cottonwood and aspen	—	—	121	34	187	67	187	64	217	69	321	143	241	115
Oak	—	—	27	13	20	11	29	15	24	21	21	15	14	14
Red alder	—	—	1,905	218	1,951	237	2,104	315	1,944	361	1,322	285	467	152
Other hardwoods	—	—	615	97	817	157	730	170	798	172	710	162	344	124
Total	—	—	2,667	247	2,974	305	3,050	373	2,983	410	2,373	352	1,065	224
All species groups	14,055	425	22,928	701	26,305	862	27,581	998	26,577	1,099	25,898	1,119	21,979	1,113

Table 17—Estimated net volume (Scribner rule)[a] of sawtimber trees[b] on timberland, by species group and diameter class, Washington, 2002–2006 (continued)

	Diameter class (inches)									
	23.0-24.9		25.0-26.9		27.0-28.9		29.0+		All classes	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (Scribner rule)									
Softwoods:										
Douglas-fir	8,379	714	7,671	796	6,695	780	30,862	2,240	117,467	4,837
Engelmann and other spruces	417	136	252	59	213	55	921	223	4,907	689
Lodgepole pine	22	14	10	9	—	—	49	38	4,277	490
Ponderosa and Jeffrey pines	1,351	207	1,225	128	885	101	3,751	440	16,131	1,107
Sitka spruce	262	155	389	160	419	205	1,386	592	3,240	840
True fir	2,535	337	2,595	336	2,349	330	9,160	1,020	37,133	2,424
Western hemlock	3,922	541	3,943	696	2,619	392	13,234	1,220	58,929	3,670
Western larch	445	132	320	65	286	74	774	160	6,238	545
Western redcedar	1,080	240	938	217	834	211	6,569	807	15,930	1,409
Western white pine	—	—	60	35	11	9	118	81	656	146
Other western softwoods	310	82	206	68	162	62	1,871	389	4,800	795
Total	18,724	1,046	17,608	1,218	14,471	1,012	68,696	3,306	269,710	7,333
Hardwoods:										
Cottonwood and aspen	289	137	771	299	421	273	1,455	401	4,208	1,003
Oak	—	—	2	2	—	—	12	12	147	57
Red alder	269	116	200	102	76	46	193	104	10,432	1,203
Other hardwoods	367	132	498	176	274	127	948	234	6,101	880
Total	925	220	1,471	383	771	304	2,608	512	20,888	1,985
All species groups	19,649	1,075	19,080	1,277	15,242	1,066	71,303	3,361	290,597	7,718

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 board feet was estimated.

[a] Volume is based on Scribner board foot rule.

[b] Sawtimber trees have merchantability limits that differ for softwood and hardwood species as follows: ≥9 inches diameter at breast height for softwoods and ≥11 inches diameter at breast height for hardwoods.

Table 18—Estimated net volume (cubic feet) of sawtimber trees[a] on timberland, by species group and owner group, Washington, 2002–2006

	USDA Forest Service		Other federal		State and local government		Corporate private		Noncorporate private		All owners	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
					Million cubic feet							
Softwoods:												
Douglas-fir	10,255	433	513	227	4,992	577	4,497	426	4,204	477	24,461	936
Engelmann and other spruces	573	63	2	2	119	84	20	11	205	66	918	124
Lodgepole pine	532	53	3	3	40	19	82	55	281	72	939	107
Ponderosa and Jeffrey pines	940	79	25	15	282	66	366	73	1,499	171	3,112	207
Sitka spruce	101	79	—	—	256	106	162	47	149	62	668	152
True fir	5,667	385	11	13	599	183	333	69	762	137	7,371	453
Western hemlock	5,008	262	92	91	3,501	561	2,850	382	1,040	206	12,491	742
Western larch	669	57	6	4	117	40	104	24	307	70	1,202	100
Western redcedar	1,404	130	98	105	548	119	689	161	936	188	3,676	317
Western white pine	59	14	2	1	18	15	10	6	33	14	122	26
Other western softwoods	864	173	—	—	43	46	57	37	98	47	1,062	189
Total	26,072	715	752	277	10,514	918	9,171	709	9,513	697	56,023	1,426
Hardwoods:												
Cottonwood and aspen	91	21	—	—	245	119	72	27	320	105	727	161
Oak	—	—	1	1	4	3	33	17	12	8	49	18
Red alder	205	36	—	—	645	144	676	162	712	136	2,238	252
Other hardwoods	78	20	—	—	198	72	209	71	645	128	1,131	159
Total	374	52	1	1	1,091	215	991	185	1,689	263	4,145	372
All species groups	26,446	721	753	277	11,605	961	10,162	762	11,202	784	60,168	1,495

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

[a] Sawtimber trees have merchantability limits that differ for softwood and hardwood species as follows: ≥9 inches diameter at breast height for softwoods and ≥11 inches diameter at breast height for hardwoods.

Table 19—Estimated aboveground biomass of all live trees on forest land, by owner class and forest land status, Washington, 2002–2006

Owner class	Unreserved forests						Reserved forests						All forest land	
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total			
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons													
USDA Forest Service:														
National forest	588.1	13.8	9.5	2.1	597.6	13.7	198.3	15.8	8.1	2.5	206.4	15.7	804.0	18.7
Other federal government:														
National Park Service	—	—	—	—	—	—	250.1	15.8	7.3	3.0	257.4	15.0	257.4	15.0
Bureau of Land Management	3.0	1.5	0.5	0.5	3.5	1.6	—	—	—	—	—	—	3.5	1.6
U.S. Fish and Wildlife Service	—	—	—	—	—	—	4.6	2.4	—	—	4.6	2.4	4.6	2.4
Department of Defense and Energy	4.9	3.1	—	—	4.9	3.1	—	—	—	—	—	—	4.9	3.1
Other federal	8.0	4.5	—	—	8.0	4.5	2.1	1.5	—	—	2.1	1.5	10.1	4.7
Total	15.8	5.5	0.5	0.5	16.4	5.5	256.8	16.1	7.3	3.0	264.1	15.3	280.5	16.2
State and local government:														
State	224.9	17.8	1.9	1.0	226.8	17.8	12.8	4.4	—	—	12.8	4.4	239.6	17.7
Local	26.6	6.9	0.5	0.5	27.0	6.9	5.2	2.9	—	—	5.2	2.9	32.2	7.5
Other public	1.9	1.8	—	—	1.9	1.8	—	—	—	—	—	—	1.9	1.8
Total	253.4	18.7	2.3	1.1	255.7	18.7	18.0	5.2	—	—	18.0	5.2	273.8	18.8
Corporate private	251.0	16.0	0.9	0.7	251.9	16.0	—	—	—	—	—	—	251.9	16.0
Noncorporate private:														
Nongovernmental conservation or natural resource organizations	13.9	4.4	—	—	13.9	4.4	—	—	—	—	—	—	13.9	4.4
Unincorporated partnerships, associations, or clubs	0.8	0.7	—	—	0.8	0.7	—	—	—	—	—	—	0.8	0.7
Native American	89.1	8.8	0.5	0.3	89.7	8.8	—	—	—	—	—	—	89.7	8.8
Individual	153.7	13.4	0.1	0.1	153.8	13.4	—	—	—	—	—	—	153.8	13.4
Total	257.5	16.0	0.6	0.3	258.2	16.0	—	—	—	—	—	—	258.2	16.0
All owners	1,365.9	28.9	13.9	2.5	1,379.8	28.9	473.1	23.1	15.4	3.9	488.5	22.5	1,868.3	34.7

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons was estimated; includes all live trees ≥1 inch diameter at breast height.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 20—Estimated aboveground biomass of all live trees on forest land, by species group and diameter class, Washington, 2002–2006

	Diameter class (inches)																	
	1.0-2.9		3.0-4.9		5.0-6.9		7.0-8.9		9.0-10.9		11.0-12.9		13.0-14.9		15.0-16.9		17.0-18.9	
Species group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million bone-dry tons																	
Softwoods:																		
Douglas-fir	7.1	0.5	8.1	0.6	17.7	0.8	31.0	1.5	41.5	2.0	48.6	2.4	51.9	2.6	49.8	2.6	47.7	2.8
Engelmann and other spruces	1.5	0.3	1.0	0.3	0.9	0.1	1.2	0.2	1.8	0.2	2.0	0.3	2.2	0.4	2.3	0.4	2.2	0.4
Lodgepole pine	1.4	0.3	2.2	0.5	5.2	0.8	7.6	0.9	6.7	0.7	6.1	0.8	4.0	0.7	2.4	0.6	1.2	0.3
Ponderosa and Jeffrey pines	0.5	0.1	1.0	0.2	1.7	0.2	2.7	0.2	4.6	0.5	5.6	0.6	5.7	0.6	6.3	0.7	6.0	0.8
Sitka spruce	0.2	0.1	0.2	0.1	0.2	0.1	0.3	0.1	0.7	0.3	0.7	0.2	0.5	0.2	0.7	0.2	0.4	0.2
True fir	9.1	0.7	7.3	0.5	11.3	0.6	15.5	0.8	17.6	0.9	19.6	1.1	20.8	1.3	20.4	1.4	19.8	1.5
Western hemlock	1.7	0.2	5.3	0.6	12.7	0.8	19.8	1.3	27.4	1.7	32.7	2.2	34.4	2.5	34.6	2.6	29.2	2.3
Western larch	0.8	0.2	0.9	0.2	2.3	0.4	3.2	0.5	3.8	0.5	4.1	0.4	3.2	0.4	3.1	0.4	2.2	0.4
Western redcedar	1.1	0.2	1.9	0.3	2.8	0.2	3.9	0.3	4.0	0.4	4.6	0.4	4.9	0.5	4.8	0.6	4.6	0.6
Western white pine	0.3	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.2	0.1	0.2	0.1	0.3	0.1	0.3	0.1	0.2	0.1
Other western softwoods	1.9	0.3	1.5	0.3	1.9	0.2	3.1	0.3	3.5	0.5	3.7	0.5	4.4	0.6	4.1	0.7	4.2	1.0
Total	25.5	1.1	29.4	1.3	57.0	1.7	88.4	2.5	111.7	3.1	127.8	3.7	132.2	4.1	128.6	4.3	117.7	4.3
Hardwoods:																		
Cottonwood and aspen	0.1	0.1	0.1	0.1	0.3	0.1	0.5	0.2	0.6	0.2	0.6	0.2	0.7	0.2	0.7	0.2	0.9	0.3
Oak	0.1	0.0	0.4	0.2	0.7	0.2	0.5	0.2	0.3	0.1	0.3	0.1	0.2	0.1	0.3	0.1	0.2	0.2
Red alder	0.7	0.1	2.1	0.3	4.4	0.5	7.4	0.7	9.2	1.0	10.3	1.1	9.4	1.1	9.3	1.3	8.2	1.4
Western woodland hardwoods	0.1	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.2	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0
Other western hardwoods	0.8	0.2	1.0	0.2	2.0	0.2	2.8	0.4	2.9	0.4	3.1	0.4	3.4	0.6	2.4	0.5	2.5	0.5
Total	1.8	0.2	3.8	0.4	7.6	0.6	11.3	0.8	13.2	1.1	14.3	1.2	13.8	1.3	12.8	1.4	11.9	1.5
All species groups	27.3	1.2	33.3	1.4	64.6	1.8	99.7	2.6	124.9	3.2	142.1	3.9	145.9	4.3	141.4	4.5	129.6	4.6

Table 20—Estimated aboveground biomass of all live trees on forest land, by species group and diameter class, Washington, 2002–2006 (continued)

	Diameter class (inches)													
	19.0-20.9		21.0-24.9		25.0-28.9		29.0-32.9		33.0-36.9		37.0+		All classes	
Species group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons													
Softwoods:														
Douglas-fir	47.0	2.9	77.1	4.8	60.9	5.1	37.0	2.8	28.5	2.2	86.9	7.8	640.6	20.2
Engelmann and other spruces	2.2	0.5	4.5	1.3	2.9	0.7	2.3	0.5	1.0	0.3	1.4	0.5	29.5	3.7
Lodgepole pine	0.3	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.1	37.6	3.8
Ponderosa and Jeffrey pines	5.9	0.8	9.0	1.2	6.7	0.6	4.5	0.5	2.8	0.5	3.5	0.6	66.4	4.1
Sitka spruce	0.9	0.3	1.4	0.6	2.9	1.0	1.0	0.5	0.5	0.2	4.7	1.7	15.2	2.8
True fir	20.7	1.8	35.1	3.1	28.3	3.1	18.8	2.0	15.8	1.7	37.3	5.3	297.5	13.9
Western hemlock	25.8	2.4	47.0	4.3	43.0	5.0	27.2	2.7	20.8	2.0	80.1	8.8	441.7	21.5
Western larch	1.9	0.4	3.9	0.9	2.5	0.5	1.5	0.3	0.7	0.2	1.1	0.3	34.9	2.8
Western redcedar	5.9	0.8	9.1	1.4	10.0	1.7	5.4	0.9	3.3	0.4	43.6	7.5	109.7	9.5
Western white pine	0.3	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.2	0.2	2.8	0.4
Other western softwoods	5.1	0.9	8.6	1.5	5.4	1.1	5.7	1.3	5.8	1.3	11.1	2.5	69.9	7.5
Total	116.0	4.4	196.1	7.6	162.8	8.4	103.5	4.9	79.2	3.8	269.9	16.3	1,745.8	33.7
Hardwoods:														
Cottonwood and aspen	1.3	0.4	1.7	0.6	3.2	1.2	1.8	0.7	1.1	0.3	1.6	0.6	15.0	2.8
Oak	0.1	0.1	0.1	0.1	0.0	0.0	—	—	0.0	0.0	—	—	3.2	0.8
Red alder	5.3	1.1	3.2	0.8	1.4	0.5	0.7	0.5	0.1	0.1	0.1	0.1	71.6	5.6
Western woodland hardwoods	—	—	—	—	—	—	—	—	—	—	—	—	1.3	0.2
Other western hardwoods	2.3	0.5	2.6	0.7	2.7	0.7	1.5	0.4	0.5	0.2	0.9	0.3	31.3	3.5
Total	9.0	1.3	7.6	1.2	7.3	1.6	4.0	0.9	1.7	0.4	2.6	0.8	122.5	7.8
All species groups	125.0	4.6	203.7	7.7	170.1	8.6	107.5	5.0	80.9	3.8	272.5	16.3	1,868.3	34.7

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons was estimated; includes all live trees ≥1 inch diameter at breast height.

Table 21—Estimated aboveground mass of carbon of all live trees on forest land, by owner class and forest land status, Washington, 2002–2006

	Unreserved forests						Reserved forests							
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total		All forest land	
Owner class	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons													
USDA Forest Service:														
National forest	306.1	7.2	5.0	1.1	311.0	7.2	103.3	8.2	4.2	1.3	107.5	8.2	418.5	9.7
Other federal government:														
National Park Service	—	—	—	—	—	—	130.3	8.3	3.8	1.6	134.1	7.8	134.1	7.8
Bureau of Land Management	1.6	0.8	0.3	0.2	1.8	0.8	—	—	—	—	—	—	1.8	0.8
U.S. Fish and Wildlife Service	—	—	—	—	—	—	2.4	1.2	—	—	2.4	1.2	2.4	1.2
Department of Defense and Energy	2.5	1.6	—	—	2.5	1.6	—	—	—	—	—	—	2.5	1.6
Other federal	4.2	2.3	—	—	4.2	2.3	1.0	0.8	—	—	1.0	0.8	5.2	2.4
Total	8.2	2.9	0.3	0.2	8.5	2.9	133.7	8.4	3.8	1.6	137.5	8.0	146.0	8.4
State and local government:														
State	116.7	9.3	1.0	0.5	117.7	9.2	6.7	2.3	—	—	6.7	2.3	124.3	9.2
Local	13.5	3.5	0.2	0.2	13.8	3.5	2.7	1.5	—	—	2.7	1.5	16.4	3.8
Other public	1.0	0.9	—	—	1.0	0.9	—	—	—	—	—	—	1.0	0.9
Total	131.2	9.7	1.2	0.6	132.4	9.7	9.3	2.7	—	—	9.3	2.7	141.7	9.8
Corporate private	129.9	8.3	0.4	0.3	130.3	8.3	—	—	—	—	—	—	130.3	8.3
Noncorporate private:														
Nongovernmental conservation or natural resource organizations	7.2	2.3	—	—	7.2	2.3	—	—	—	—	—	—	7.2	2.3
Unincorporated partnerships, associations, or clubs	0.4	0.4	—	—	0.4	0.4	—	—	—	—	—	—	0.4	0.4
Native American	46.3	4.6	0.3	0.2	46.6	4.6	—	—	—	—	—	—	46.6	4.6
Individual	78.8	6.9	0.1	0.1	78.9	6.9	—	—	—	—	—	—	78.9	6.9
Total	132.8	8.3	0.3	0.2	133.1	8.3	—	—	—	—	—	—	133.1	8.3
All owners	708.2	15.0	7.2	1.3	715.4	15.0	246.3	12.0	8.0	2.0	254.3	11.7	969.7	18.0

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons was estimated; includes all live trees ≥1 inch diameter at breast height.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 22—Estimated aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002–2006

