Forests of Southeast and South-Central Alaska, 2004–2008

Five-Year Forest Inventory and Analysis Report

General Technical Report
PNW-GTR-835
March 2011

United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

Technical Editors

Tara M. Barrett is a research forester, Forestry Sciences Laboratory, 3301 C Street Suite 200, Anchorage, AK 99503; and **Glenn A. Christensen** is a forester, Forestry Sciences Laboratory, 620 SW Main Street, Suite 400, Portland, OR 97205.

Contributing Authors

Hans-Erik Andersen is a research forester, **Bethany K. Schulz** is a research ecologist, and **Kenneth Winterberger** is a remote sensing specialist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99503; **John Caouette** (deceased) was a statistician, The Nature Conservancy, 416 Harris Street, Suite 301, Juneau, AK 99801; **Lisa K. Crone** is a research economist, formerly with U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Sitka Wood Utilization Center, 204 Siginaka Way, Sitka, AK 99835; **Paul Hennon** is a research pathologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 11305 Glacier Highway, Juneau, AK 99801; **Connie Hubbard** is an ecologist, Chugach National Forest, 3301 C Street, Suite 300, Anchorage, AK 99503; **Theresa Jain** is a research forester, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory, 1221 S Main, Moscow, ID 83843; **Sarah Jovan** is a research ecologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 620 SW Main Street, Suite 400, Portland, OR 97205; **John E. Lundquist** is a forest entomologist, U.S. Department of Agriculture, Forest Service, Forest Health Protection Alaska Region and Pacific Northwest Research Station, 3301 C Street, Suite 202, Anchorage, AK 99503; **Todd A. Morgan** is director of forest industry research, Bureau of Business and Economic Research, University of Montana, 32 Campus Drive, Missoula, MT 59812; **Mark Schultz** is an entomologist, and **Dustin Wittwer** is a biological technician, U.S. Department of Agriculture, Forest Service, Forest Health Protection Alaska Region, 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801.

Cover photo by Jon Williams.

Abstract

Barrett, Tara M.; Christensen, Glenn A., tech. eds. 2011. Forests of southeast and south-central Alaska, 2004–2008: five-year forest inventory and analysis report. Gen. Tech. Rep. PNW-GTR-835. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 156 p.

This report highlights key findings from the most recent (2004–2008) data collected by the Forest Inventory and Analysis program across all ownerships in southeast and south-central Alaska. We present basic resource information such as forest area, ownership, volume, biomass, carbon sequestration, growth, and mortality; structure and function topics such as vegetation and lichen diversity and forest age distribution; disturbance topics such as insects and diseases, yellow-cedar decline, fire, and invasive plants; and information about the forest products industry in Alaska, the potential of young growth for timber supply, biofuels, 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: Coastal Alaska, temperate rain forests, boreal forests, climate change, carbon accounting, mistletoe, yellow-cedar, Kenai Peninsula, invasive species, timber volume, timberland, wood products.

Contents

Summary

Forests in southeast and south-central Alaska are unique in many ways. The largest old-growth temperate rain forest on Earth extends through most of the region, with huge old Sitka spruce and western hemlock intermixed with yellow-cedar and western redcedar at lower elevations and mountain hemlock (see "Common and Scientific Names") at higher elevations. But the south-central region also contains the southernmost extent of Alaska's boreal forest, characterized by black spruce, white spruce, and hardwoods such as aspen, birch, and willow. This report shows that relative to the rest of the U.S. coastal regions, Alaska's coastal region contains slower growing forest, older forest, less forest in private ownership, and much more forest per capita.

Although only approximately 12 percent of Alaska's forest land is found in the southeast and south-central region, the area contains about half of the state's timberland and half of the state's population. Public agencies manage 88 percent of the 15.3 million acres of forest land in the coastal region, with most forest in the two largest national forests in the United States, the Tongass and Chugach National Forests. Although private ownership is only about 12 percent of the forested area in the region, it contains 24 percent of timberland.

Nearly 1.3 billion tons of biomass are stored within the live trees of coastal Alaska. Significant amounts of carbon and biomass are also contained in snags, particularly on the Kenai Peninsula where 47 percent of biomass is within dead white spruce, most likely killed by bark beetles (*Dendroctonus rufipennis* [Kirby]) in the 1990s. There was no net change of live-tree carbon or biomass between 1995–2003 and 2004–2008.

There has been speculation that the 2- to 3- °F average annual temperature increase that the coastal region has experienced over the past half century could lead to forestation through increasing elevation of treeline, drying of wetlands, and glacial recession. Although change in forest area was difficult to assess because of procedural changes to the Forest Inventory and Analysis (FIA) inventory, a rough estimate of a 0.7 percent increase in forest area per decade suggests that climate-related changes are not yet noticeably impacting biomass and carbon through forestation.