	Biomass								Carbon							
	Live trees (≥1 in d.b.h.)		Snags (≥5 in d.b.h.)		Down wood[a] (≥3 in l.e.d.)		Total Biomass		Live trees (≥1 in d.b.h.)		Snags (≥5 in d.b.h.)		Down wood[a] (≥3 in l.e.d.)		Total Carbon	
Forest type group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons															
Softwoods:																
Douglas-fir	694.0	26.9	48.5	2.9	128.8	6	871.3	32.1	361	14	25.2	1.5	67.0	3.1	453.3	16.7
Fir/spruce/mountain hemlock	369.8	21.9	41.5	3.1	69.0	4.4	480.2	26.9	193	11	21.6	1.6	35.9	2.3	250.2	14.0
Hemlock/Sitka spruce	534.0	31.9	39.5	3.4	105.0	6.8	678.5	39.1	278	17	20.5	1.7	54.7	3.5	353.1	20.4
Lodgepole pine	38.6	5.7	5.3	1	8.5	1.3	52.5	7.4	20.1	3	2.8	0.5	4.4	0.7	27.3	3.9
Ponderosa pine	61.9	4.9	4.6	0.8	10.0	1.2	76.5	6.0	32.2	2.5	2.4	0.4	5.2	0.6	39.8	3.1
Western larch	22.7	4	2.2	0.5	3.6	0.7	28.5	5.1	11.8	2.1	1.2	0.3	1.9	0.4	14.8	2.6
Western white pine	0.3	0.2	0.2	0.2	0.3	0.2	0.8	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.4	0.3
Other western softwoods	3.5	0.9	0.9	0.4	1.0	0.3	5.4	1.4	1.8	0.5	0.5	0.2	0.5	0.1	2.8	0.7
Total	1,724.7	34.5	142.7	4.7	326.2	8.6	2,193.6	40.9	898	18	74.3	2.5	169.8	4.5	1,1417	21.3
Hardwoods:																
Alder/maple	119.5	10.7	7.6	1	25.1	2.5	152.2	12.7	60	5.4	3.9	0.5	12.9	1.3	76.8	6.4
Aspen/birch	4.3	1.4	0.4	0.1	0.9	0.3	5.6	1.7	2.2	0.7	0.2	0.1	0.5	0.2	2.8	0.9
Elm/ash/cottonwood	10.8	3.3	0.4	0.2	1.4	0.5	12.5	3.7	5.4	1.6	0.2	0.1	0.7	0.3	6.2	1.9
Western oak	3.4	1.4	0.2	0.1	0.1	0.1	3.7	1.5	1.7	0.7	0.1	0	0.1	0	1.9	0.8
Woodland hardwoods	1.8	0.6	0.4	0.2	0.9	0.3	3.0	1.0	0.9	0.3	0.2	0.1	0.5	0.2	1.6	0.5
Other hardwoods	2.6	1.2	0.1	0	1.1	0.6	3.8	1.5	1.3	0.6	—	—	0.6	0.3	1.9	0.8
Total	142.4	11.3	9	1	29.4	2.6	180.9	13.4	71.5	5.7	4.6	0.5	15.2	1.4	91.2	6.8
Nonstocked	1.1	0.3	6.5	1.5	5.8	1.1	13.4	2.2	0.6	0.1	3.4	0.8	3.0	0.6	7.0	1.2
All forest types	1,868.3	34.7	158.3	4.9	361.4	8.6	2,387.9	40.5	969.7	18.0	82.3	2.5	188.0	4.5	1,240.0	21.1

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error;—= less than 50,000 bone-dry tons was estimated; d.b.h. = diameter at breast height; l.e.d. = large-end diameter of the log.

[a] Down wood in this table includes coarse woody material only; an additional 108.0 million tons of biomass and 54.6 million tons of carbon were estimated for fine woody material.

Table 23—Average aboveground biomass and carbon mass of live trees, snags, and down wood on forest land, by forest type group, Washington, 2002–2006

	Biomass								Carbon							
	Live trees (≥1 in d.b.h.)		Snags (≥5 in d.b.h.)		Down wood[a] (≥3 in l.e.d.)		Total		Live trees (≥1 in d.b.h.)		Snags (≥5 in d.b.h.)		Down wood[a] (≥3 in l.e.d.)		Total	
Forest type group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Bone-dry tons per acre															
Softwoods:																
Douglas-fir	80.2	2.4	5.6	0.3	14.9	0.6	100.6	2.7	41.7	1.2	2.9	0.2	7.7	0.3	52.4	1.4
Fir/spruce/mountain hemlock	92.6	4.1	10.4	0.7	17.3	0.8	120.3	4.8	48.3	2.1	5.4	0.3	9.0	0.4	62.7	2.5
Hemlock/Sitka spruce	161.8	6.0	12.0	0.9	31.8	1.4	205.6	7.0	84.2	3.1	6.2	0.5	16.6	0.8	107.0	3.7
Lodgepole pine	59.4	4.6	8.2	1.2	13.1	1.4	80.6	5.5	30.9	2.4	4.2	0.6	6.8	0.7	42.0	2.8
Ponderosa pine	29.9	1.6	2.2	0.3	4.8	0.5	37.0	1.9	15.6	0.8	1.2	0.2	2.5	0.2	19.3	1.0
Western larch	71.5	7.1	7.0	1.3	11.3	1.4	89.8	8.7	37.2	3.7	3.6	0.7	5.9	0.7	46.7	4.5
Western white pine	29.5	10.2	16.5	10.3	24.8	7.3	70.8	16.8	15.4	5.3	8.6	5.4	12.8	3.7	36.8	8.7
Other western softwoods	18.6	2.0	5.0	1.7	5.2	1.0	28.8	3.0	9.7	1.0	2.6	0.9	2.7	0.5	15.0	1.6
Total	89.9	1.7	7.4	0.2	17.0	0.4	114.3	1.9	46.8	0.9	3.9	0.1	8.9	0.2	59.5	1.0
Hardwoods:																
Alder/maple	62.7	4.2	4.0	0.4	13.2	1.0	79.9	4.6	31.5	2.1	2.0	0.2	6.8	0.5	40.3	2.3
Aspen/birch	31.5	7.1	3.0	0.8	6.5	1.0	40.9	7.5	15.8	3.6	1.5	0.4	3.3	0.5	20.6	3.8
Elm/ash/cottonwood	59.0	12.7	1.9	0.7	7.7	2.3	68.6	13.6	29.4	6.3	1.0	0.3	3.9	1.2	34.2	6.7
Western oak	27.3	7.8	1.5	0.6	0.9	0.4	29.7	7.7	13.7	4.0	0.7	0.3	0.5	0.2	14.9	3.9
Woodland hardwoods	15.4	1.9	3.5	1.5	7.6	2.2	26.6	3.1	8.0	1.0	1.8	0.8	4.0	1.1	13.8	1.6
Other hardwoods	23.2	7.6	0.5	0.2	9.7	4.9	33.4	8.0	11.6	3.7	0.3	0.1	5.0	2.5	16.8	3.9
Total	55.2	3.4	3.5	0.3	11.4	0.8	70.2	3.7	27.7	1.7	1.8	0.2	5.9	0.4	35.4	1.9
Nonstocked	1.8	0.4	10.5	2.0	9.2	1.5	21.5	2.4	0.9	0.2	5.5	1.0	4.8	0.8	11.2	1.3
All forest types	83.5	1.5	7.1	0.2	16.1	0.4	106.7	1.7	43.3	0.8	3.7	0.1	8.4	0.2	55.4	0.9

Note: Means are calculated using a ratio of means formula across plots within forest type groups; data subject to sampling error; SE = standard error; d.b.h. = diameter at breast height; l.e.d. = large-end diameter of the log.

[a] Down wood in this table includes coarse woody material only; an additional 4.8 tons per acre of biomass and 2.4 tons per acre of carbon were estimated for fine woody material.

Table 24—Estimated average biomass, volume, and density of down wood on forest land, by forest type group and diameter class, Washington, 2002–2006

	Biomass Diameter class (inches at large end)								Volume Diameter class (inches at large end)							
	FWM		CWM						FWM		CWM					
	< 3 in		3 to 19 in		≥20 in		Total		< 3 in		3 to 19 in		≥20 in		Total	
Forest type group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Bone-dry tons per acre								*Cubic feet per acre*							
Softwoods:																
Douglas-fir	5.4	0.2	7.5	0.2	7.4	0.5	21.2	0.7	392.6	12.5	893.6	23.7	926.5	58.7	2,212.8	75.8
Fir/spruce/mountain hemlock	3.6	0.2	8.8	0.3	8.5	0.7	21.6	0.9	301.2	12.6	1,114.1	41.7	1,061.1	82.3	2,476.2	105.9
Hemlock/Sitka spruce	6.7	0.4	11.4	0.4	20.4	1.3	38.5	1.6	430.5	19.6	1,463.9	45.9	2,676.9	170.1	4,571.2	190.1
Lodgepole pine	4.6	0.5	10.9	0.9	2.2	1.0	18.3	1.4	378.6	38.7	1,411.8	126.7	308.6	153.8	2,099.0	204.8
Ponderosa pine	3.3	0.4	3.2	0.2	1.7	0.3	8.5	0.7	269.1	28.2	370.7	26.8	206.7	32.6	846.6	64.5
Western larch	5.8	0.9	9.0	1.1	2.3	0.6	18.9	1.5	432.4	41.3	1,063.9	127.6	276.5	69.8	1,772.8	160.9
Western white pine	4.3	1.0	20.6	9.2	4.2	3.5	29.1	7.7	364.5	75.3	2,563.5	1,099.7	528.5	373.2	3,456.4	858.3
Other western softwoods	1.8	0.5	4.4	0.8	0.8	0.3	7.7	1.3	149.6	23.3	531.5	96.5	127.3	54.3	808.4	138.9
Total	4.7	0.1	8.1	0.1	8.9	0.4	22.7	0.5	364.6	7.8	999.1	17.6	1,138.3	44.5	2,501.9	55.2
Hardwoods:																
Alder/maple	4.6	0.4	6.0	0.4	7.1	0.8	19.0	1.1	370.7	26.2	814.0	44.7	1,010.5	112.4	2,195.1	138.2
Aspen/birch	4.4	1.1	5.5	1.1	1.0	0.3	12.2	1.6	358.5	58.1	763.7	137.6	131.4	44.1	1,253.6	156.9
Elm/ash/cottonwood	4.1	1.4	5.4	1.7	2.3	0.9	14.4	2.6	356.9	49.4	627.5	165.4	363.2	176.5	1,347.6	337.0
Western oak	29.2	25.4	0.9	0.4	—	—	30.6	25.5	2,573.8	2,300.3	113.1	43.5	—	—	2,686.8	2,317.7
Woodland hardwoods	5.3	2.2	5.1	1.4	2.5	1.2	13.0	4.1	422.2	188.0	579.6	164.9	292.9	137.6	1,294.6	419.9
Other hardwoods	4.4	1.6	3.7	0.8	6.0	4.2	16.4	5.1	321.2	48.5	449.0	103.2	711.0	467.5	1,481.1	560.7
Total	5.8	1.3	5.6	0.3	5.9	0.6	18.5	1.5	476.5	119.6	737.6	38.3	823.5	89.4	2,037.7	159.7
Nonstocked	3.8	1.2	6.1	0.8	3.1	0.9	15.2	2.2	303.3	53.8	637.5	83.1	375.2	106.0	1,315.1	193.1
All forest types	4.8	0.2	7.8	0.1	8.4	0.3	22.0	0.4	375.8	15.4	958.9	15.9	1,080.8	39.6	2,415.4	50.9

Table 24—Estimated average biomass, volume, and density of down wood on forest land, by forest type groupand diameter class, Washington, 2002–2006 (continued)

	Density Diameter class (inches at large end)					
	CWM[a]					
	3 to 19 in		≥20 in		Total	
Forest type group	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
	Logs per acre					
Softwoods:						
Douglas-fir	282.0	7.4	14.2	0.9	296.3	7.7
Fir/spruce/mountain hemlock	279.9	11.8	14.6	1.1	294.5	12.1
Hemlock/Sitka spruce	411.9	14.8	35.3	2.0	447.2	15.5
Lodgepole pine	363.4	25.3	3.9	1.5	367.3	25.1
Ponderosa pine	145.8	10.1	3.1	0.6	149.0	10.2
Western larch	284.7	24.5	3.8	0.9	288.4	24.5
Western white pine	386.4	111.5	17.8	11.9	404.2	104.1
Other western softwoods	178.2	30.3	2.1	0.9	180.3	30.7
Total	291.3	5.1	16.1	0.6	307.4	5.3
Hardwoods:						
Alder/maple	272.2	15.2	13.6	1.5	285.8	15.6
Aspen/birch	256.8	37.9	4.2	2.7	261.0	38.0
Elm/ash/cottonwood	248.0	45.5	5.6	2.4	253.6	44.9
Western oak	101.6	32.3	—	—	101.6	32.3
Woodland hardwoods	239.2	67.9	9.9	4.3	249.1	68.3
Other hardwoods	181.1	32.0	9.2	5.7	190.3	31.4
Total	256.0	12.6	11.5	1.2	267.5	12.9
Nonstocked	209.8	28.2	6.7	3.1	216.5	29.7
All forest types	285.0	4.7	15.3	0.5	300.3	4.9

Note: Means are calculated using a ratio of means formula across plots within forest type groups; data subject to sampling error; SE = standard error; — = less than 0.05 bone-dry tons per acre, 0.05 cubic feet per acre, and 0.05 logs per acre were estimated; CWM = coarse woody material; FWM = fine woody material.

[a] An estimate of pieces per acre is not possible for fine woody material.

Table 25—Estimated biomass and carbon mass of down wood[a] on forest land, by forest type group and owner group, Washington, 2002–2006

Forest type group	U.S. Forest Service				Other federal				State and local government				Corporate private				Other private				All owners			
	Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons																							
Softwoods:																								
Douglas-fir	44.0	2.2	22.9	1.2	5.2	1.3	2.7	0.7	22.6	3.0	11.7	1.6	41.5	4.0	21.6	2.1	15.6	2.6	8.1	1.4	128.8	6.0	67	3.1
Fir/spruce/mountain hemlock	42.8	3.0	22.3	1.6	7.6	1.5	4.0	0.8	4.4	1.6	2.3	0.9	8	1.8	4.2	1.0	6.2	1.4	3.2	0.7	69	4.4	35.9	2.3
Western hemlock/Sitka spruce	34.6	3.2	18.0	1.7	24.8	3.9	12.9	2.0	17.2	2.8	9.0	1.5	19.5	3.0	10.2	1.6	8.9	2.2	4.6	1.1	105	6.8	54.7	3.5
Lodgepole pine	6.2	0.9	3.2	0.5	—	—	—	—	0.3	0.2	0.1	0.1	0.1	0.1	—	—	2	0.9	1	0.5	8.5	1.3	4.4	0.7
Ponderosa pine	3.5	0.8	1.8	0.4	0.3	0.1	0.1	0.1	0.8	0.3	0.4	0.2	1.8	0.5	0.9	0.3	3.7	0.6	1.9	0.3	10	1.2	5.2	0.6
Western larch	2.4	0.5	1.3	0.2	0.1	0.1	—	—	0.6	0.5	0.3	0.2	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0	3.6	0.7	1.9	0.4
Western white pine	0.3	0.2	0.1	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.2	0.1	0.1
Other western softwoods	0.9	0.3	0.5	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	0.3	0.5	0.1
Total	134.6	4.1	70.1	2.1	37.9	3.6	19.8	1.9	45.8	3.9	23.8	2.0	71.4	4.9	37.1	2.6	36.5	3.7	19	1.9	326.2	8.6	170	4.5
Hardwoods:																								
Alder/maple	3.0	0.7	1.5	0.4	0.9	0.6	0.5	0.3	5.3	1.3	2.7	0.7	9.2	1.6	4.7	0.8	6.7	1.1	3.5	0.6	25.1	2.5	12.9	1.3
Aspen/birch	0.1	0.1	—	—	—	—	—	—	0.1	0.1	—	—	0.2	0.2	0.1	0.1	0.5	0.2	0.3	0.1	0.9	0.3	0.5	0.2
Elm/ash/cottonwood	0.3	0.1	0.1	0.1	0.1	0.1	—	—	0.6	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.3	0.1	0.1	0.1	1.4	0.5	0.7	0.3
Western oak	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.1	0.1	0	—	—	—	—	0.1	0.1	0.1	0
Woodland hardwoods	0.3	0.1	0.2	0.1	—	—	—	—	—	—	—	—	—	—	—	—	0.5	0.3	0.3	0.2	0.9	0.3	0.5	0.2
Other hardwoods	0.1	0.1	0.1	-	—	—	—	—	—	—	—	—	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1	1.1	0.6	0.6	0.3
Total	3.7	0.7	1.9	0.4	1.0	0.6	0.5	0.3	5.9	1.4	3.1	0.7	10.5	1.7	5.4	0.9	8.3	1.2	4.2	0.6	29.4	2.6	15.2	1.4
Nonstocked	2.7	0.6	1.4	0.3	—	—	—	—	0.4	0.2	0.2	0.1	1.9	0.8	1.0	0.4	0.7	0.5	0.4	0.2	5.8	1.1	3	0.6
All forest types	141.1	4.1	73.5	2.1	39.0	3.7	20.3	1.9	52.1	3.9	27.1	2.0	83.8	5.1	43.6	2.6	45.5	3.8	23.6	2.0	361.4	8.6	188.0	4.5

Note: Totals may be off because of rounding; data subject to sampling error; —= less than 50,000 bone-dry tons was estimated. Standard errors available upon request.

[a] In this table, down wood includes logs ≥3 inches in diameter at the large end (coarse woody material); an additional 108.0 million tons of biomass and 54.6 million tons of carbon were estimated for fine woody material in the state.

Table 26—Estimated average biomass, volume, and density of snags on forest land, by forest type group and diameter class, Washington, 2002–2006

	Biomass Diameter class (inches)								Volume Diameter class (inches)								Density Diameter class (inches)							
	5 to 19		20 to 39		≥ 40		Total		5 to 19		20 to 39		≥ 40		Total		5 to 19		20 to 39		≥ 40		Total	
Forest type group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Bone-dry tons per acre								*Cubic feet per acre*								*Trees per acre*							
Softwoods:																								
Douglas-fir	3.1	0.2	1.7	0.2	0.9	0.1	5.6	0.3	151.3	9.3	75.4	8.3	26.3	3.6	253.0	15.7	18.9	0.8	1.6	0.1	0.3	0.3	20.9	0.8
Fir/spruce/mountain hemlock	5.5	0.5	3.6	0.3	1.4	0.2	10.4	0.7	320.9	29.2	208.8	19.5	67.8	11.4	597.5	41.0	28.7	2.1	2.9	0.3	0.4	0.1	31.9	2.1
Hemlock/Sitka spruce	3.0	0.2	4.1	0.3	4.8	0.7	12.0	0.9	153.3	11.9	204.8	17.6	220.2	33.9	578.2	44.4	22.5	1.5	4.0	0.3	1.1	0.1	27.6	1.6
Lodgepole pine	7.2	1.0	0.9	0.5	0.1	0.1	8.2	1.2	398.5	61.2	52.9	26.9	4.6	2.7	456.0	70.7	57.1	6.4	0.8	0.3	0.1	0.1	57.9	6.5
Ponderosa pine	1.3	0.2	0.8	0.2	0.1	0.1	2.2	0.3	73.8	11.6	47.8	13.5	6.8	3.1	128.4	19.7	8.0	0.9	0.8	0.3	—	—	8.9	0.9
Western larch	6.0	1.0	0.9	0.4	—	—	7.0	1.3	308.8	60.9	50.6	23.4	—	—	359.4	72.2	43.8	6.3	0.7	0.3	—	—	44.5	6.3
Western white pine	15.9	10.6	0.6	0.6	—	—	16.5	10.3	1,012.3	708.3	34.4	33.7	—	—	1,046.7	690.4	68.6	40.5	0.6	0.6	—	—	69.2	40.2
Other western softwoods	4.4	1.5	0.6	0.2	—	—	5.0	1.7	243.2	85.5	39.2	14.0	—	—	282.3	93.6	47.3	17.1	2.2	0.8	—	—	49.6	17.7
Total	3.6	0.1	2.3	0.1	1.5	0.1	7.4	0.2	190.9	8.1	120.9	6.3	64.7	6.5	376.6	13.4	22.4	0.7	2.2	0.1	0.4	0.4	25.0	0.7
Hardwoods:																								
Alder/maple	2.0	0.2	0.7	0.2	1.3	0.3	4.0	0.4	94.1	10.7	26.7	6.2	33.5	8.2	154.2	15.8	15.0	1.4	1.1	0.2	0.6	0.1	16.6	1.4
Aspen/birch	2.3	0.7	0.2	0.2	0.5	0.4	3.0	0.8	134.0	44.1	11.7	11.2	9.8	5.9	155.6	47.0	15.9	4.6	0.1	0.1	0.3	0.1	16.3	4.6
Elm/ash/cottonwood	1.6	0.7	0.1	0.1	0.3	0.3	1.9	0.7	88.5	41.1	4.2	2.6	1.2	1.0	93.8	41.0	9.4	3.0	0.1	0.1	0.1	0.1	9.7	3.0
Western oak	1.5	0.6	—	—	—	—	1.5	0.6	71.4	29.6	—	—	—	—	71.4	29.6	12.6	3.7	—	—	—	—	12.6	3.7
Woodland hardwoods	1.7	1.1	0.9	0.5	0.9	0.7	3.5	1.5	84.0	54.2	50.2	30.2	41.9	32.8	176.2	77.0	8.2	4.2	1.3	0.7	0.2	0.1	9.7	4.2
Other hardwoods	0.5	0.2	—	—	—	—	0.5	0.2	29.8	13.0	—	—	—	—	29.8	13.0	5.6	2.4	—	—	—	—	5.6	2.4
Total	1.9	0.2	0.6	0.1	1.0	0.2	3.5	0.3	91.5	9.2	22.9	4.9	27.2	6.3	141.5	13.0	13.8	1.1	0.9	0.2	0.5	0.1	15.1	1.2
Nonstocked	7.5	1.7	2.5	0.7	0.5	0.2	10.5	2.0	430.1	102.1	136.5	36.1	19.7	8.7	586.4	115.5	46.5	11.6	1.8	0.4	0.2	0.1	48.5	11.7
All forest types	3.5	0.1	2.2	0.1	1.4	0.1	7.1	0.2	186.1	7.5	110.1	5.5	59.2	5.7	355.4	11.8	22.1	0.7	2.0	0.1	0.4	0.4	24.5	0.7

Note: Means are calculated using a ratio of means formula across plots within forest type groups; data subject to sampling error; SE = standard error; — = less than 0.05 bone-dry tons per acre, 0.05 cubic feet per acre, and 0.05 trees per acre were estimated; includes snags ≥ 5 inches in diameter at breast height.

Table 27—Estimated biomass and carbon mass of snags on forest land, by forest type group and owner group, Washington, 2002–2006

	U.S. Forest Service				Other federal				State and local government				Corporate private				Other private				All owners			
	Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon	
Forest type group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million bone-dry tons																							
Softwoods:																								
Douglas-fir	25.1	2.0	12.6	1.0	3.9	1.0	1.9	0.5	6.9	1.2	3.5	0.6	6.8	1.0	3.4	0.5	5.8	1.1	2.9	0.5	48.5	2.9	24.2	1.4
Fir/spruce/mountain hemlock	30.0	2.5	15.0	1.3	5.5	1.2	2.8	0.6	1.3	0.6	0.7	0.3	0.3	0.1	0.2	0.1	4.3	1.2	2.1	0.6	41.5	3.1	20.7	1.6
Hemlock/Sitka spruce	17.4	2.0	8.7	1.0	11.8	2.1	5.9	1.0	6.0	1.6	3.0	0.8	2.5	0.5	1.2	0.3	1.8	0.5	0.9	0.2	39.5	3.4	19.7	1.7
Lodgepole pine	4.1	0.9	2.1	0.5	—	—	—	—	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.3	0.4	0.2	5.3	1.0	2.7	0.5
Ponderosa pine	2.2	0.6	1.1	0.3	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.1	0.3	0.1	0.2	0.1	1.6	0.4	0.8	0.2	4.6	0.8	2.3	0.4
Western larch	1.7	0.5	0.8	0.2	—	—	—	—	0.1	0.1	—	—	0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.1	2.2	0.5	1.1	0.3
Western white pine	0.2	0.2	0.1	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	0.2	0.1	0.1
Other western softwoods	0.9	0.4	0.5	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.9	0.4	0.5	0.2
Total	81.6	3.3	40.8	1.7	21.4	2.0	10.7	1.0	14.8	1.9	7.4	1.0	10.3	1.1	5.1	0.6	14.7	1.7	7.3	0.8	142.7	4.7	71.4	2.4
Hardwoods:																								
Alder/maple	0.8	0.2	0.4	0.1	0.5	0.3	0.3	0.2	1.7	0.5	0.8	0.3	1.8	0.5	0.9	0.2	2.8	0.6	1.4	0.3	7.6	1.0	3.8	0.5
Aspen/birch	0.1	0.1	—	—	—	—	—	—	0.1	0.1	—	—	0.1	0.1	—	—	0.2	0.1	0.1	0.1	0.4	0.1	0.2	0.1
Elm/ash/cottonwood	—	—	—	—	—	—	—	—	0.1	0.1	—	—	0.2	0.1	0.1	0.1	—	—	—	—	0.4	0.2	0.2	0.1
Western oak	—	—	—	—	0.1	0.1	—	—	—	—	—	—	0.1	0.1	0.1	—	—	—	—	—	0.2	0.1	0.1	0.1
Woodland hardwoods	0.3	0.2	0.2	0.1	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.1	—	—	0.4	0.2	0.2	0.1
Other hardwoods	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—
Total	1.2	0.3	0.6	0.2	0.6	0.3	0.3	0.2	1.9	0.5	0.9	0.3	2.2	0.5	1.1	0.2	3.2	0.6	1.6	0.3	9.0	1.0	4.5	0.5
Nonstocked	5.7	1.5	2.9	0.7	—	—	—	—	0.5	0.3	0.2	0.2	0.1	0.1	—	—	0.3	0.2	0.1	0.1	6.5	1.5	3.3	0.8
All forest types	88.6	3.5	44.3	1.7	21.9	2.1	11.0	1.0	17.2	2.0	8.6	1.0	12.5	1.2	6.2	0.6	18.1	1.8	9.0	0.9	158.3	4.9	79.1	2.4

Note: Totals may be off because of rounding; data subject to sampling error; — = less than 50,000 bone-dry tons was estimated; includes snags ≥5 inches in diameter at breast height.

Table 28—Index of vascular plant species richness on forest land by ecological section, Washington, 2004–2005

Ecological section	Number of plots	Species richness/plot Mean	Species richness/plot SE	Total richness	Species turnover	Native richness/plot Mean	Native richness/plot SE	Nonnative richness/plot Mean	Nonnative richness/plot SE	Native species cover (sum) Mean	Native species cover (sum) SE	Nonnative cover (sum) Mean	Nonnative cover (sum) SE
Blue Mountains	2	66.0	5.0	112	1.7	56.5	2.5	5.0	0.0	150	28.0	1.2	0.3
Coast Ranges	19	30.3	2.6	182	6.0	25.9	2.2	1.6	0.6	200	13.0	7.6	5.9
Columbia Basin	2	49.5	17.5	91	1.8	36.0	15.0	11.0	1.0	148	4.2	46.3	43.5
Eastern Cascades	5	38.8	3.3	135	3.5	33.0	4.3	2.6	1.0	109	5.3	1.8	1.2
Northern Cascades	26	33.5	2.3	327	9.8	30.1	2.0	1.1	0.5	139	11.0	2.6	1.7
Okanogan Highland	14	53.6	4.6	309	5.8	47.1	4.0	3.7	1.0	149	6.8	10.5	4.6
Puget Trough	6	28.3	4.4	100	3.5	23.3	3.1	1.8	0.9	238	15.9	12.2	8.1
Western Cascades	17	39.1	3.1	253	6.5	33.1	2.8	2.6	1.0	168	21.0	9.4	8.1

Note: Data subject to sampling error; SE = standard error. Native and nonnative species values only include vegetation records identified to the species level. Species' cover at the plot level were summed with no overlap assumptions (total cover could exceed 100 percent).

Table 29—Lichen community indicator species richness on forest land, Pacific Northwest and Washington, 1998–2001, 2003

Parameter	Pacific Northwest	Washington	Blue Mountains	Columbia Basin	Eastern Cascades	Northern Cascades	Okanogan Highland	OR and WA Coast Ranges	Puget Trough	Western Cascades
Number of plots[a]	491	199	6	4	17	46	41	37	18	30
Number of plots by lichen species richness category:										
0 to 6 species	60	16	0	1	0	4	0	7	1	3
7-15 species	186	68	1	1	1	19	7	17	9	13
16-25 species	188	94	2	1	15	21	24	12	6	13
>25 species	57	21	3	1	1	2	10	1	2	1
Median	15	17	25	15.5	20	15.5	23	11	15	15
Range of species richness per plot (low to high)	0 to 45	0 to 34	12 to 27	5 to 27	13 to 33	0 to 34	9 to 34	4 to 28	6 to 30	1 to 29
Average lichen species richness per plot (alpha diversity)	15.9	17.1	22.8	15.8	21.2	15.1	22.2	12.9	16.2	15.6
Standard deviation of lichen species richness per plot	7.1	7.1	5.6	9.0	4.5	6.6	5.7	6.9	6.4	6.3
Species turnover rate (beta diversity)[b]	13.12	9.82	2.06	2.53	3.25	6.75	3.83	7.83	4.38	5.83
Total number of species per area (gamma diversity)	208	168	47	40	69	102	85	101	71	91

[a] Plot totals do not include quality assurance surveys.
[b] Beta diversity is calculated as gamma diversity divided by alpha diversity.

Table 30—Estimated area and net volume of live trees on riparian forest land,[a] by location and survey unit, Washington, 2002–2006

Location and survey unit	Riparian area				Riparian volume			
	Riparian[a] area	SE	Proportion of all forest land[b]	SE	Riparian[a] volume	SE	Proportion of all forest volume[b]	SE
	Thousand acres		*– – – Percent – – –*		*Million cubic feet*		*– – – Percent – – –*	
Western Washington:								
Olympic Unit	486	55	12.18	1.36	2,919	462	12.52	1.92
Puget Sound Unit	517	58	11.63	1.26	3,395	552	12.26	1.83
Southwestern Unit	673	67	17.11	1.61	3,327	400	17.04	1.92
Total	1,676	104	13.55	0.81	9,641	817	13.67	1.10
Eastern Washington:								
Central Unit	357	47	5.94	0.77	1,504	281	8.61	1.50
Eastern Unit	235	35	5.80	0.85	815	150	8.46	1.47
Total	592	58	5.88	0.57	2,318	318	8.56	1.10
Total Washington	2,269	118	10.11	0.52	11,960	871	12.25	0.85

Note: Data subject to sampling error; SE = standard error.

[a] Riparian forest land is defined as forest land within 100 feet of a permanent water body.

[b] Riparian as a percentage of all forest land within each category.

Table 31—Estimated area of riparian forest land,[a] by forest type group, broad owner group, and location, Washington, 2002–2006

Forest type and owner group	Western Washington				Eastern Washington				All Washington			
	Riparian[a] area	SE	Proportion of all forest land[b]	SE	Riparian[a] area	SE	Proportion of all forest land[b]	SE	Riparian[a] area	SE	Proportion of all forest land[b]	SE
	Thousand acres		*– – – Percent – – –*		*Thousand acres*		*– – – Percent – – –*		*Thousand acres*		*– – – Percent – – –*	
Softwoods:												
Public	811	72	13.24	1.11	320	40	5.77	0.70	1,131	81	9.69	0.68
Private	432	55	11.02	1.36	192	38	5.29	1.03	623	67	8.27	0.86
Total	1,243	90	12.37	0.86	512	54	5.58	0.59	1,754	104	9.13	0.53
Hardwoods:												
Public	140	33	23.37	4.42	15	6	12.28	4.51	155	33	21.48	3.80
Private	273	46	17.87	2.71	57	19	16.15	4.84	330	49	17.55	2.38
Total	414	56	19.42	2.32	72	20	15.14	3.77	485	59	18.64	2.02
Nonstocked	20	12	10.16	5.68	9	5	2.13	1.15	29	13	4.69	2.03
All public	964	79	14.19	1.09	344	41	5.76	0.67	1,308	88	10.25	0.67
All private	712	67	12.77	1.22	248	42	6.07	1.01	960	81	9.93	0.83
Total Washington	1,676	104	13.55	0.81	592	58	5.88	0.57	2,269	118	10.11	0.52

Note: Data subject to sampling error; SE = standard error.

[a] Riparian forest land is defined as forest land within 100 feet of a permanent water body.

[b] Riparian as a percentage of all forest land area within each category.

Table 32—Estimated net volume of live trees on riparian forest land,[a] by species group, broad owner group, and location, Washington 2002–2006

Species and owner group	Western Washington				Eastern Washington				All Washington			
	Riparian[a] volume	SE	Proportion of all forest volume[b]	SE	Riparian[a] volume	SE	Proportion of all forest volume[b]	SE	Riparian[a] volume	SE	Proportion of all forest volume[b]	SE
	Million cubic feet		*– – – Percent – – –*		*Million cubic feet*		*– – – Percent– – –*		*Million cubic feet*		*– – – Percent – – –*	
Softwoods:												
Public	6,314	700	12.68	1.34	1,470	238	7.91	1.19	7,785	733	11.38	1.03
Private	2,100	332	14.12	2.09	725	203	9.23	2.45	2,825	389	12.43	1.60
Total	8,414	773	13.01	1.14	2,195	313	8.30	1.11	10,609	828	11.64	0.87
Hardwoods:												
Public	512	106	23.25	4.21	195	24	25.70	9.23	562	108	23.45	3.93
Private	716	146	19.41	3.41	73	16	16.38	6.71	788	149	19.09	3.13
Total	1,227	180	20.85	2.65	123	38	19.23	5.70	1,350	184	20.69	2.45
All public	6,826	721	13.13	1.32	1,520	242	8.09	1.19	8,346	754	11.79	1.02
All private	2,815	388	15.17	1.94	798	206	9.61	2.35	3,613	439	13.45	1.52
Total Washington	9,641	817	13.67	1.10	2,318	318	8.56	1.10	11,960	871	12.25	0.85

Note: Data subject to sampling error; SE = standard error.

[a] Riparian forest land is defined as forest land within 100 feet of a permanent water body.

[b] Net volume in riparian forests as a percentage of net volume in forest land within each category.