The most common species in the region—western hemlock, Sitka spruce, mountain hemlock, and yellow-cedar—did not show any significant change in live tree biomass between 1995–2003 and 2004–2008. Because the range of western hemlock, mountain hemlock, Sitka spruce, and yellow-cedar is quite broad within the inventory region, it is possible that slow migration or more localized changes could be occurring without impact on total biomass for the region. Western redcedar showed a significant increase, as did hardwoods such as cottonwood, quaking aspen, and red alder. Lodgepole pine showed a significant decrease in biomass. Overall, harvest removals were 23 percent of mortality from other causes. Mortality ranged from a low of 0.22 (standard error [SE] = 0.06) percent of western redcedar dying annually to a high of about 2.57 percent (SE = 0.47) of white spruce trees dying annually.

By ownership, no statistically significant change in live tree carbon and biomass was detected on private lands or the Tongass National Forest, but state and local government had an estimated 8-percent increase and the Chugach National Forest had an estimated 4-percent increase between the 1995–2003 and 2004–2008 inventories. Carbon in live trees increased in two higher elevation ecoregions, one in south-central Alaska and one in south-east Alaska, but no significant increase of live tree carbon was detected in lower elevation ecoregions containing most of the forest land.

Average lichen species richness is higher for southeast Alaska than compared to the similar Coast Range ecological region in Oregon or Washington. Unlike the Oregon and Washington Coast Range ecosystems, almost all sampled communities contained species within both the functionally important cyanolichen (nitrogen fixers) and wildlife forage groups. Widespread abundance of pollution-sensitive species suggests a lichen flora characteristic of forest ecosystems unstressed by the regional air-quality issues of the other U.S. Pacific Coast States.

The vegetation indicator is used to assess species composition and structure, which in turn help determine potential productivity and wildlife habitat. The average species richness on the 0.17-acre sample areas was 37.1 species. Of species found, 99.7 percent were native. Seven species were extremely common, found on over 70 percent of all plots. The highest species richness for the inventory area was found on sites dominated by yellow-cedar, mountain hemlock, and western redcedar.

The coastal Alaska region is unique within the United States because of the substantial amount of older forest. In the Temperate Rainforest ecoregion, 67 percent of federal forest land is in older forest, 35 percent of state and local government forest land is in older forest, and 34 percent of private land is in older forest. Of the 8.9 million acres (SE = 0.3) of older forest in the coastal inventory region, 35 percent is reserved. Older forests in the Temperate Rainforest ecoregion store substantial amounts of carbon. The greatest amounts of carbon mass were stored in older forests of the Sitka spruce forest type, estimated at 107.2 tons per acre (SE = 12.2) in live and dead trees in forest that was at least 200 years of age.

A map of yellow-cedar decline, appearing as patches of high mortality, is included in the report with more than 2,000 locations and half a million acres of mapped mortality. Yellow-cedar decline is thought to be related to climate warming, with roots freezing when snow depth is not adequate to protect them from spring freezes. Overall, live tree biomass for yellow-cedar was unchanged between 1995–1998 and 2004–2008, suggesting that yellow-cedar may be migrating rather than declining, with regeneration and growth currently compensating for mortality. Surviving smaller trees are more common at higher elevations, whereas dead trees (and the associated yellow-cedar decline) are more common at lower elevations, supporting the migration hypothesis. An additional explanation for the carbon and biomass stability is that mortality associated with the decline could be episodic, with lower levels during the 1995–2003 to 2004–2008 remeasurement period than in preceding decades.

Compared to those of the other 49 States, Alaska's coastal forests are relatively free of introduced species. Less than 2 percent of forested plots had introduced or native noxious plants compared to 67 percent of plots in other parts of the United States. This means that Alaska has a unique window of opportunity to prevent establishment of invasive species in its forests, an opportunity no longer available to other states.

Forest insect pests are surveyed annually by the Forest Health Protection branch of the USDA Forest Service, and summarized results are available in Forest Conditions Reports from 1970 to the present. The most widespread insect pest in coastal Alaska since 2003 has been the spruce needle aphid (*Elatobium abietinum* [Walker]). Another important insect within the region is the spruce beetle, which was responsible for the outbreaks of the 1990s, mostly on the Kenai Peninsula, which affected millions of acres of forest. The FIA inventory data collected in Alaska have been used to build predictive models of spruce beetle risk and hazard.