Table 33—Estimated mean crown density and other statistics[a] for live trees on forest land, by species group, Washington, 2002–2006

			Crown density				
Species group	**Plots**	**Trees**	**Mean**	**SE[b]**	**Minimum**	**Median**	**Maximum**
	– – Number – –		*– – – – – – – – – – – – Percent – – – – – – – – – – – –*				
Softwoods:							
Douglas-fir	63	912	41.0	1.9	5	40	90
Engelmann and other spruces	12	58	44.2	4.4	20	45	85
Lodgepole pine	15	213	42.2	3.6	5	40	85
Other western softwoods	6	34	38.1	3.5	5	40	65
Ponderosa and Jeffrey pines	20	97	51.5	3.1	0	50	90
Sitka spruce	7	41	44.1	3.0	25	45	70
True fir	36	356	43.0	2.5	5	45	85
Western hemlock	37	376	43.7	2.0	5	45	85
Western larch	9	47	46.0	2.3	15	45	85
Western redcedar	21	155	39.9	3.7	5	40	80
Western white pine	4	9	45.0	—	20	45	65
Total	91	2,298	42.5	1.2	0	40	90
Hardwoods:							
Cottonwood and aspen	4	15	38.7	—	10	45	60
Oak	2	19	47.4	—	30	50	70
Other western hardwoods	14	81	45.5	2.6	0	40	90
Red alder	17	96	43.8	1.3	5	45	65
Western woodland hardwoods	4	7	28.6	—	0	20	70
Total	35	218	43.9	1.6	0	45	90
All species	94	2,516	42.6	1.2	0	40	90

Note: Data subject to sampling error; SE = standard error; includes live trees > 4.9 inches in diameter at breast height.

[a] The mean, standard error (SE), and median calculations consider the clustering of trees on plots.

[b] Standard error may not be calculated if sample size is insufficient.

Table 34—Mean foliage transparency and other statistics[a] for live trees on forest land, by species group, Washington, 2002–2006

Species group	Plots	Trees	Foliage transparency: Mean	SE[b]	Minimum	Median	Maximum
	– – *Number* – –		– – – – – – – – – – – – *Percent* – – – – – – – – – – – –				
Softwoods:							
Douglas-fir	63	912	23.8	1.8	10	20	70
Engelmann and other spruces	12	58	22.5	2.8	10	25	35
Lodgepole pine	15	213	24.6	1.0	10	25	95
Other western softwoods	6	34	12.6	1.9	10	10	25
Ponderosa and Jeffrey pines	20	97	24.2	1.7	15	25	50
Sitka spruce	7	41	21.8	2.7	10	20	55
True fir	36	356	19.6	1.3	0	15	65
Western hemlock	37	376	22.8	3.3	0	15	90
Western larch	9	47	21.5	2.2	10	20	35
Western redcedar	21	155	25.4	4.5	10	25	80
Western white pine	4	9	23.3	—	5	20	45
Total	91	2,298	22.9	1.2	0	20	95
Hardwoods:							
Cottonwood and aspen	4	15	19.0	—	10	15	40
Oak	2	19	19.5	—	15	20	35
Other western hardwoods	14	81	29.0	1.6	15	25	99
Red alder	17	96	29.3	5.3	15	25	65
Western woodland hardwoods	4	7	38.4	—	20	30	99
Total	35	218	27.9	2.7	10	25	99
All species	94	2,516	23.3	1.2	0	20	99

Note: Data subject to sampling error; SE = standard error; includes live trees > 4.9 inches in diameter at breast height.

[a] The mean, standard error (SE), and median calculations consider the clustering of trees on plots.

[b] Standard error may not be calculated if sample size is insufficient.

Table 35—Mean crown dieback and other statistics[a] for live trees on forest land, by species group, Washington, 2002–2006

			Crown dieback				
Species group	Plots	Trees	Mean	SE[b]	Minimum	Median	Maximum
	– – Number – –		*– – – – – – – – – – – Percent – – – – – – – – – – –*				
Softwoods:							
Douglas-fir	63	912	1.2	0.3	0	0	70
Engelmann and other spruces	12	58	4.8	2.4	0	0	20
Lodgepole pine	15	213	3.8	1.1	0	0	95
Other western softwoods	6	34	2.1	1.9	0	0	20
Ponderosa and Jeffrey pines	20	97	3.0	0.9	0	0	99
Sitka spruce	7	41	1.0	0.6	0	0	15
True fir	36	356	2.1	0.5	0	0	90
Western hemlock	37	376	1.3	0.5	0	0	50
Western larch	9	47	0.9	0.5	0	0	20
Western redcedar	21	155	2.2	1.3	0	0	25
Western white pine	4	9	5.5	—	0	0	50
All softwoods	91	2,298	1.8	0.3	0	0	99
Hardwoods:							
Cottonwood and aspen	4	15	6.7	—	0	5	20
Oak	2	19	7.9	—	0	5	30
Other western hardwoods	14	81	8.0	3.7	0	0	99
Red alder	17	96	0.4	0.2	0	0	5
Western woodland hardwoods	4	7	15.6	—	0	0	99
All hardwoods	35	218	4.8	2.2	0	0	99
All trees	94	2,516	2.1	0.4	0	0	99

Note: Data subject to sampling error; SE = standard error; includes live trees > 4.9 inches in diameter at breast height.

[a] The mean, standard error (SE), and median calculations consider the clustering of trees on plots.

[b] Standard error may not be calculated if sample size is insufficient.

Table 36—Mean cover of understory vegetation on forest land, by forest type group and life form, Washington, 2002-2006

	Seedlings and saplings		Shrubs		Forbs		Graminoids		All understory plants		Bare soil	
Forest type group	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
							Percent					
Softwoods:												
Douglas-fir	4.3	0.2	38.1	0.7	21.2	0.5	9.9	0.4	64.0	0.7	2.5	0.2
Fir/spruce/mountain hemlock	8.7	0.3	33.6	0.9	18.6	0.7	5.7	0.4	58.5	1.0	3.3	0.3
Hemlock/Sitka spruce	7.0	0.4	27.6	1.0	22.0	0.9	1.7	0.2	51.0	1.3	0.9	0.1
Lodgepole pine	6.4	0.7	36.9	2.1	13.6	1.2	11.2	1.4	61.2	2.2	2.5	0.5
Other western softwoods	6.3	1.0	17.9	2.7	13.5	2.0	9.7	2.2	44.6	3.7	8.6	1.9
Ponderosa pine	3.2	0.2	23.5	1.2	13.5	0.7	32.7	1.4	63.9	1.4	4.3	0.5
Western larch	10.4	1.1	30.3	2.7	19.1	1.8	9.9	1.7	59.7	3.1	1.3	0.3
Western white pine	7.6	5.6	32.8	12.9	48.5	20.7	8.1	6.6	79.3	8.2	3.6	3.6
Total	5.7	0.1	33.4	0.4	19.6	0.3	10.1	0.3	60.3	0.5	2.6	0.1
Hardwoods:												
Alder/maple	3.4	0.5	49.9	1.7	38.8	1.6	9.5	1.1	81.5	1.1	1.3	0.2
Aspen/birch	14.2	5.6	50.7	7.5	30.2	5.3	23.2	6.7	81.7	4.8	1.0	0.2
Elm/ash/cottonwood	6.8	1.6	51.4	4.9	26.0	4.6	17.8	3.8	83.5	3.1	2.6	1.0
Other western hardwoods	7.4	1.4	37.9	5.0	30.7	4.3	20.8	3.6	76.1	3.9	3.6	1.5
Western oak	5.1	1.3	22.0	8.2	10.8	2.8	34.9	5.9	63.8	6.5	6.9	2.3
Total	4.7	0.5	47.7	1.5	35.4	1.4	13.0	1.1	80.3	1.0	1.9	0.3
Nonstocked	0.9	0.1	19.6	2.0	14.0	1.4	19.1	2.0	47.6	3.0	15.5	1.7
All forest type groups	5.5	0.1	34.7	0.4	21.3	0.3	10.7	0.3	62.3	0.4	2.9	0.1

Note: Data subject to sampling error; SE = standard error.

Table 37—Mean cover of understory vegetation on forest land, by forest type class, age class, and life form, Washington, 2002–2006

Forest type class[a] and age class	Seedlings and saplings Mean	Seedlings and saplings SE	Shrubs Mean	Shrubs SE	Forbs Mean	Forbs SE	Graminoids Mean	Graminoids SE	All understory plants Mean	All understory plants SE	Bare soil Mean	Bare soil SE
	Percent											
Dry conifer:												
0-19	7.2	1.6	30.2	4.1	16.0	1.6	33.4	4.4	74.5	3.4	6.6	2.1
20-39	3.6	0.7	30.0	2.8	13.0	1.5	32.4	3.5	70.1	2.9	4.3	0.8
40-79	5.0	0.5	31.4	1.8	14.8	1.1	22.2	1.6	64.4	1.7	2.6	0.3
80-159	4.3	0.4	22.5	1.3	13.7	0.9	28.4	1.8	60.5	1.8	3.6	0.5
160+	3.1	0.7	22.1	3.0	14.2	1.6	14.7	2.1	49.5	3.3	6.0	1.9
All ages	4.6	0.3	27.1	1.0	14.3	0.6	25.6	1.1	62.9	1.1	3.6	0.3
Wet conifer:												
0-19	4.6	0.3	37.1	1.3	24.4	0.9	11.3	0.8	66.2	1.4	6.0	0.6
20-39	4.4	0.3	35.3	1.2	21.7	0.9	4.4	0.5	57.8	1.4	1.7	0.2
40-79	4.8	0.3	36.7	1.1	21.2	0.8	8.0	0.6	61.6	1.1	1.9	0.2
80-159	6.1	0.3	29.7	0.8	17.6	0.6	10.4	0.6	56.3	0.9	3.1	0.2
160+	8.8	0.3	32.9	1.0	18.4	0.8	3.0	0.4	55.6	1.1	2.5	0.3
All ages	5.8	0.1	34.1	0.5	20.4	0.4	7.7	0.3	59.3	0.5	2.9	0.1
Dry hardwood:												
0-19	9.8	6.2	58.0	11.9	40.2	12.2	10.5	3.5	83.4	6.8	1.0	0.4
20-39	5.0	1.9	58.3	10.8	16.8	4.0	22.6	9.9	87.3	4.7	0.7	0.4
40-79	6.0	1.4	28.9	8.1	20.5	6.2	27.7	5.7	67.4	7.2	2.7	1.3
80-159	6.5	1.2	22.9	5.1	23.3	4.4	29.0	5.2	69.4	4.8	8.4	2.6
160+												
All ages	6.6	1.0	32.4	4.4	23.8	3.3	25.7	3.2	71.8	3.5	4.7	1.3
Wet hardwood:												
0-19	7.9	1.6	49.0	2.6	29.8	2.4	12.7	1.9	81.3	1.9	1.4	0.6
20-39	3.4	1.2	48.2	3.8	34.3	3.3	12.5	2.6	80.2	2.4	1.6	0.4
40-79	2.1	0.3	51.5	2.5	44.1	2.2	8.0	1.4	82.8	1.4	1.5	0.3
80-159	5.1	1.7	50.6	5.4	36.6	4.7	15.8	5.0	81.3	3.8	1.1	0.4
160+	6.5	6.1	66.2	21.3	33.4	2.1	6.0	9.9	86.6	5.6	2.2	1.0
All ages	4.4	0.6	50.1	1.6	37.2	1.4	11.0	1.1	81.7	1.0	1.4	0.2
All forest type classes:												
0-19	5.4	0.4	39.2	1.1	25.2	0.8	12.6	0.7	69.5	1.2	5.2	0.5
20-39	4.2	0.3	36.8	1.1	22.6	0.9	7.8	0.7	62.0	1.2	1.9	0.2
40-79	4.5	0.2	37.7	0.9	23.4	0.7	11.2	0.6	65.4	0.9	2.0	0.1
80-159	5.7	0.2	28.7	0.7	17.6	0.5	14.8	0.6	58.4	0.8	3.2	0.2
160+	8.4	0.3	32.3	1.0	18.2	0.8	3.7	0.4	55.3	1.1	2.7	0.3
All ages	5.5	0.1	34.7	0.4	21.3	0.3	10.7	0.3	62.3	0.4	2.9	0.1

Note: Data subject to sampling error; SE = standard error.

[a] Dry conifer includes the ponderosa, western white, and lodgepole pines, and western larch forest type groups. Wet conifer includes the Douglas-fir, fir/spruce/mountain hemlock, hemlock/Sitka spruce, and nonstocked forest type groups. Dry hardwood includes the western oak, and other hardwoods forest type groups. Wet hardwood includes the elm/ash/cottonwood, aspen/birch, and alder/maple forest type groups.

Table 38—Estimated number of live trees with damage on forest land, by species and type of damage, Washington, 2002–2006

Species	Total number of live trees[a]		Number of live trees with damage[b]		Type of damage											
	Total	SE	Total	SE	Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
	Thousand trees															
Softwoods:																
Alaska yellow-cedar	104,948	24,250	39,901	11,301	1,243	—	15	—	—	—	—	1,535	—	24,501	319	16,330
Douglas-fir	1,942,876	62,122	426,031	18,835	20,493	7,249	18,441	32,797	59,056	—	6,090	11,895	1,971	227,250	105,910	13,610
Engelmann spruce	146,252	18,526	33,188	5,016	565	1,449	4,062	3,971	224	—	2,641	852	8,448	12,507	3,743	824
Grand fir	404,828	39,055	118,789	16,300	497	2,113	2,060	21,933	2,183	—	897	2,665	8,663	55,790	47,675	2,455
Knobcone pine	2,851	2,867	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lodgepole pine	355,843	41,961	146,786	17,819	3,262	13,285	43,834	999	14,950	—	1,845	2,657	198	73,011	11,002	10,973
Mountain hemlock	256,049	37,067	87,675	19,957	1,523	117	1,440	5,510	1,691	—	—	5,073	—	49,769	2,382	30,382
Noble fir	49,629	8,238	12,097	2,542	1,547	67	398	810	165	—	1,517	89	558	4,936	3,954	266
Pacific silver fir	963,088	73,272	202,335	19,053	7,125	3,800	4,392	15,433	14,014	—	7,583	9,733	19,200	105,542	29,034	16,321
Pacific yew	17,955	6,319	5,986	2,533	280	—	—	—	—	—	—	46	—	5,706	—	—
Ponderosa pine	359,206	35,314	88,172	14,409	6,661	4,346	10,059	1,308	16,226	—	2,603	747	129	43,196	10,821	9,276
Sitka spruce	41,243	7,281	3,378	740	77	—	282	18	—	—	—	359	69	2,867	5	19
Subalpine fir	495,266	60,141	140,140	18,382	3,353	983	4,424	20,707	462	—	4,517	3,969	1,222	82,022	25,636	22,838
Subalpine larch	25,877	11,039	5,293	3,087	—	—	—	—	24	—	—	205	—	5,134	—	491
Western hemlock	1,603,572	88,787	283,956	18,439	6,342	1,745	6,700	2,193	58,883	—	2,051	13,192	540	159,646	65,016	11,019
Western juniper	62	40	—	—	—	—	—			—	—	—	—	—	—	—
Western larch	124,327	13,255	44,860	6,362	453	1,507	4,020	568	10,478	—	2,425	3,714	23	20,575	10,410	134
Western redcedar	690,731	74,010	127,648	25,946	6,582	588	1,507	927	554	—	102	14,028	122	77,540	38,650	6,020
Western white pine	29,435	5,449	11,535	2,790	573	43	7,052	336	48	—	—	88	—	4,319	2,689	93
White fir	7,343	6,645	194	176	—	—	—	—	—	—	—	65	—	130	—	—
Whitebark pine	32,124	8,923	14,705	3,624	415	81	7,943	—	—	—	—	92	—	7,637	—	3,106
Unknown softwood	304	312	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total softwoods	7,653,809	192,739	1,792,668	63,932	60,989	37,372	116,629	107,511	178,957	—	32,273	71,005	41,143	962,077	357,246	144,156

Table 38—Estimated number of live trees with damage on forest land, by species and type of damage, Washington, 2002–2006 (continued)

Species	Total number of live trees[a]		Number of live trees with damage[b]		Type of damage											
	Total	SE	Total	SE	Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
								Thousand trees								
Hardwoods:																
Bigleaf maple	153,587	28,467	23,413	5,480	46	—	188	—	—	—	—	1,757	—	17,666	4,742	330
Bitter cherry	83,886	20,961	10,860	3,810	—	—	258	—	—	—	—	163	—	9,284	1,612	—
Black cottonwood	26,338	10,331	1,915	539	139	299	66	—	—	—	—	330	—	1,340	130	23
Black walnut	5,058	3,613	2,645	1,911	—	—	—	—	—	—	—	89	—	2,645	—	—
Boxelder	281	273	281	273	226	—	—	—	—	—	—	36	36	281	—	—
Chokecherry	6,843	3,607	882	920	—	—	—	—	—	—	—	—	—	882	—	—
Curlleaf mountain-mahogany	867	830	28	27	—	—	—	—	—	—	—	—	—	28	—	—
Giant chinkapin	419	402	84	80	—	—	—	—	—	—	—	—	—	84	—	—
Oregon ash	9,597	4,736	2,540	1,192	—	—	—	—	—	—	—	581	—	2,116	—	—
Oregon crab apple	30,973	18,661	2,940	1,644	—	—	—	—	—	—	—	170	—	2,891	—	—
Oregon white oak	57,004	15,276	9,167	3,074	—	—	—	—	—	—	—	1,117	—	8,302	—	12
Pacific dogwood	12,658	6,184	749	438	—	—	—	—	—	—	—		—	693	80	—
Pacific madrone	3,581	2,105	972	496	—	—	—	—	—	—	—	160	—	972	—	—
Paper birch	61,047	22,445	8,753	5,137	—	—	47	1,991	—	—	—	458	—	6,280	375	282
Quaking aspen	13,059	4,555	2,583	773	66	—	134	—	—	—	—	539	—	2,081	359	66
Red alder	553,999	48,257	68,648	9,482	7,417	93	196	635	—	—	217	5,829	336	54,287	4,296	130
Rocky mountain maple	98,856	23,828	9,688	3,658	23	—	—	—	—	—	—	300	—	6,180	3,419	—
Water birch	1,456	781	192	116	—	—	—	—	—	—	—	—	—	192	—	—
White alder	3,299	2,146	1,270	907	—	—	—	—	—	—	—	345	—	1,132	—	—
Willow spp.	43	33	43	33	—	—	—	—	—	—	—	24	—	43	19	—
Total hardwoods	1,122,852	83,062	147,655	15,664	7,917	392	889	2,626	—	—	217	11,897	372	117,379	15,033	843
Unknown tree species	879	888	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total, all species	8,777,539	209,620	1,940,323	66,406	68,906	37,765	117,518	110,138	178,957	—	32,490	82,902	41,516	1,079,457	372,278	144,999

Note: Data subject to sampling error; SE = standard error; — = less than 500 trees were estimated.