Another important impact on coastal forests is hemlock dwarf mistletoe (*Arceuthobium tsugense* [Rosendhal] G.N. Jones), a parasitic plant of older western hemlock trees throughout southeast Alaska. Using measurements from FIA plots, dwarf mistletoe is estimated to infect about 1 million acres of forest land. Analysis of inventory data reveals that mistletoe infection is sharply reduced above about 500 feet in elevation, compared to its host species western hemlock, which is found up to elevations of 2,000 feet or higher. Because the disease and host appear to have different climatic envelopes, the range of this disease may potentially expand with a warming climate.

Young-growth forests, defined in this report as a stand age of 150 years or less of any stand size on timberland, are currently estimated to cover 2.9 million acres. Private owners currently own 1.2 million acres of this young growth, whereas national forests manage about 1.0 million acres of these forests. However, more than half of the young-growth volume (52 percent) is found on the national forests. By forest type, the majority of young-growth stands are classified as either Sitka spruce or western hemlock forests; these forest types also contain the majority of the larger sawtimber-sized stands.

In 2005, the total timber harvest in Alaska was 268.2 million board feet Scribner. The harvest in southeast Alaska has dropped substantially in recent years from contributing factors such as lawsuits over timber sales on the Tongass National Forest, lower timber inventories on some native corporation lands, high operating costs throughout the region, and shifting global markets and competition. National forests supplied only 18 percent of total harvest volume in 2005, but they supplied 53 percent of the timber that went to Alaska mills. Forest industry employment was 1,049 workers in 2005, and product and mill residue sales were about $150 million, mostly as saw-log and pulpwood exports.

As the cost of traditional petroleum-based fuel products continues to rise, there is increasing interest in the use of forest biomass as an alternative fuel source for power generation in rural Alaska. The advantages include the renewable nature of the resource, reducing wildfire hazard near rural communities, and possibly creating local employment opportunities. Constraints on the realization of these opportunities for bioenergy include high transportation costs, currently inadequate harvesting systems, and limited information on available biomass supply.

Nontimber forest products, also known as special forest products, include a wide range of botanical resources of the forest, with each agency currently using different policies and regulations for management. Many of the plants that have been inquired about for commercial harvest on the Chugach and Tongass National Forests also serve documented subsistence or traditional uses, which raises concern among many Alaska Native tribes and organizations in the region. Products currently being produced in Alaska include crafts, artwork, dyes, floral greenery, berries and other wild fruits, syrups, teas, flavorings, edible and medicinal plants, native seeds, edible mushrooms, and medicinal fungi.


Jon Williams

Chapter 1: Introduction

This report describes the status of and changes in forests in southeast and south-central Alaska along with some contemporary forest issues that can be addressed with inventory data. Most estimates of the characteristics of Alaska's coastal forests are derived from measurements taken on field plots between 2004 and 2008 by the Forest Inventory and Analysis (FIA) program[1] of the Pacific Northwest Research Station.

The FIA program is charged with the responsibility of monitoring status and trends of all the public and private forests of the United States. The FIA program was created within the U.S. Department of Agriculture in 1928 to conduct assessments of all the Nation's forested lands for economic and forest management planning. In the 1970s through the 1990s, the program expanded from what had largely been a timber-orientated program to a more comprehensive suite of forest monitoring methods. During this process, many protocols became regionalized, making it difficult to address issues that cross state and regional boundaries.

The Agriculture Research and Education Reform Act of 1998 substantially changed the FIA program, creating a common set of core measurements that are used across the United States. As part of the revision, the FIA program switched to an annualized system, which means that a subsample of plots is measured in each state in each year. The new system, commonly referred to as "annual FIA," was implemented on a state-by-state schedule starting in 2000.

As of 2010, Alaska is the only U.S. state where the annual FIA system has not been fully implemented. Alaska is also unique among all U.S. States in never having had an FIA inventory of all forested lands, although a collection of outdated timber inventories exists for some areas of the state. This contrasts sharply with other states, many of which are on the 5th to 10th complete remeasurement of all forested lands. Alaska is believed to have about 16 to 17 percent of total U.S. forest land area.

Although most of the forest land in Alaska is not included in the current FIA program, in southeast and south-central Alaska, the annual FIA program was fully implemented in 2004. This annual FIA inventory is also remeasuring many of the plots established in comprehensive forest inventories taken in the southeast Alaska region from 1995 through 2000 and taken in the south-central Alaska region from 1999 through 2003. This report summarizes data collected from 2004 through 2008, which is about 50 percent of all plots that will be installed in the coastal region, and uses the remeasurement plots to estimate change for the region.

The region covered by this report includes the Tongass and Chugach National Forests, which contain most of the forest in the region, and also land owned by other public and private entities (fig. 1). In 2005, the inventory included all lands in the region excluding only Glacier Bay National Park. However, since 2006, the inventory has been excluded from the wilderness and wilderness study areas of the Tongass and Chugach National Forests (fig. 2). Although we have used the 2005 data from the wilderness areas where possible throughout this report, it adds imprecision to estimates owing to the very small number of plots from those areas. Estimates of change and estimates from attributes measured in the 1995 through 2003 inventories (e.g., hemlock dwarf mistletoe) do not include any data from the Tongass and Chugach wilderness and wilderness study areas. The base set of field plots (called phase 2 plots) are spaced at approximate 3-mile intervals on a hexagonal grid throughout forested lands in the coastal region (fig. 3). One out of every 16 phase 2 plots is also a phase 3 plot, where detailed information on forest health is collected, including measurement for vegetation diversity and lichens (fig. 4). Additional information on inventory techniques is provided in appendix 1.

The report consists of 14 different issue-focused summaries of current topics in forest health and management. Each section includes background information, key findings from the FIA inventory data, and interpretation. Information is aggregated to levels that differ depending on the issue, such as ecoregions, forest types, or ownership groups. The issues addressed by this report cover only a small portion of possible analyses with the FIA data. Customized summaries can be made from tools at the national Web site, and the data can also be downloaded in standardized data tables from the Web site at http://www.fia.fs.fed.us.

---

[1] The Forest Inventory and Analysis unit is now part of the Resource Monitoring and Assessment Program at the Pacific Northwest Research Station.