[a] Includes live trees ≥1 inch diameter at breast height.

[b] Number of live trees ≥1 inch diameter at breast height with one or more types of damage recorded.

Table 39—Estimated area of forest land with more than 25 percent of the tree basal area damaged, by forest type and type of damage, Washington, 2002–2006

Forest type	Total forest land: Total	Total forest land: SE	Forest land with damage[a]: Total	Forest land with damage[a]: SE	Type of damage: Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
									Thousand acres							
Softwoods:																
Alaska-yellow-cedar	83	30	61	26	—	—	—	—	—	—	4	21	—	46	—	4
Douglas-fir	8,448	222	3,661	161	75	92	34	191	683	—	32	106	15	1,977	697	44
Engelman spruce/ subalpine fir	463	64	259	48	29	7	22	50	8	—	4	—	7	82	52	—
Engelmann spruce	157	39	74	23	—	3	3	7	4	—	14	5	9	42	9	—
Grand fir	630	76	454	66	—	5	2	49	6	—	1	12	17	329	54	4
Lodgepole pine	627	73	383	54	14	31	55	27	22	—	—	—	—	245	24	8
Misc. western softwoods	69	30	57	29	—	—	—	1	—	—	—	—	—	43	1	—
Mountain hemlock	528	74	394	64	—	—	22	3	9	—	—	32	—	287	10	40
Noble fir	138	35	69	24	3	—	1	16	—	—	—	—	3	36	3	9
Pacific silver fir	1,229	102	831	85	11	8	—	50	93	—	11	84	12	594	58	6
Ponderosa pine	2,012	130	1,075	98	—	46	94	37	350	—	41	13	—	584	65	25
Port-Orford-cedar	8	4	2	1	—	1	1	—	—	—	—	—	—	2	1	—
Sitka spruce	47	19	22	13	—	—	—	—	5	—	—	—	—	—	—	—
Subalpine fir	661	83	482	71	—	5	23	9	5	—	—	8	—	374	46	89
Western hemlock	2,527	145	1,286	101	18	—	14	7	337	—	29	157	—	810	92	6
Western larch	316	45	218	38	4	20	34	8	36	—	4	23	—	84	40	—
Western redcedar	644	79	344	56	1	1	32	—	19	—	—	78	2	274	14	—
Western white pine	11	7	8	6	4	—	4	4	4	—	—	—	—	4	4	—
Whitebark pine	109	38	95	36	—	—	9	—	—	—	—	—	—	44	—	9
Total softwoods	18,709	207	9,776	224	158	218	349	460	1,581	—	139	538	67	5,858	1,170	244

Table 39—Estimated area of forest land with more than 25 percent of the tree basal area damaged, by forest type and type of damage, Washington, 2002–2006 (continued)

	Total forest land		Forest land with damage[a]		Type of damage											
Forest type	Total	SE	Total	SE	Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
	Thousand acres															
Hardwoods:																
Aspen	72	27	43	21	—	—	—	—	—	—	—	13	—	6	—	—
Bigleaf maple	418	65	146	38	—	—	—	—	—	—	—	6	—	126	10	3
Cottonwood	135	35	48	21	—	—	—	—	—	—	—	13	—	48	—	—
Cottonwood/willow	19	13	6	4	—	—	—	—	1	—	—	—	4	4	—	—
Intermountain maple	114	37	35	18	—	—	—	—	—	—	—	—	—	15	9	—
Oregon ash	25	16	22	15	—	—	—	—	—	—	—	—	—	—	—	—
Oregon white oak	124	36	25	15	—	—	—	—	—	—	—	—	—	25	—	—
Paper birch	57	25	48	23	—	—	—	—	—	—	—	—	—	23	—	—
Red alder	1,413	111	482	69	9	—	—	4	1	—	—	58	7	389	7	16
Other hardwoods	110	33	57	25	—	—	—	—	—	—	11	—	—	36	—	—
Total hardwoods	2,488	142	911	92	9	—	—	4	2	—	11	90	11	672	25	19
Nonstocked	264	48	164	38	3	15	23	—	36	—	—	—	—	120	—	5
Total	21,461	189	10,852	236	170	234	373	463	1,620	—	150	628	79	6,651	1,195	268

Note: Data subject to sampling error; SE = standard error; — = less than 500 acres was estimated.

[a] Acres of forest land with >25 percent of tree basal area with recorded damage.

Table 40—Estimated gross volume of live trees with damage on forest land, by species and type of damage, Washington, 2002–2006

Species	Total gross volume of live trees[a] Total	Total gross volume of live trees[a] SE	Gross volume of trees with damage[b] Total	Gross volume of trees with damage[b] SE	Type of damage: Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
	Thousand cubic feet															
Softwood:																
Alaska yellow-cedar	578,738	132,591	284,433	73,537	15,633	—	2,310	—	—	—	—	108,493	—	205,540	3,481	11,984
Douglas-fir	32,314,033	1,083,383	8,697,468	365,253	221,964	203,230	201,716	528,153	1,243,298	—	48,767	653,140	22,411	5,354,931	1,817,166	138,107
Engelmann spruce	1,907,902	266,510	555,965	91,889	18,880	42,718	30,178	58,503	8,519	—	48,494	22,793	17,390	231,542	148,615	7,932
Grand fir	2,945,089	288,095	1,341,470	157,125	7,849	43,310	21,304	269,682	56,865	—	20,332	201,626	81,428	755,025	300,092	19,665
Lodgepole pine	2,061,641	221,410	881,325	95,115	21,335	110,143	177,397	3,125	53,293	—	17,279	27,616	2,374	551,601	87,546	40,979
Mountain hemlock	2,862,085	373,374	1,236,042	187,617	16,634	3,061	31,229	27,097	79,781	—	—	332,955	—	940,450	58,098	48,539
Noble fir	998,751	237,080	369,680	86,567	4,571	3,529	3,789	28,293	17,360	—	21,940	30,666	3,877	263,828	46,493	707
Pacific silver fir	10,607,701	745,258	4,417,858	399,287	163,013	100,901	99,925	219,343	590,564	—	45,990	972,512	114,593	2,756,541	363,348	106,908
Pacific yew	6,761	1,925	2,700	805	—	—	—	—	—	—	—	127	—	2,700	—	—
Ponderosa pine	3,707,620	230,663	1,299,162	120,048	6,653	70,861	61,187	3,930	275,574	—	101,474	63,555	4,646	878,735	57,719	18,856
Sitka spruce	903,778	173,909	173,227	46,435	6,923	—	4,591	1,565	—	—	—	33,138	447	141,394	10,432	151
Subalpine fir	2,141,699	241,441	901,200	99,077	62,700	20,029	34,943	127,185	4,867	—	3,721	83,033	2,304	583,193	135,693	34,469
Subalpine larch	51,856	22,199	20,643	8,917	—	—	—	—	630	—	—	7,922	—	15,481	—	693
Western hemlock	22,018,643	1,085,924	8,148,825	504,414	126,488	21,835	253,537	15,244	2,620,922	—	286,267	1,537,580	10,746	4,937,497	654,732	121,981
Western juniper	461	392	—	—	—	—	—			—	—	—	—	—	—	—
Western larch	1,662,303	140,905	695,704	68,794	3,799	36,780	46,595	7,684	197,785	—	9,323	94,472	741	360,414	135,502	6,397
Western redcedar	6,621,765	564,439	2,798,057	337,000	83,404	9,250	169,262	111	6,012	—	14,323	1,147,142	12,927	2,262,717	108,317	30,360
Western white pine	167,216	28,960	94,224	20,563	4,672	197	23,724	6,978	5,408	—	—	7,483	—	59,878	18,440	1,384
White fir	23,446	21,217	18,651	16,878	—	—	—	—	—	—	—	18,443	—	208	—	—
Whitebark pine	97,554	22,477	64,308	14,899	2,672	2,073	32,355	—	—		—	242	—	54,039	—	3,941
Total softwoods	91,679,041	1,843,574	32,000,942	922,012	767,189	667,915	1,194,042	1,296,894	5,160,878	—	617,908	5,342,941	273,883	20,355,714	3,945,672	593,051

Table 40—Estimated gross volume of live trees with damage on forest land, by species and type of damage, Washington, 2002-2006 (continued)

Species	Total gross volume of live trees[a]		Gross volume of trees with damage[b]		Type of damage											
	Total	SE	Total	SE	Animal	Bark beetles	Cankers	Defoliators	Dwarf mistletoe	Leafy mistletoe	Foliage diseases	Stem decay	Other insects	Physical damage or defect	Root disease	Weather
	Thousand cubic feet															
Hardwoods:																
Bigleaf maple	1,526,476	202,623	529,218	102,237	15,931	—	16,172	—	—	—	—	96,645	—	417,121	46,532	4,245
Bitter cherry	32,514	15,056	5,594	2,470	—	—	2,036	—	—	—	—	230	—	4,402	127	—
Black cottonwood	764,271	168,592	157,249	50,148	4,206	—	7,581	—	—	—	—	44,233	—	109,849	8,343	42
Black walnut	67,075	48,377	40,498	28,978	—	—	—	—	—	—	—	2,107	—	40,498	—	—
Boxelder	108	128	108	128	—	—	—	—	—	—	—	68	70	108	—	—
Chokecherry	2,121	1,796	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Curlleaf mountain-mahogany	451	432	158	151	—	—	—	—	—	—	—	—	—	158	—	—
Giant chinkapin	5,361	5,135	292	280	—	—	—	—	—	—	—	—	—	292	—	—
Oregon ash	148,977	77,731	42,448	26,618	—	—	—	—	—	—	—	24,630	—	20,916	—	—
Oregon crab apple	1,597	1,219	1,170	1,175	—	—	—	—	—	—	—	1,080	—	756	—	—
Oregon white oak	127,547	36,246	42,229	14,500	—	—	—	—	—	—	—	13,811	—	28,718	—	2,212
Pacific dogwood	1,306	428	377	242	—	—	—	—	—	—	—	—	—	258	184	—
Pacific madrone	38,422	19,992	13,775	7,552	—	—	—	—	—	—	—	586	—	13,775	—	—
Paper birch	103,754	27,599	24,270	7,025	—	—	476	—	—	—	—	5,896	—	18,026	3,368	2,643
Quaking aspen	146,720	42,443	53,121	18,413	237	—	1,545	—	—	—	—	11,766	—	44,456	9,922	321
Red alder	3,798,974	316,187	818,652	110,506	16,298	633	4,711	16,360	—	—	6,403	194,876	20,465	677,510	30,207	2,815
Rocky mountain maple	50,873	8,538	13,429	3,522	67	—	—	—	—	—	—	4,143	—	10,804	837	—
Water birch	2,549	1,569	800	462	—	—	—	—	—	—	—	—	—	800	—	—
White alder	15,218	6,358	7,627	4,242	—	—	—	—	—	—	—	1,123	—	7,251	—	—
Willow spp.	43	51	43	51	—	—	—	—	—	—	—	—	—	43	43	—
Total hardwoods	6,834,357	468,814	1,751,061	175,269	36,739	633	32,522	16,360	—	—	6,403	401,193	20,535	1,395,742	99,564	12,278
Total, all species	98,513,398	1,916,601	33,752,003	940,977	803,928	668,548	1,226,564	1,313,254	5,160,878	—	624,312	5,744,134	294,418	21,751,456	4,045,235	605,330

Note: Data subject to sampling error; SE = standard error; — = less than 500 cubic feet were estimated.

[a] Includes gross volume of live trees ≥5 inches diameter at breast height.

[b] Includes gross volume of live trees ≥5 inches diameter at breast height with one or more damages recorded. Gross volume (vs net volume) was used in order to capture rotten, missing, and form cull volume as net volume would not include this volume. Because a number of damages result in rotten cull or are the result of form cull, we wanted to present an accurate proportion of damaged volume (including cull volume) to total volume. Ideally, we would separate out missing cull volume but did not do so for these tables.

Table 41—Estimated damage to live trees, by geographic region and broad owner group, Washington, 2002–2006

Geographic region and broad owner group	Number of live trees with damage[a]		Acres of forest land with damage[b]		Gross volume of live trees with damage[c]	
	Total	SE	Total	SE	Total	SE
	– Thousand trees –		*– Thousand acres –*		*– Thousand cubic feet –*	
Puget Sound:						
Public	316,441	27,218	1,686	111	8,161,052	634,301
Private	130,056	18,497	676	76	1,795,118	214,969
Total	446,497	32,590	2,361	132	9,956,170	661,925
Olympic Peninsula:						
Public	202,845	22,054	1,098	77	6,976,823	504,775
Private	65,311	7,485	437	64	1,129,200	177,975
Total	268,156	23,179	1,535	100	8,106,024	533,607
Southwest:						
Public	233,476	23,970	976	71	4,703,665	348,165
Private	53,850	7,636	290	53	743,300	89,642
Total	287,326	25,127	1,267	88	5,446,965	358,585
Central:						
Public	420,504	24,940	2,563	113	5,234,707	317,615
Private	130,262	22,178	891	83	1,344,075	177,842
Total	550,766	33,265	3,454	139	6,578,782	363,033
Inland Empire:						
Public	280,166	34,218	1,271	69	2,562,076	155,602
Private	107,411	14,936	965	87	1,101,987	112,576
Total	387,577	37,315	2,235	111	3,664,062	191,686
Total, Washington:						
Public	1,453,433	57,291	7,594	175	27,638,323	878,511
Private	486,890	34,182	3,258	164	6,113,680	359,053
Total	1,940,323	66,406	10,852	236	33,752,003	940,977

Note: Data subject to sampling error; SE = standard error.

[a] Number of live trees ≥1 inch diameter at breast height.

[b] Number of forest land acres with ≥25 percent of the basal area damaged.

[c] Gross volume of live trees ≥5 inches diameter at breast height. Gross volume (vs. net volume) was used in order to capture rotten, missing, and form cull volume as net volume would not include this volume. Because a number of damages result in rotten cull or are the result of form cull, we wanted to present an accurate proportion of damaged volume (including cull volume) to total volume. Ideally, we would separate out missing cull volume but did not do so for these tables.

Table 42—Estimated area of forest land covered by selected nonnative vascular plant species and number of sample plots,[a] by life form and species, Washington, 2002–2006

Plant	Scientific name	Common name	Area covered Total	Area covered SE	Number of plots
			– – – Acres	*– – –*	
Shrubs					
	Cytisus scoparius	Scotch broom	28,500	10,000	33
	Hedera helix	English ivy	4,600	3,500	4
	Ilex aquifolium	English holly	2,900	700	30
	Rubus discolor	Himalayan blackberry	72,900	13,300	101
	Rubus laciniatus	Cutleaf blackberry	22,200	5,500	50
Forbs					
	Centaurea biebersteinii	Spotted knapweed	1,700	900	10
	Centaurea diffusa	White knapweed	3,300	2,500	6
	Cirsium	Thistle	7,300	2,200	46
	Cirsium arvense	Canada thistle	24,900	9,300	48
	Cirsium vulgare	Bull thistle	8,800	3,600	49
	Digitalis purpurea	Purple foxglove	16,800	3,300	72
	Hypericum perforatum	Common St. Johnswort	19,100	3,700	77
	Hypochaeris radicata	Hairy cat's ear	19,700	8,700	39
	Leucanthemum vulgare	Oxeye daisy	3,700	2,400	12
	Linaria dalmatica	Dalmatian toadflax	1,300	500	15
	Mycelis muralis	Wall-lettuce	7,100	3,900	26
	Senecio jacobaea	Stinking willie	5,100	2,200	24
	Verbascum thapsus	Common mullein	2300	800	26
Grasses					
	Bromus tectorum	Cheatgrass	133,100	19,000	152
	Dactylis glomerata	Orchardgrass	7,800	3,500	31
	Holcus lanatus	Common velvetgrass	40,000	11,500	38

Note: Estimates are likely low for most grasses and some forbs because of short flowering seasons and difficulty of species identification; data subject to sampling error; SE = standard error.

[a] Total number of sample plots was 2,978 (1,884 base grid).

Table 43—Forest Inventory and Analysis plots sampled for lichen community, air quality index information, western Pacific Northwest (PNW) and western Washington, 1998–2001, 2003

Parameter	Western PNW	Western Washington	Northern Cascades	Oregon and Washington Coast Ranges	Puget Trough	Western Cascades
Number of plots surveyed[a]	243	103	19	37	18	29
Number of plots by air quality index category:[b]						
Best: -1.4 to -0.11	111	46	12	21	1	12
Good: -0.11 to 0.02	26	10	0	5	1	4
Fair: 0.02 to 0.21	40	17	2	6	5	4
Degraded: 0.21 to 0.35	21	8	2	3	0	3
Poor: 0.35 to 0.49	13	5	1	0	2	2
Worst: 0.49 to 2.00	32	17	2	2	9	4
Air quality score extremes	-1.28 to 1.59	-1.22 to 1.59	-1.08 to 1.23	-1.22 to 1.59	-0.73 to 1.49	-1.07 to 0.81
Average score on air quality index	-0.06	-0.07	-0.28	-0.23	0.38	-0.02
Standard deviation on air quality index	0.49	0.56	0.63	0.52	0.46	0.45

[a] Plot totals do not include quality assurance surveys or plots without lichens present.
[b] Categories are based on the analysis of Geiser and Neitlich (2007).

Table 44—Forest Inventory and Analysis plots sampled for lichen community, climate index information, western Pacific Northwest (PNW) and western Washington, 1998–2001, 2003

Parameter	Western PNW	Western Washington	Northern Cascades	Oregon and Washington Coast Ranges	Puget Trough	Western Cascades
Number of plots surveyed[a]	243	103	19	37	18	29
Number of plots by climate index category:[b]						
Maritime (warmest): -1.4 to -0.25	73	32	2	24	8	7
Lowland: -0.25 to 0.23	54	29	2	7	10	6
Montane: 0.23 to 0.66	57	38	7	4	0	8
High elevation (coolest): 0.66 to 1.73	59	41	8	2	0	8
Climate index extremes	-1.41 to 1.73	-1.41 to 1.15	0.57 to 1.15	-1.41 to 1.00	-0.79 to 0.18	-1.08 to 1.05
Average score on climate index	0.14	-0.03	0.49	-0.36	-0.24	0.2
Standard deviation on climate index	0.64	0.6	0.44	0.55	0.31	0.57

[a] Plot totals do not include quality assurance surveys or plots without lichens present.
[b] Categories are based on the analysis of Geiser and Neitlich (2007).

Table 45—Ozone injury by year, Washington, 2002–2006

Ozone biomonitoring plots	2000	2001	2002	2003	2004	2005	2006	All years
Number of plots	28	27	30	32	28	32	32	209
Number of plots with injury	1	1	0	1	1	1	0	5
Biosite index category[a] (percentage of plots):								
0 to 4.9 (least injured)	96.4	96.3	100	96.9	96.4	96.9	100	97.6
5.0 to 14.9	0	3.7	0	0	3.6	0	0	1.0
15 to 24.9	3.6	0	0	3.1	0	3.1	0	1.4
≥25 (most injured)	0	0	0	0	0	0	0	0.0
Average biosite index score	0.6	0.3	0	0.2	0.3	0.6	0	0.3
Average number of species per plot	1.8	2	2.6	3.1	3.3	2.8	2.9	2.6
Number of plants evaluated	1,281	1,250	2,072	2,693	2,497	2,490	2,510	14,793
Number of plants injured	7	6	0	4	4	5	0	26
Number of plants evaluated by species:								
Blue elderberry	0	0	37	120	103	57	23	340
Jeffrey pine	26	30	55	58	56	60	90	375
Ninebark	90	85	104	108	111	90	90	678
Ponderosa pine	193	196	300	360	330	300	300	1,979
Quaking aspen	90	90	157	157	190	190	174	1,048
Red alder	205	228	337	525	429	461	431	2,616
Red elderberry	214	150	297	242	260	268	240	1671
Scouler's willow	185	207	395	451	461	439	436	2,574
Snowberry	146	130	180	346	313	360	360	1,835
Thinleaf huckleberry	132	134	210	326	244	265	281	1,592
Biosite index category[b] (percentage of forest land):								
0 to 4.9 (least injured)	—	—	—	—	—	100	—	—
5.0 to 14.9	—	—	—	—	—	0	—	—
15 to 24.9	—	—	—	—	—	0	—	—
≥25 (most injured)	—	—	—	—	—	0	—	—

Note: — = data not available.

[a] The biosite index is based on the average injury score (amount x severity) for each species averaged across all species on the plot. Biosite categories represent a relative measure of tree-level response to ambient ozone exposure.

[b] Percentage of forest land is estimated after interpolating the biosite values, 2000–2005, to generate a biological response surface across the landscape. The distribution of forest land among biosite index categories is not expected to change with the addition of 2006 data.

Table 46—Forest land area on which evidence of fire was observed, by year and geographic location, Washington, 1998–2005

	West of the Cascades		East of the Cascades		Total	
Year	Total	SE	Total	SE	Total	SE
			Acres			
Land with fire evidence:						
1998	98,050	72,869	—	—	98,050	72,869
1999	—	—	34,669	18,821	34,669	18,821
2000	—	—	38,269	24,480	38,269	24,480
2001	20,600	18,356	131,290	41,619	151,890	45,487
2002	—	—	94,675	25,611	94,675	25,611
2003	—	—	154,685	57,715	154,685	57,715
2004	—	—	91,687	29,515	91,687	29,515
2005	—	—	23,934	21,978	23,934	21,978
Average	14,831	9,227	71,151	11,055	85,982	14,400
All forest land	12,118,208	157,400	9,901,553	156,646	22,019,761	171,944

Note: Data subject to sampling error; SE = standard error; — = less than 0.5 acre was estimated.

Table 47—Percentage of forest land area by owner group, survey unit, and fire type, and the total forest land area by owner group and survey unit, Washington, 2002–2006

Owner group and survey unit	Surface fire		Conditional fire		Passive fire		Active fire		Forest land area	
	Percent[a]	SE	Percent[a]	SE	Percent[a]	SE	Percent[a]	SE	Mean	SE
	Percent								*Thousand acres*	
USDA Forest Service:										
Puget Sound	17.07	2.49	7.42	1.95	29.87	3.09	45.64	3.42	1,713	89
Olympic Peninsula	20.33	3.48	8.26	2.28	29.69	3.85	41.72	4.63	576	31
Southwest	14.26	1.90	5.45	1.26	40.79	3.25	39.50	3.25	1,294	59
Central	36.51	2.16	13.30	1.62	30.63	2.16	19.57	2.16	3,431	105
Inland Empire	48.28	2.98	12.33	1.94	24.99	2.54	14.40	2.28	1,544	59
All Washington	30.29	1.19	10.42	0.88	30.93	1.29	28.36	1.31	8,558	84
Other federal:										
Puget Sound	11.05	4.75	9.41	5.10	54.79	7.63	24.75	7.35	415	59
Olympic Peninsula	19.82	5.28	10.75	4.24	35.69	6.32	33.74	6.35	709	54
Southwest	23.52	14.51	15.94	15.17	60.54	18.05	0.00	0.00	68	28
Central	49.53	17.14	19.58	13.42	30.89	16.47	0.00	0.00	96	32
Inland Empire	62.61	16.50	12.94	13.12	15.46	11.03	8.98	9.28	90	29
All Washington	22.23	3.73	11.36	3.06	41.02	4.41	25.40	4.08	1,378	95
State and local government:										
Puget Sound	30.31	5.81	17.32	4.94	26.08	5.56	26.29	5.74	775	82
Olympic Peninsula	32.65	6.18	12.82	4.60	34.61	6.29	19.92	5.31	697	79
Southwest	44.08	7.17	12.73	4.97	32.27	6.82	10.91	4.62	587	63
Central	40.72	7.07	18.46	5.92	39.05	7.20	1.77	2.04	566	57
Inland Empire	78.88	8.16	7.86	5.68	13.25	6.71	0.00	0.00	297	48
All Washington	40.58	3.11	14.58	2.35	30.57	2.97	14.26	2.29	2,921	133

Table 47—Percentage of forest land area by owner group, survey unit, and fire type, and the total forest land area by owner group and survey unit, Washington, 2002–2006 (continued)

Owner group and	Surface fire		Conditional fire		Passive fire		Active fire		Forest land area	
survey unit	Percent[a]	SE	Percent[a]	SE	Percent[a]	SE	Percent[a]	SE	Mean	SE
	Percent								*Thousand acres*	
Corporate:										
Puget Sound	32.00	5.12	0.00	0.00	34.33	5.24	33.67	5.51	887	80
Olympic Peninsula	22.90	3.84	9.48	2.85	48.95	4.85	18.68	3.89	1,227	87
Southwest	34.19	4.25	14.14	3.28	31.88	4.07	19.78	3.72	1,445	77
Central	49.82	6.69	10.10	4.13	34.49	6.41	5.60	3.17	663	80
Inland Empire	52.53	7.24	4.08	2.86	32.14	6.70	11.25	4.56	574	76
All Washington	35.25	2.31	8.57	1.41	37.09	2.34	19.08	1.98	4,797	175
Noncorporate private:										
Puget Sound	49.78	6.02	1.71	1.75	35.50	5.82	13.01	4.26	732	77
Olympic Peninsula	34.78	5.98	9.57	3.86	39.39	6.18	16.26	4.83	727	80
Southwest	47.64	7.04	0.00	0.00	47.21	7.00	5.14	3.30	531	69
Central	46.25	4.84	5.76	2.34	39.12	4.72	8.88	2.85	1,260	88
Inland Empire	64.72	4.25	4.99	1.93	28.43	3.96	1.87	1.22	1,540	92
All Washington	51.14	2.43	4.83	1.09	36.06	2.34	7.96	1.37	4,789	181
All owners:										
Puget Sound	27.01	2.04	6.92	1.25	33.30	2.19	32.78	2.20	4,522	125
Olympic Peninsula	25.89	2.24	10.14	1.63	39.44	2.56	24.54	2.24	3,935	84
Southwest	30.73	2.28	9.18	1.53	37.45	2.36	22.63	1.96	3,924	96
Central	40.62	1.91	11.95	1.29	33.63	1.88	13.80	1.46	6,016	140
Inland Empire	57.70	2.39	8.05	1.23	26.24	2.13	8.00	1.24	4,046	101
All Washington	36.64	0.97	9.43	0.62	33.92	0.98	20.01	0.81	22,443	175

Note: Data subject to sampling error; SE = standard error.

[a] Percentage of forest land area within the owner class that is likely to experience each type of fire.

Table 48—Estimated ratio of periodic mortality and removals volume to growth volume of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990–1991 to 2000–2001

Location and species group	State, local and other federal		Corporate private		Noncorporate private		All owners	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Ratio							
Eastern Washington:								
Softwood	0.596	0.135	1.806	0.307	1.114	0.111	1.176	0.098
Hardwood	0.841	0.617	0.669	0.321	0.603	0.290	0.652	0.236
Total	0.602	0.134	1.788	0.303	1.099	0.110	1.163	0.097
Western Washington:								
Softwood	0.439	0.104	1.184	0.114	1.162	0.211	0.983	0.080
Hardwood	0.765	0.244	1.470	0.275	1.247	0.195	1.218	0.139
Total	0.480	0.103	1.212	0.109	1.187	0.170	1.018	0.074
All Washington:								
Softwood	0.462	0.091	1.241	0.107	1.141	0.127	1.021	0.067
Hardwood	0.767	0.238	1.458	0.271	1.209	0.184	1.197	0.134
Total	0.497	0.091	1.261	0.103	1.154	0.114	1.043	0.063

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error.

Table 49—Estimated periodic gross cubic-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990–1991 to 2000–2001

Location and species group	State, local and other federal								Corporate private							
	Periodic gross growth		Periodic mortality		Periodic removals		Net change		Periodic gross growth		Periodic mortality		Periodic removals		Net change	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet															
Eastern Washington:																
Softwood	591	65	-179	42	-173	59	239	90	724	104	-128	31	-1,179	237	-584	211
Hardwood	14	7	-12	7	—	—	2	9	12	5	-2	2	-6	4	4	4
Total	605	65	-191	43	-173	59	241	90	736	107	-130	32	-1,185	239	-580	212
Western Washington:																
Softwood	3,361	211	-512	84	-962	362	1,887	360	7,119	335	-300	62	-8,126	938	-1,308	819
Hardwood	493	79	-210	72	-168	96	116	125	779	97	-253	67	-892	219	-366	209
Total	3,854	207	-722	108	-1,129	401	2,003	406	7,898	331	-553	97	-9,018	977	-1,674	869
All Washington:																
Softwood	3,952	221	-691	94	-1,134	367	2,126	371	7,843	351	-428	70	-9,306	968	-1,891	846
Hardwood	507	79	-221	73	-168	96	118	125	791	97	-255	67	-898	219	-362	209
Total	4,459	217	-913	116	-1,302	405	2,244	416	8,633	348	-683	102	-10,204	1,006	-2,254	895

Table 49—Estimated periodic gross cubic-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990–1991 to 2000–2001 (continued)

Location and species group	Noncorporate private								All others							
	Periodic gross growth		Periodic mortality		Periodic removals		Net change		Periodic gross growth		Periodic mortality		Periodic removals		Net change	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet															
Eastern Washington:																
Softwood	1,824	99	-407	53	-1,626	221	-208	202	3,139	143	-714	74	-2,978	321	-554	305
Hardwood	57	27	-28	12	-7	5	23	25	83	29	-41	14	-13	7	29	27
Total	1,881	102	-435	54	-1,632	221	-186	206	3,222	146	-756	75	-2,991	322	-525	308
Western Washington:																
Softwood	2,255	199	-228	52	-2,392	535	-365	478	12,734	431	-1,040	116	-11,479	1,138	214	1,014
Hardwood	921	107	-312	59	-836	163	-227	170	2,193	161	-774	115	-1,896	288	-478	296
Total	3,175	223	-540	80	-3,228	590	-592	540	14,927	428	-1,815	163	-13,375	1,207	-263	1,100
All Washington:																
Softwood	4,079	222	-635	74	-4,017	578	-574	519	15,873	454	-1,755	138	-14,457	1,182	-339	1,059
Hardwood	978	110	-339	60	-843	163	-204	172	2,275	163	-816	116	-1,909	288	-449	297
Total	5,057	245	-974	97	-4,860	630	-778	578	18,149	452	-2,571	180	-16,366	1,249	-788	1,143

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 cubic feet was estimated.

Table 50—Estimated periodic gross board-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and owner group, Washington, 1990–1991 to 2000–2001

Location and species group	State, local and other federal								Corporate private							
	Periodic gross growth		Periodic mortality		Periodic removals		Net change		Periodic gross growth		Periodic mortality		Periodic removals		Net change	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (Scribner)															
Eastern Washington:																
Softwood	2,880	349	-656	152	-718	249	1,506	401	3,560	532	-364	104	-5,592	1,133	-2,397	960
Hardwood	56	28	-43	32	—	—	13	33	5	4	—	—	—	—	5	4
Total	2,936	349	-698	156	-718	249	1,520	407	3,565	532	-364	104	-5,592	1,133	-2,392	960
Western Washington:																
Softwood	15,017	1,067	-1,513	326	-4,435	1,778	9,069	1,635	30,473	1,833	-998	261	-36,889	4,363	-7,414	3,537
Hardwood	2,008	410	-502	234	-563	350	944	488	3,188	503	-524	259	-3,478	837	-815	805
Total	17,026	1,075	-2,015	396	-4,997	1,912	10,013	1,787	33,661	1,843	-1,522	385	-40,367	4,500	-8,229	3,731
All Washington:																
Softwood	17,897	1,123	-2,169	359	-5,153	1,795	10,575	1,684	34,033	1,908	-1,362	281	-42,482	4,508	-9,811	3,665
Hardwood	2,064	411	-545	237	-563	350	957	490	3,192	503	-524	259	-3,478	837	-810	805
Total	19,961	1,131	-2,714	426	-5,715	1,928	11,533	1,833	37,226	1,918	-1,886	399	-45,960	4,640	-10,620	3,853

Table 50—Estimated periodic gross board-foot growth, mortality, and removals of growing stock on non-national-forest timberland, by location, species group, and group class, Washington, 1990–1991 to 2000–2001 (continued)

Location and species group	Noncorporate private								All owners							
	Periodic gross growth		Periodic mortality		Periodic removals		Net change		Periodic gross growth		Periodic mortality		Periodic removals		Net change	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (Scribner)															
Eastern Washington:																
Softwood	9,268	555	-1,451	225	-7,725	1,136	92	1,040	15,707	774	-2,471	288	-14,035	1,590	-798	1,472
Hardwood	160	81	-24	19	-15	17	121	67	220	86	-66	37	-15	17	139	75
Total	9,427	554	-1,474	225	-7,740	1,137	213	1,043	15,928	773	-2,537	290	-14,050	1,591	-659	1,475
Western Washington:																
Softwood	9,996	1,003	-790	211	-11,388	2,710	-2,182	2,289	55,487	2,296	-3,301	466	-52,712	5,432	-527	4,517
Hardwood	4,201	543	-802	201	-3,409	703	-10	708	9,397	830	-1,829	403	-7,449	1,144	119	1,175
Total	14,197	1,136	-1,592	291	-14,797	2,945	-2,192	2,538	64,884	2,335	-5,130	618	-60,162	5,698	-407	4,849
All Washington:																
Softwood	19,264	1,146	-2,241	309	-19,113	2,939	-2,090	2,515	71,194	2,423	-5,772	547	-66,747	5,660	-1,325	4,751
Hardwood	4,361	549	-826	202	-3,424	703	111	711	9,618	834	-1,895	405	-7,464	1,144	259	1,177
Total	23,625	1,264	-3,067	368	-22,537	3,157	-1,979	2,744	80,812	2,460	-7,667	683	-74,211	5,916	-1,066	5,068

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 500,000 board feet was estimated.