Kenneth C. Winterberger

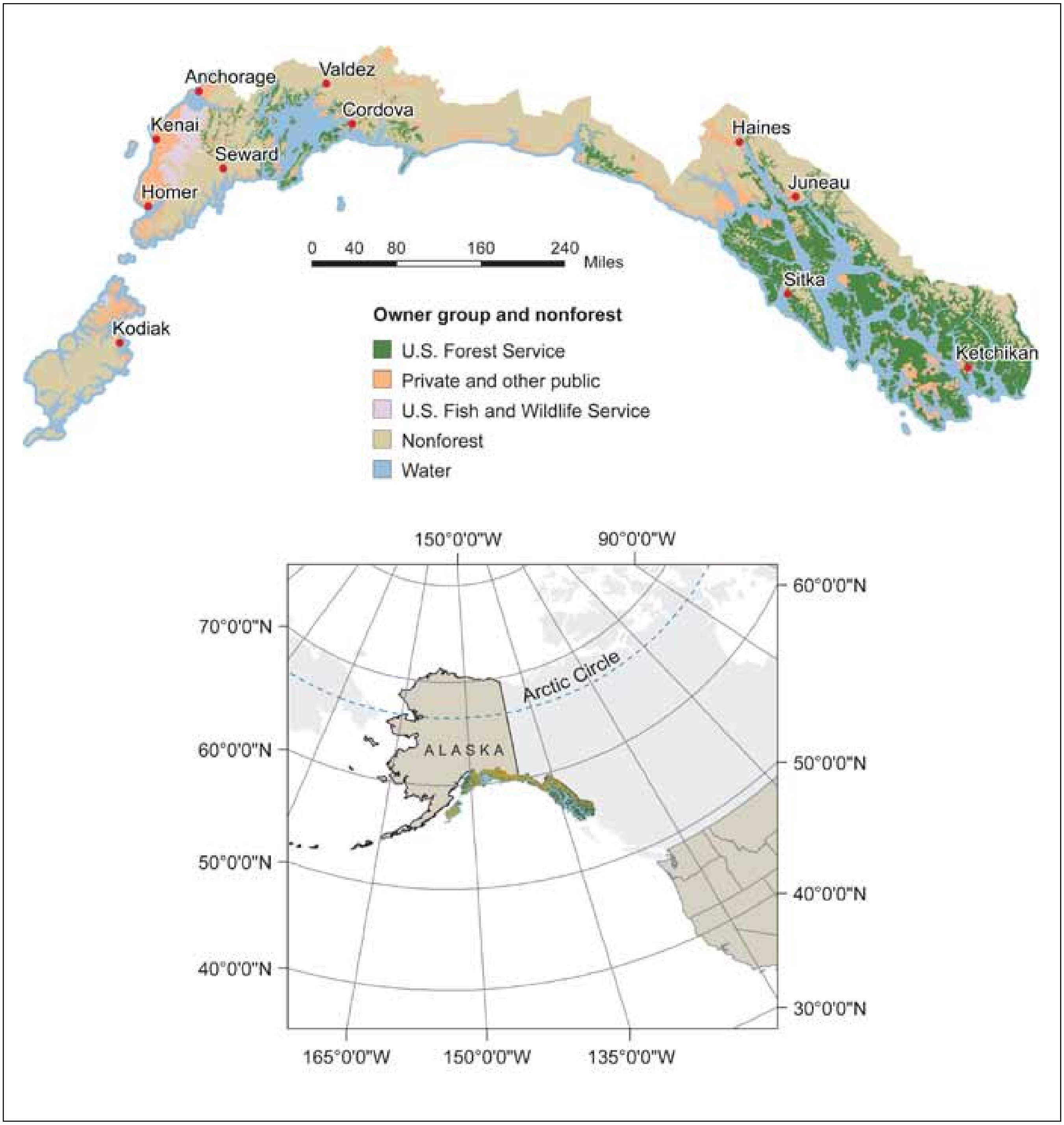
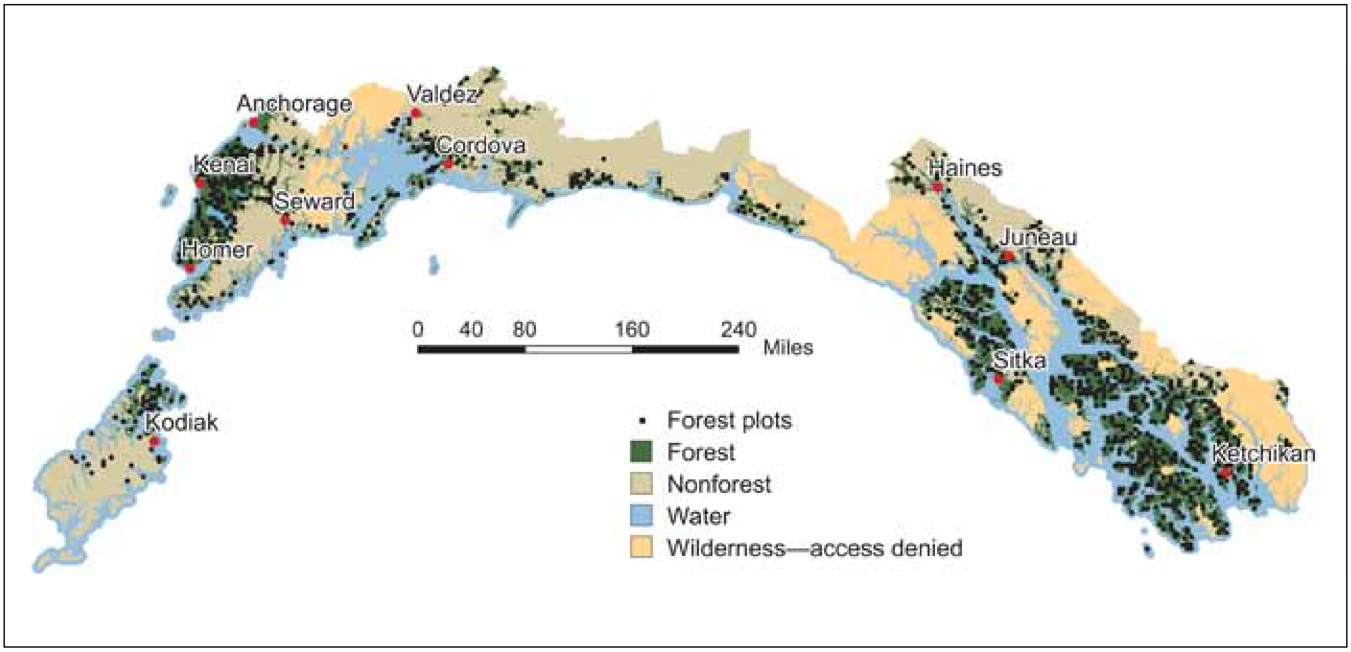


Figure 1—Forested land by owner group for southeast and south-central Alaska. Projection: Alaska Albers NAD 83. Source: USDA Forest Service, Forest Inventory and Analysis program, 2004–2008 data. Ownership data was derived from various sources.



Kenneth C. Winterberger

Figure 2—Forest, nonforest, and inaccessible wilderness areas for the coastal Alaska inventory region (depicted plot locations are approximate).