Table 51—Estimated periodic gross cubic-foot growth, mortality, and removals of growing stock on national forest land, by location, type of forest land, and reserved status, Washington, 1993–1997 to 1999–2006

	Unreserved forests						Reserved forests						All forest land	
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total			
Location	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
Eastern Washington:														
Growth	1,420	33	28	5	1,448	32	384	35	64	12	448	33	1,897	46
Mortality	860	50	14	4	874	50	436	64	42	12	478	64	1,351	81
Harvest	141	27	1	1	142	27	0	0	0	0	0	0	142	27
Net change	419	60	13	4	432	60	-52	67	22	12	-30	68	403	91
Western Washington:														
Growth	2,141	60	53	12	2,194	59	473	40	63	16	535	40	2,729	70
Mortality	736	46	20	6	755	46	334	95	30	14	363	95	1,119	106
Harvest	119	35	2	1	120	35	0	0	0	0	0	0	120	35
Net change	1,287	76	31	12	1,318	76	139	100	33	19	172	101	1,490	127
All Washington:														
Growth	3,561	68	81	13	3,642	67	856	53	127	20	984	52	4,626	83
Mortality	1,596	68	33	7	1,629	68	769	115	72	18	841	115	2,470	133
Harvest	260	44	3	2	263	44	0	0	0	0	0	0	263	44
Net change	1,706	97	45	12	1,750	97	87	120	55	23	142	122	1,893	156

Note: Mean remeasurement period was 8 years; totals may be off because of rounding; data subject to sampling error; SE = standard error.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 52—Estimated periodic gross board-foot growth, mortality, and removals of sawtimber on national forest land, by location, type of forest land, and reserved status, Washington, 1993–1997 to 1999–2006

	Unreserved forests						Reserved forests						All forest land	
	Timberland[a]		Other forest[b]		Total		Productive[a]		Other forest[b]		Total			
Location	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (Scribner)													
Eastern Washington:														
Growth	6,530	171	125	22	6,656	169	1,797	183	300	63	2,097	181	8,752	247
Mortality	3,491	233	51	16	3,542	233	1,998	295	168	51	2,166	296	5,708	377
Harvest	498	107	6	6	504	107	0	0	0	0	0	0	504	107
Net change	2,541	277	68	20	2,609	277	-202	294	133	60	-69	299	2,540	408
Western Washington:														
Growth	9,098	283	193	48	9,291	280	2,213	202	229	66	2,442	203	11,733	339
Mortality	3,360	244	79	25	3,440	244	1,473	407	95	57	1,567	409	5,007	475
Harvest	479	137	9	7	488	137	0	0	0	0	0	0	488	137
Net change	5,259	353	105	46	5,364	354	741	433	134	83	875	440	6,239	563
All Washington:														
Growth	15,629	330	318	53	15,947	327	4,010	273	529	91	4,539	272	20,486	419
Mortality	6,851	337	130	30	6,982	337	3,471	503	262	77	3,733	505	10,715	606
Harvest	977	173	15	10	992	174	0	0	0	0	0	0	992	174
Net change	7,800	448	173	51	7,973	449	539	523	267	102	806	532	8,779	695

Note: Mean remeasurement period was 8 years; totals may be off because of rounding; data subject to sampling error; SE = standard error.

[a] Forest land that is capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

[b] Forest land that is not capable of producing in excess of 20 cubic feet/acre/year of wood at culmination of mean annual increment.

Table 53—Total roundwood output by product, species group, and source of material, Washington, 2004

Product and species group	Sawtimber	Poletimber	Other sources	All sources
	Thousand cubic feet			
Saw logs:				
Softwoods	713,855	2,647	34,312	750,814
Hardwoods	35,749	133	373	36,255
Total	749,604	2,779	34,685	787,068
Veneer logs:				
Softwoods	58,252	216	1,356	59,825
Hardwoods	3,078	11	32	3,121
Total	61,331	227	1,388	62,946
Pulpwood:[a]				
Softwoods	72,323	268	741	73,333
Hardwoods	22,034	82	226	22,342
Total	94,358	350	967	95,675
Poles and posts:				
Softwoods	3,963	551	46	4,561
Hardwoods	—	—	—	—
Total	3,963	551	46	4,561
Other miscellaneous:				
Softwoods	2,239	8	57	2,304
Hardwoods	—	—	—	—
Total	2,239	8	57	2,304
Total industrial products:				
Softwoods	850,632	3,691	36,513	890,836
Hardwoods	60,861	226	631	61,718
Total	911,494	3,916	37,144	952,554
Fuelwood:				
Softwoods	—	—	98,404	98,404
Hardwoods	—	—	5,821	5,821
Total	—	—	104,225	104,225
All products:				
Softwoods	850,632	3,691	134,917	989,240
Hardwoods	60,861	226	6,452	67,539
Total	911,494	3,916	141,369	1,056,779

Note: Data subject to sampling error; excludes removals from precommercial thinnings; — = less than 500 cubic feet found.
[a] Pulpwood includes timber chipped for a variety of industrial uses, including pulp, paper, and composite panels.

Table 54—Volume of timber removals by type of removal, source of material, and species group, Washington, 2004

	Growing stock			Other sources			All sources		
Removal type	Softwoods	Hardwoods	Total	Softwoods	Hardwoods	Total	Softwoods	Hardwoods	Total
				Thousand cubic feet					
Roundwood products:									
Saw logs	716,502	35,881	752,383	34,312	373	34,685	750,814	36,255	787,068
Veneer logs	58,468	3090	61,558	1,356	32	1,388	59,825	3121	62,946
Pulpwood	72,592	22,116	94,708	741	226	967	73,333	22,342	95,675
Fuelwood	—	—	—	98,404	5,821	104,225	98,404	5,821	104,225
Posts, poles, and pilings	4,514	—	4,514	46	—	46	4,561	—	4,561
Miscellaneous products	2,247	—	2,247	57	—	57	2,304	—	2,304
Total	854,323	61,087	915,410	134,917	6,452	141,369	989,240	67,539	1,056,779
Logging residues	53,112	3,798	56,910	203,417	16,470	219,887	256,529	20,268	276,797
Total all removals	907,435	64,885	972,320	338,334	22,922	361,256	1,245,769	87,807	1,333,576

Note: Data subject to sampling error; excludes removals from precommercial thinnings; — = less than 500 cubic feet found.

Table 55—Estimated area of forest land covered by vascular plant nontimber forest products, by plant group and species, Washington, 2002–2006

Plant group and scientific name	Common name	Total	SE
		Acres	
Tree seedlings and saplings:			
Abies procera	Noble fir	4,900	900
Crataegus	Hawthorn	11,900	3,200
Pseudotsuga menziesii	Douglas-fir	158,200	8,500
Taxus brevifolia	Pacific yew	9,700	2,000
Thuja plicata	Western redcedar	87,600	7,100
Shrubs:			
Acer circinatum	Vine maple	725,200	41,500
Arctostaphylos nevadensis	Pinemat manzanita	33,400	5,000
Arctostaphylos uva-ursi	Kinnikinnick	98,000	9,400
Ceanothus velutinus	Snowbrush ceanothus	83,100	10,900
Chimaphila umbellata	Pipsissewa	52,500	4,900
Cytisus scoparius	Scotch broom	28,500	10,000
Frangula purshiana	Pursh's buckthorn	154,800	16,500
Frangula purshiana	Pursh's buckthorn	7,000	6,200
Gaultheria shallon	Salal	842,100	51,900
Mahonia aquifolium	Hollyleaved barberry	30,100	5,500
Mahonia nervosa	Cascade barberry	411,100	26,700
Mahonia repens	Creeping barberry	9,200	2,600
Oplopanax horridus	Devilsclub	68,800	9,300
Paxistima myrsinites	Oregon boxleaf	146,900	11,300
Ribes	Currant	63,700	6,100
Rosa	Rose	116,800	6,700
Rubus parviflorus	Thimbleberry	126,000	12,100
Rubus spectabilis	Salmonberry	602,500	40,500
Sambucus racemosa	Red elderberry	77,500	12,500
Vaccinium membranaceum	Thinleaf huckleberry	355,900	26,100
Vaccinium ovalifolium	Oval-leaf blueberry	353,000	30,000
Vaccinium parvifolium	Red huckleberry	164,300	10,500
Herbs:			
Achillea millefolium	Common yarrow	63,900	4,500
Anaphalis margaritacea	Western pearly everlasting	15,800	2,300
Arnica cordifolia	Heartleaf arnica	58,100	6,200
Arnica latifolia	Broadleaf arnica	23,600	4,200
Asarum caudatum	British Columbia wildginger	6,000	1,200
Hypericum perforatum	St. Johnswort	19,100	3,700
Polystichum munitum	Western swordfern	1,139,100	53,000
Pteridium aquilinum	Western brackenfern	257,900	20,900
Trillium ovatum	Pacific trillium	5,000	600
Urtica dioica	Stinging nettle	16,900	3,800
Valeriana sitchensis	Sitka valerian	29,400	5,800
Verbascum thapsus	Common mullein	2,300	800
Xerophyllum tenax	Common beargrass	93,600	11,800

Note: Data subject to sampling error; SE = standard error.

Glossary

abiotic—Pertaining to nonliving factors such as temperature, moisture, and wind (Goheen and Willhite 2006).

aerial photography—Imagery acquired from an aerial platform (typically aircraft or helicopter) by means of a specialized large-format camera with well-defined optical characteristics. The geometry of the aircraft orientation at the time of image acquisition is also recorded. The resultant photograph will be of known scale, positional accuracy, and precision. Aerial photography for natural resource use is usually either natural color or color-infrared, and is film based or acquired using digital electronic sensors.

air quality index—Value or set of values derived from a multivariate model that examines the composition of lichen communities at each plot to provide a relative estimate of air quality.

anthropogenic—Of human origin or influence (Helms 1998).

aspect—Compass direction that a slope faces.

basal area—The cross-sectional area of a tree's trunk.

biodiversity—Variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequencies. http://www.epa.gov/OCEPAterms/bterms.html. (21 March 2008).

bioenergy—Renewable energy made available from materials derived from biological sources. http://en.wikipedia.org/wiki/Bioenergy. (21 March 2008).

biomass—The aboveground weight of wood and bark in live trees 1.0 inch diameter at breast height (d.b.h.) and larger from the ground to the tip of the tree, excluding all foliage. The weight of wood and bark in lateral limbs, secondary limbs, and twigs under 0.5 inch in diameter at the point of occurrence on sapling-size trees is included in the measure, but on poletimber- and sawtimber-sized trees, this material is excluded. Biomass is typically expressed as green or oven-dry weight in tons (USDA Forest Service 2006).

biosite index, ozone—A value calculated from the amount and severity of ozone injury at a site (biosite) that reflects local air quality and plant response and therefore potential risk of ozone impact in the area represented by that biosite (Campbell et al. 2007).

biotic—Pertaining to living organisms and their ecological and physiological relations (Helms 1998).

board foot—A volume measure of lumber 1 foot wide, 1 foot long, and 1 inch thick (12 in by 12 in by 1 in = 144 cubic inches). http://www.ccffa-oswa.org/B.html. (21 March 2008).

bole—Trunk or main stem of a tree. (USDA Forest Service 2006)

carbon mass—The estimated weight of carbon stored within wood tissues. On average, carbon mass values are about half of biomass values for trees, and are summarized as thousand tons or mean tons per acre.

carbon sequestration—Incorporation of carbon dioxide into permanent plant tissues (Helms 1998).

climate index—A value or set of values derived from a multivariate model that examines the composition of lichen communities at each plot that provides a relative estimate of air quality.

coarse woody material—Down dead tree and shrub boles, large limbs, and other woody pieces that are severed from their original source of growth. Coarse woody material also includes dead trees that are supported by roots, severed from roots, or uprooted, and leaning >45 degrees from vertical (USDA Forest Service 2006).

corporate forest land—An ownership class of private forest lands owned by a company, corporation, legal partnership, investment firm, bank, timberland investment management organization (TIMO), or real-estate investment trust (REIT).

crook—Abrupt bend in a tree or log (Helms 1998).

crown—The part of a tree or woody plant bearing live branches or foliage (Helms 1998).

crown density—The amount of crown stem, branches, twigs, shoots, buds, foliage, and reproductive structures that block light penetration through the visible crown. Dead branches and dead tops are part of the crown. Live and dead branches below the live crown base are excluded. Broken or missing tops are visually reconstructed when forming this crown outline by comparing outlines of adjacent healthy trees of the same species and ratio of diameter breast height to diameter at root collar (USDA Forest Service 2006).

crown dieback—Recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is only considered when it occurs in the upper and outer portions of the tree (USDA Forest Service 2006).

crown fire—Fire that spreads across the tops of trees or shrubs more or less independently of a surface fire. Crown fires are sometimes classed as running (independent or active) or dependent (passive) to distinguish the degree of independence from the surface fire (Helms 1998).

current gross annual growth—The total growth of a given stand of trees, within a defined area, over the period of 1 year.

cyanolichens—Lichen species containing cyanobacteria, which fixes atmospheric nitrogen into a form that plants can use.

damage—Damage to trees caused by biotic agents such as insects, diseases, and animals or abiotic agents such as weather, fire, or mechanical equipment.

defoliation—Premature removal of foliage (Goheen and Willhite 2006).

diameter at breast height (d.b.h.)—The diameter of a tree stem, located at 4.5 feet above the ground (breast height) on the uphill side of a tree. The point of diameter measurement may vary on abnormally formed trees (USDA Forest Service 2006).

diameter at root collar (d.r.c.)—The diameter of a tree (usually a woodland species), measured outside of the bark at the ground line or stem root collar (USDA Forest Service 2006).

dieback—Progressive dying from the extremity of any part of the plant. Dieback may or may not result in death of the entire plant (Helms 1998).

disturbance—Any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment (Helms 1998).

down woody material (DWM)—Dead material on the ground in various stages of decay, including coarse and fine woody material. Previously named down woody debris (DWD). The DWM indicator for Forest Inventory and Analysis includes measurements of depth of duff layer, litter layer, and overall fuelbed; fuel loading on the microplot; and residue piles (USDA Forest Service 2006).

ecological region—A top-level scale in a hierarchical classification of ecological units subdivided on the basis of global, continental, and regional climatic regimes and broad physiography. Ecological regions (ecoregions) are further subdivided into domains, divisions, and provinces. The next level down in the hierarchy, subregion, is divided into ecological sections (ecosections) and subsections (Cleland et al. 1997).

ecosection—A level in a hierarchical classification of ecological units for a geographic area delineated on the basis of similar climate, geomorphic processes, stratigraphy, geologic origin, topography, and drainage systems (Cleland et al. 1997).

ecosystem—A spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and components of the abiotic environment within its boundaries. An ecosystem can be of any size: a log, a pond, a field, a forest, or the Earth's biosphere (Helms 1998).

elevation—Height above a fixed reference point, often the mean sea level. http://en.wikipedia.org/wiki/Elevation (21 March 2008).

endemic—(1) Indigenous to or characteristic of a particular restricted geographical area. Antonym: exotic. (2) Referring to a disease constantly infecting a few plants throughout an area. (3) A population of potentially injurious plants, animals, or viruses that are at low levels (see **epidemic**) (Helms 1998).

epidemic—(1) Entomology: pertaining to populations of plants, animals, and viruses that build up, often rapidly, to unusually and generally injuriously high levels. Synonym: outbreak. Many insect and other animal populations cycle periodically or irregularly between endemic and epidemic levels. (2) Pathology: a disease sporadically infecting a large number of hosts in an area and causing considerable loss (Helms 1998).

epiphyte—Plant growing on but not nourished by another plant (Helms 1998).

erosion—The wearing away of the land surface by running water, wind, ice, or other geological agents (USDA Forest Service 2006).

federal forest land—An ownership class of public lands owned by the U.S. government (USDA Forest Service 2006).

fine woody material (FWM)—Down dead branches, twigs, and small tree or shrub boles <3 inches in diameter not attached to a living or standing dead source (USDA Forest Service 2006).

fire regime—The characteristic frequency, extent, intensity, severity, and seasonality of fires within an ecosystem (Helms 1998).

fixed-radius plot—A circular sampled area with a specified radius in which all trees of a given size, shrubs, and other items, are tallied (USDA Forest Service 2006).

foliage transparency—The amount of skylight visible through micro-holes in the live portion of the crown, i.e., where you see foliage, normal or damaged, or remnants of its recent presence (USDA Forest Service 2006).

forb—A broad-leaved herbaceous plant, as distinguished from grasses, shrubs, and trees (USDA Forest Service 2006).

forest industry land—An ownership class of private lands owned by a company or an individual(s) operating a primary wood-processing plant (USDA Forest Service 2006).

forest land—Land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and not currently developed for a nonforest use. The minimum area for classification as forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must be at least 120 feet wide to qualify as forest land (USDA Forest Service 2006).

forest type—A classification of forest land based on and named for the tree species that forms the plurality of live-tree stocking (USDA Forest Service 2006).

forest type group—A combination of forest types that share closely associated species or site requirements (USDA Forest Service 2006).

fork—The place on a tree where the stem separates into two pieces; usually considered a defect.

fuel treatment—Any manipulation or removal of wildland fuels to reduce the likelihood or ignition or to lessen potential fire damage and resistance to control; e.g., lopping, chipping, crushing, piling, and burning. Synonym: fuel modification, hazard reduction (Helms 1998).

fuelwood—Wood salvaged from mill waste, cull logs, branches, etc., and used to fuel fires in a boiler or furnace. http://nfdp.ccfm.org/glossary_e.php. (20 July 2009).

fungus—Member of a group of saprophytic and parasitic organisms that lack chlorophyll, have cell walls made of chitin, and reproduce by spores; includes molds, rusts, mildews, smuts, and mushrooms. Fungi absorb nutrients from the organic matter in which they live. Not classified as plants; instead fungi are placed in the Kingdom: Fungi (Goheen and Willhite 2006).

geospatial—The combination of spatial software and analytical methods with terrestrial or geographic data sets. Often used in conjunction with geographic information systems and geomatics. http://en.wikipedia.org/wiki/Geospatial. (21 March 2008).

graminoid—Grasses (family Gramineae or Poaceae) and grasslike plants such as sedges (family Cyperaceae) and rushes (family Juncaceae). http://www.biology-online.org/dictionary/Graminoid. (21 March 2008).

grassland—Land on which the vegetation is dominated by grasses, grasslike plants, or forbs (Helms 1998).