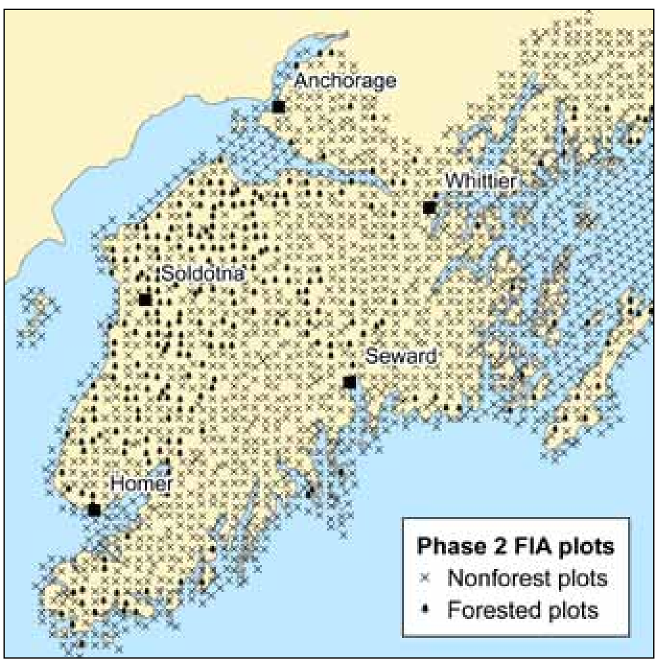


Figure 3—Forest Inventory and Analysis (FIA) phase 2 plots on the Kenai Peninsula, south-central Alaska (plot locations shown have some deliberate spatial error added to protect privacy of private landowners).

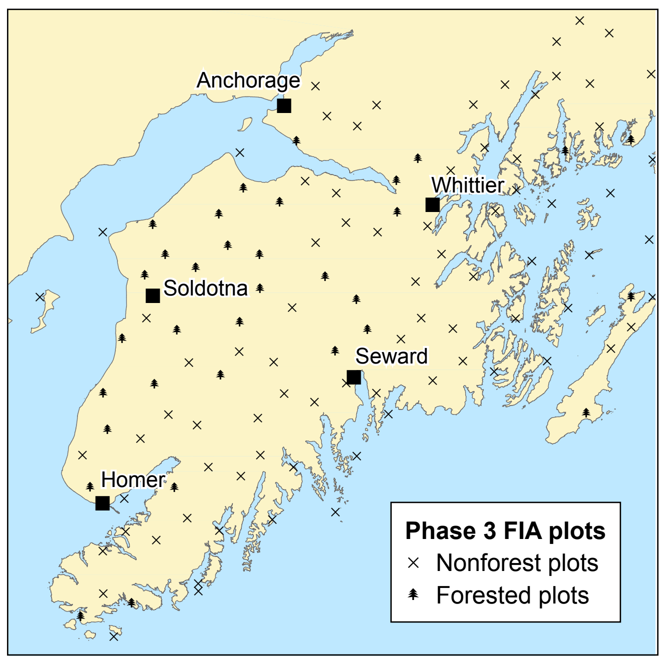


Figure 4—Forest Inventory and Analysis (FIA) phase 3 plots on the Kenai Peninsula, south-central Alaska (plot locations shown have some deliberate spatial error added to protect privacy of private landowners).

Misha Yatskov

Chapter 2: Basic Resource Information

This chapter provides an overview of the distribution, composition, and ownership of forests in the coastal Alaska inventory unit. The basic physical, ecological, and socioeconomic attributes of the region are described, providing context for later chapters in the report. Aboveground forest biomass and carbon are characterized by forest type, tree size, and ownership. The chapter concludes with a description of recent change in the inventory area, including changes in forest area, numbers of trees, biomass, carbon, and volume.

Forest Area, Composition, and Ownership[1]

Background

Ecological provinces—
The coastal Alaska region is characterized by outstanding natural beauty, with a rocky forested archipelago and coastline bordered by the Pacific Ocean on one side and glacier-studded mountains on the other. This report highlights the current status and trends of forests in the 37.8-million-acre coastal inventory region, which stretches 1,170 miles from Kodiak Island in the southwest to the Canadian border in the southeast. As the inventory unit crosses two different broad ecoregional divisions within Alaska (fig. 5), two groups of forest types are represented: boreal forest types on the western Kenai Peninsula and Cook Inlet region, and coastal temperate rain forests in the rest of the inventory unit.

[1] Authors: Tara M. Barrett and Kenneth Winterberger.

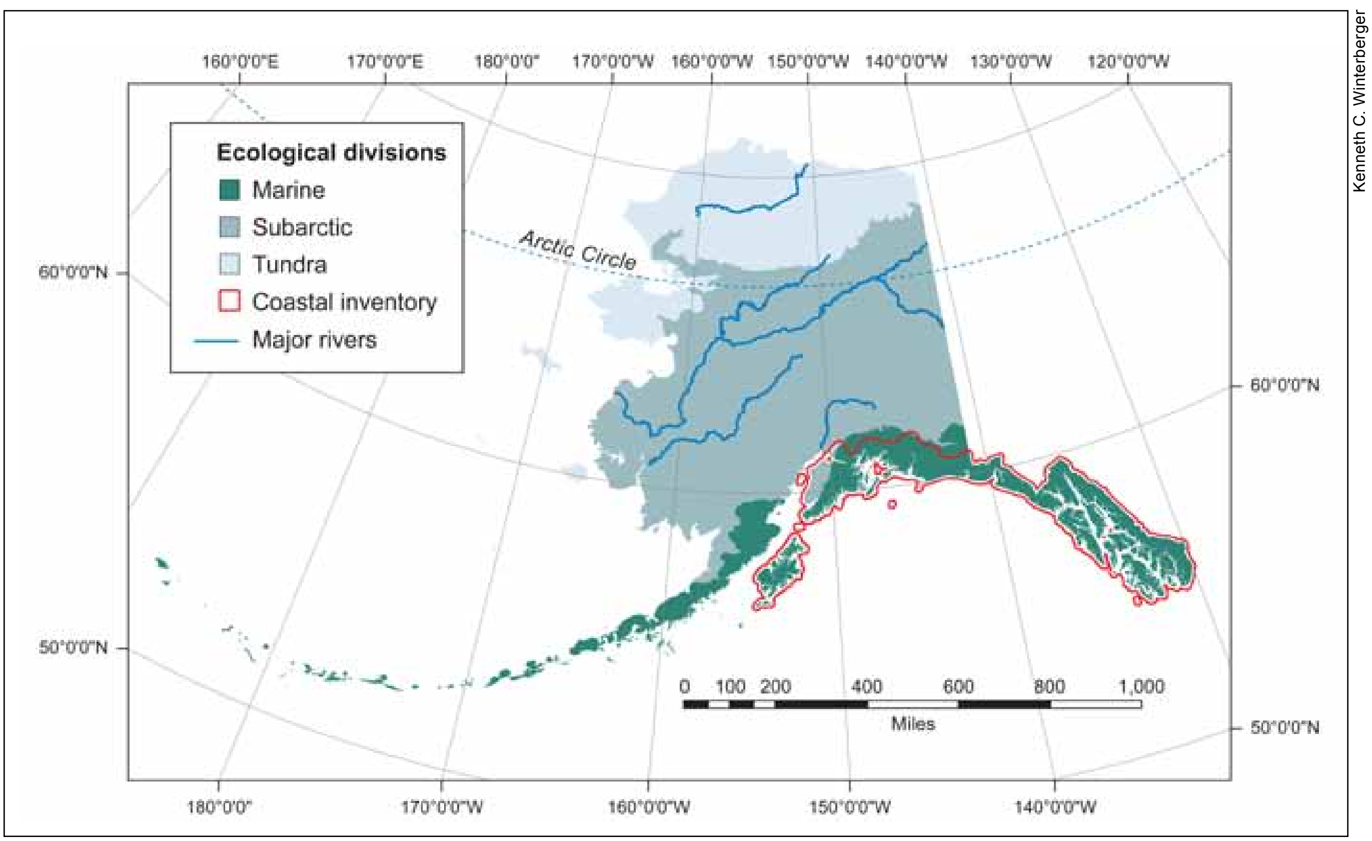


Figure 5—Alaska division-level ecoregions: Marine, Subarctic (boreal), and Tundra (arctic) (division boundaries are based on Nowacki et al. 2002). Projection: Alaska Albers NAD 83.

The Coastal Rainforests ecological province (fig. 6) that falls into the inventory region consists of the Kodiak Island, Gulf of Alaska Coast, and Alexander Archipelago ecological sections (Nowaki et al. 2002) (fig. 7). Wildlife includes bald eagles; otters; black bear; moose; Sitka black-tailed deer; the Alaskan brown bear; and pink, chum, king, and sockeye salmon (see "Common and Scientific Names"). The most characteristic tree species for the Coastal Rainforests province are Sitka spruce and western hemlock, with mountain hemlock at higher elevations. In the southeast portion of this province, yellow-cedar, western redcedar, and small amounts of lodgepole pine are found. Cottonwood grows along riparian areas, with alder, willow, and birch shrubs also occurring in wetland areas.

On the western side of the Kenai Peninsula, boreal forest in the Cook Inlet Basin ecological section falls within the boundaries of the coastal inventory unit (Nowaki et al. 2002) (fig. 7). In this region, wetlands are common, as are numerous small lakes. Much of the lowland area is characterized by black spruce, with cottonwoods, alder, and willow in riparian areas. More productive well-drained sites have white spruce, Lutz spruce (a Sitka spruce/white spruce hybrid), birch, and aspen. Wildlife includes dense populations of moose; black bear; beavers; and muskrats; and sockeye, king, and silver salmon are found in the rivers and streams of the area.