greenhouse gas—A gas, such as carbon dioxide or methane, that contributes to potential climate change. http://www.epa.gov/OCEPAterms/gterms.html. (21 March 2008).

growing stock—All live trees 5 inches d.b.h or larger that are considered merchantable in terms of saw-log length, and grade; excludes rough and rotten cull trees (USDA Forest Service 2006).

hardwood—Tree species belonging to the botanical subdivision Angiospermae, class Dicotyledonous, usually broad-leaved and deciduous (USDA Forest Service 2006).

herbivory—The consumption of herbaceous vegetation by organisms ranging from insects to large mammals such as deer, elk, or cattle. http://www.biology-online.org/dictionary/Herbivory. (21 March 2008).

increment borer—An auger-like instrument with a hollow bit and an extractor, used to extract thin radial cylinders of wood (increment cores) from trees having annual growth rings, to determine increment or age (Helms 1998).

interpolation—A method of reallocating attribute data from one spatial representation to another. Kriging is a more complex example that allocates data from sample points to a surface. http://hds.essex.ac.uk/g2gp/gis/sect101.asp. (21 March 2008).

invasive plant—Plants that are not native to the ecosystem under consideration and that cause or are likely to cause economic or environmental harm or harm to human, animal, or plant health. http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf. (21 March 2008).

ladder fuel—Combustible material that provides vertical continuity between vegetation strata and allows fire to climb into the crowns of trees or shrubs with relative ease. Ladder fuels help initiate and ensure the continuation of a crown fire (Helms 1998).

late-successional reserves (LSRs)—Federally managed forests held in reserve for wildlife habitat and thus set aside from most commercial logging. The LSRs may contain old clearcuts as well as old-growth forests. Logging may be allowed in an LSR if it will accelerate development of old-growth characteristics. http://www.umpqua-watersheds.org/glossary/gloss_l.html. (21 March 2008).

lichen—An organism consisting of a fungus and an alga or cyanobacterium living in symbiotic association. Lichens look like masses of small, leafy, tufted or crustlike plants (USDA Forest Service 2006).

live trees—All living trees, including all size classes, all tree classes, and both commercial and noncommercial species for tree species listed in the FIA field manual (USDA Forest Service 2006).

mean annual increment (MAI) at culmination—A measure of the productivity of forest land expressed as the average increase in cubic feet of wood volume per acre per year. For a given species and site index, the mean is based on the age at which the MAI culminates for fully stocked natural stands. The MAI is based on the site index of the plot (Azuma et al. 2004).

mensuration—Determination of dimensions, form, weight, growth, volume, and age of trees, individually, or collectively, and of the dimensions of their products (Helms 1998).

mesic—Describes sites or habitats characterized by intermediate moisture conditions; i.e., neither decidedly wet nor dry (Helms 1998).

microclimate—The climate of a small area, such as that under a plant or other cover, differing in extremes of temperature and moisture from the larger climate outside (Helms 1998).

MMBF—A million board feet of wood in logs or lumber (Helms 1998).

model—(1) An abstract representation of objects and events from the real world for the purpose of simulating a process, predicting an outcome, or characterizing a phenomenon. (2) Geographic information system (GIS) data representative of reality (e.g., spatial data models), including the arc-node, georelational model, rasters or grids, polygon, and triangular irregular networks (Helms 1998).

Montréal Process—In September 1993, the Conference on Security and Cooperation in Europe (CSCE) sponsored an international seminar in Montréal, Canada, on the sustainable development of boreal and temperate forests, with a focus on developing criteria and indicators for the assessment of these forests. After the seminar, Canada drew together countries from North and South America, Asia, and the Pacific Rim to develop criteria and indicators for nontropical forests, and in June 1994, the initiative now known as the Montréal Process began. The European countries elected to work as a region in the Pan-European Forest Process in the followup to the Ministerial Conferences on the Protection of Forests in Europe. http://www.mpci.org/rep-pub/1999/broch_e.html#2. (21 March 2008).

mortality—The death of trees from natural causes, or subsequent to incidents such as storms, wildfire, or insect and disease epidemics (Helms 1998).

multivariate analysis—Branch of statistics concerned with analyzing multiple measurements that have been made on one or several individuals (Helms 1998).

municipal land—Land owned by municipalities or land leased by them for more than 50 years (USDA Forest Service 2006).

mycelium—Vegetative part of a fungus, composed of hyphae and forming a thallus (Helms 1998).

mycorrhiza—The usually symbiotic association between higher plant roots (host) and the mycelia of specific fungi. Mycorrhizae often aid plants in the uptake of water and certain nutrients and may offer protection against other soil-borne organisms (Helms 1998).

national forest lands—Federal lands that have been designated by Executive order or statute as national forest or purchase units and other lands under the administration of the U.S. Department of Agriculture, Forest Service, including experimental areas and Bankhead-Jones Title III lands (Azuma et al. 2004).

Native American lands—Tribal lands, and allotted lands held in trust by the federal government. Native American lands are grouped with farmer-owned and miscellaneous private lands as other private lands (Azuma et al. 2004).

native species—Plant species that were native to an American region prior to Euro-American settlement. For vascular plants, they are the species that are not present on the USDA Natural Resources Conservation Service (NRCS) (2000) list of nonnative species (see **nonnative species**) (USDA NRCS 2000).

net primary production (NPP)—NPP represents the amount of chemical energy that is available to consumers in an ecosystem. It is the remaining energy from gross primary productivity discounting the loss of energy required by primary producers for respiration (adapted from Campbell 1990).

net volume—Gross volume less deductions for sound and rotten defects. Growing-stock net volume is gross volume (in cubic feet) less deductions for rot and missing bole sections on poletimber and sawtimber growing-stock trees. Sawtimber net volume is gross volume (in board feet) less deductions for rot, sweep, crook, missing bole sections, and other defects that affect the use of sawtimber trees for lumber (Azuma et al. 2004).

nitrogen oxides (NOx)—Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules, produced in the emissions of vehicle exhausts and from power stations. Atmospheric NOx contributes to formation of photochemical ozone (smog), which can impair visibility and harm human health. http://www.climatechange.ca.gov/glossary/letter_n.html. (21 March 2008).

nitrophyte—One of a group of lichen species that grow in nitrogen-rich habitats.

noncorporate forest land—Private forest land owned by nongovernmental conservation or natural resource organizations; unincorporated partnerships, associations, or clubs; individuals or families; or Native Americans.

nonforest inclusion—An area that is not forested and is less than 1.0 acre and does not qualify as its own condition class (USDA Forest Service 2006).

nonnative species—Plant species that were introduced to America subsequent to Euro-American settlement. Nonnative vascular plants are present on the USDA (USDA Natural Resources Conservation Service 2000).

nonstocked areas—Timberland that is less than 10 percent stocked with live trees. Recent clearcuts scheduled for planting are classified as nonstocked area (Azuma et al. 2004).

nontimber forest products (NTFP)—Species harvested from forests for reasons other than production of timber commodities. Vascular plants, lichens, and fungi are the primary organisms included in NTFPs.

old-growth forest—Old-growth forest is differentiated from younger forest by its structure and composition, and often by its function. Old-growth stands are typified by the presence of large older trees; variety in tree species, sizes, and spacing; multiple canopy layers; high amounts of standing and down dead wood; and broken, deformed, or rotting tops, trunks, and roots (Franklin et al. 1986).

other private forest lands—Lands in private ownership and not reported separately. These may include coal companies, land trusts, and other corporate private landowners (USDA Forest Service 2006).

overrun—Difference between the log scale of a shipment of timber and the actual volume of lumber obtained from it. http://forestry.about.com/library/glossary/blforglo.htm. (21 March 2008).

overstory—That portion of the trees, in a forest of more than one story, forming the uppermost canopy layer (Helms 1998).

owner class—A variable that classifies land into categories of ownership. Current ownership classes are listed in the FIA field manual (USDA Forest Service 2006).

owner group—A variable that combines owner classes into the following groups: Forest Service, other federal agency, state and local government, and private. Different categories of owner group on a plot result in different conditions (USDA Forest Service 2006).

ownership—A legal entity having an ownership interest in land, regardless of the number of people involved. An ownership may be an individual; a combination of persons; a legal entity such as corporation, partnership, club, or trust; or a public agency. An ownership has control of a parcel or group of parcels of land (USDA Forest Service 2006).

ozone (O3), tropospheric—A regional, gaseous air pollutant produced primarily through sunlight-driven chemical reactions of nitrogen oxide (NO2) and hydrocarbons in the troposphere (the lowest layer of the atmosphere). Ozone plays a significant role in greenhouse warming and urban smog and causes foliar injury to deciduous trees, conifers, shrubs, and herbaceous species (Air and Waste Management Association 1998).

paleoecology—Study of the relationships of past organisms and the environment in which they lived (Helms 1998).

pathogen—Parasitic organism directly capable of causing disease (Helms 1998).

photointerpretation (aerial photography)—A process whereby points, or areas of interest on an aerial photograph, are studied to determine information about land cover. The FIA Program uses photointerpretation to determine whether field plots are forested or not, the possible forest type, and size class, and uses it in analysis for land cover and land use changes.

phytotoxic—Poisonous to plants (Helms 1998).

prescribed burn—Deliberate burning of wildland fuels in either their natural or their modified state and under specified environmental conditions, usually to make the site less susceptible to severe wildfire. Synonym: controlled burn, prescribed fire (adapted from Helms 1998).

productive forest land—Forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of wood at culmination of mean annual increment (MAI) without regard to reserved status (USDA Forest Service 2006).

public land—An ownership group that includes all federal, state, county, and municipal lands (USDA Forest Service 2006).

pulpwood—Whole trees, tree chips, or wood residues used to produce wood pulp for the manufacture of paper products. Pulpwood is usually wood that is too small, of inferior quality, or the wrong species for the manufacture of lumber or plywood (adapted from Helms 1998).

quadrat—The basic 3.28-square-foot sampling unit for the phase 3 vegetation indicator (USDA Forest Service 2006).

rangeland—Expansive, mostly unimproved lands on which a significant proportion of the natural vegetation is native grasses, grasslike plants, forbs, and shrubs. Rangelands include natural grasslands, savannas, shrublands, many deserts, tundra, alpine communities, coastal marshes, and wet meadows. http://en.wikipedia.org/wiki/Rangeland. (21 March 2008).

regeneration (artificial and natural)—The established progeny from a parent plant, seedlings or saplings existing in a stand, or the act of renewing tree cover by establishing young trees naturally or artificially. May be artificial (direct seeding or planting) or natural (natural seeding, coppice, or root suckers) (adapted from Helms 1998).

remote sensing—Capture of information about the Earth from a distant vantage point. The term is often associated with satellite imagery but also applies to aerial photography, airborne digital sensors, ground-based detectors, and other devices. http://www.nsc.org/ehc/glossary.html. (20 July 2009).

reserved forest land—Land permanently reserved from wood products utilization through statute or administrative designation. Examples include national forest wilderness areas and national parks and monuments (USDA Forest Service 2006).

richness—The number of different species in a given area, often referred to at the plot scale as alpha diversity and at the regional scale as gamma diversity (USDA NRCS 2000).

riparian—Related to, living in, or associated with a wetland, such as the bank of a river or stream or the edge of a lake or tidewater. The riparian biotic community significantly influences and is influenced by the neighboring body of water (Helms 1998).

salvage cutting—Removal of dead trees, or trees damaged or dying because of injurious agents other than competition, to recover economic value that would otherwise be lost. Synonym: salvage felling, salvage logging (Helms 1998).

sampling error—Difference between a population value and a sample estimate that is attributable to the sample, as distinct from errors due to bias in estimation, errors in observation, etc. Sampling error is measured as the standard error of the sample estimate (Helms 1998).

sapling—A live tree 1.0 to 4.9 inches in diameter (USDA Forest Service 2006).

saw log—A log meeting minimum standards of diameter, length, and defect for manufacture into lumber or plywood. The definition includes logs with a minimum diameter outside bark of 7 inches for softwoods and 9 inches for hardwoods (Azuma et al. 2004).

sawtimber trees—Live softwood trees of commercial species at least 9.0 inches in d.b.h. and live hardwood trees of commercial species at least 11.0 inches in d.b.h. At least 25 percent of the board-foot volume in a sawtimber tree must be free from defect. Softwood trees must contain at least one 12-foot saw log with a top diameter of not less than 7 inches outside bark; hardwood trees must contain at least one 8-foot saw log with a top diameter of not less than 9 inches outside bark (Azuma et al. 2004).

seedlings—Live trees <1.0 inch d.b.h. and at least 6 inches in height (softwoods) or 12 inches in height (hardwoods) (USDA Forest Service 2006).

shrub—Perennial, multistemmed woody plant, usually less than 13 to 16 feet in height, although under certain environmental conditions shrubs may be single-stemmed or taller than 16 feet. Includes succulents (e.g., cacti) (USDA Forest Service 2007b).

shrubland—A shrub-dominated vegetation type that does not qualify as forest.

slope—Measure of change in surface value over distance, expressed in degrees or as a percentage (Helms 1998).

snag—Standing dead tree ≥5 inches d.b.h. and ≥4.5 feet in length, with a lean of <45 degrees. Dead trees leaning more than 45 degrees are considered to be down woody material. Standing dead material shorter than 4.5 feet are considered stumps (USDA Forest Service 2007a).

species group—A collection of species used for reporting purposes (USDA Forest Service 2006).

species turnover—A measure of difference in species composition among plots within an area (e.g., ecological section). Also known as beta diversity. Species turnover is calculated by dividing the total number of species in an area by the mean number of species per plot (USDA NRCS 2000).

specific gravity constants—Ratio of the density (weight per unit volume) of an object (such as wood) to the density of water at 4 degrees C (39.2 degrees F) (Helms 1998).

stand age—Average age of the live dominant and codominant trees in the predominant stand size class (USDA Forest Service 2006).

state land—An ownership class of public lands owned by states or lands leased by states for more than 50 years (USDA Forest Service 2006).

stocked/nonstocked—In the FIA Program, a minimum stocking value of 10 percent live trees is required for accessible forest land (USDA Forest Service 2007a).

stocking—(1) At the tree level, the density value assigned to a sampled tree (usually in terms of numbers of trees or basal area per acre), expressed as a percentage of the total tree density required to fully use the growth potential of the land. (2) At the stand level, the sum of the stocking values of all trees sampled (Bechtold and Patterson 2005).

stratification—A statistical tool used to reduce the variance of the attributes of interest by partitioning the population into homogenous strata (Bechtold and Patterson 2005).

succession—The gradual supplanting of one community of plants by another (Helms 1998).

surface fire—A fire that burns only surface fuels, such as litter, loose debris, and small vegetation (Helms 1998).

sustainability—The capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity in the long run, in the context of human activity and use (Helms 1998).

terrestrial—Of or relating to the Earth or its inhabitants; of or relating to land as distinct from air or water. http://www.merriam-webster.com/dictionary/terrestrial. (21 March 2008).

timberland—Forest land that is producing or capable of producing >20 cubic feet per acre per year of wood at culmination of mean annual increment (MAI). Timberland excludes reserved forest lands (USDA Forest Service 2006).

transect—A narrow sample strip or a measured line laid out through vegetation chosen for study (Helms 1998).

tree—A woody perennial plant, typically large, with a single well-defined stem carrying a more or less definite crown; sometimes defined as attaining a minimum diameter of 3 inches and a minimum height of 15 feet at maturity. For FIA, any plant on the tree list in the current field manual is measured as a tree (USDA Forest Service 2006).

understory—All forest vegetation growing under an overstory (Helms 1998).

unproductive forest land—Forest land that is not capable of producing in excess of 20 cubic feet per acre per year of wood at culmination of mean annual increment without regard to reserved status (USDA Forest Service 2006).

unreserved forest land—Forest land that is not withdrawn from harvest by statute or administrative regulation. Includes forest lands that are not capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands (Smith et al. 2004).

upland—Any area that does not qualify as a wetland because the associated hydrologic regime is not sufficiently wet to produce vegetation, soils, or hydrologic characteristics associated with wetlands. In flood plains, such areas are more appropriately termed nonwetlands. http://www.biology-online.org/dictionary/Upland. (21 March 2008).

vascular plant—A plant possessing a well-developed system of conducting tissue to transport water, mineral salts, and sugars. http://www.biology-online.org/dictionary/Vascular_plant. (21 March 2008).

veneer log—A high-quality log of a desirable species suitable for conversion to veneer. Veneer logs must be large, straight, of minimum taper, and free of defects. http://www.dnr.state.md.us/forests/gloss.html. (December 2009).

wilderness—(1) According to the Wilderness Act of 1964, "a wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." (2) A roadless land legally classified as a component area of the National Wilderness Preservation System and managed to protect its qualities of naturalness, solitude, and opportunity for primitive recreation. Wilderness areas are usually of sufficient size to make maintenance in such a state feasible (Helms 1998).

wildfire—Any uncontained fire, other than prescribed fire, occurring on wildland. Synonym: wildland fire (Adapted from Helms 1998).

wildland—Land other than that dedicated for uses such as agriculture, urban, mining, or parks (Helms 1998).

wildland forest—A large continuous tract of forest with few or no developed structures on it. Delineated on aerial imagery for the purpose of detecting land use change. The PNW-FIA Program and the Oregon Department of Forestry jointly use a minimum of 640 acres with fewer than five developed structures to designate wildland forest.

wildland-urban interface (WUI)—A term used to describe an area where various structures (most notably private homes) and other human developments meet or are intermingled with forest and other vegetative fuel types. http://www.borealforest.org/nwgloss13.htm. (21 March 2008).

xeric—Pertaining to sites or habitats characterized by decidedly dry conditions (Helms 1998).

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