These two ecological provinces are distinguished by differences in climate. Throughout the Coastal Rainforests ecological province, mean annual temperature is moderate (fig. 8), mean annual precipitation is high (fig. 9), and fire is very uncommon. The Cook Inlet ecological section on the western Kenai Peninsula has a lower average annual temperature and less annual precipitation than the Coastal Rainforests province. Historical fire occurrence on the western Kenai, while low when compared with that in much of the Western United States, is more frequent than in the Coastal Rainforests. Permafrost occurs on the western Kenai, although it is probably only present in small areas of the landscape and at substantial soil depths (Berg 2009).

Kenneth C. Winterberger

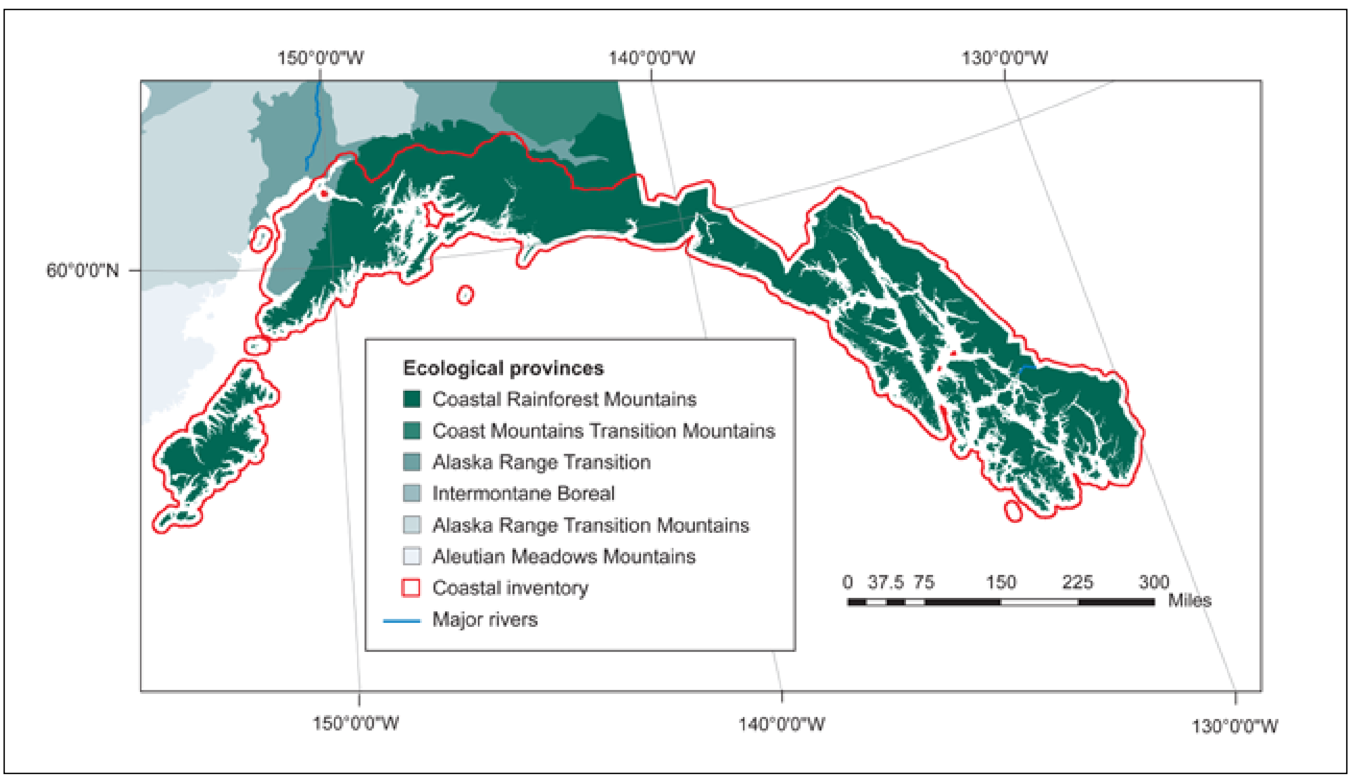


Figure 6—The Forest Inventory and Analysis coastal inventory unit. Most of the area consists of the Coastal Rainforest ecological province, but it also contains a small portion of the Alaskan boreal forests (Alaska Range Transition ecological province) on the western Kenai (division boundaries are based on Nowacki et al. 2002). Projection: Alaska Albers NAD 83.

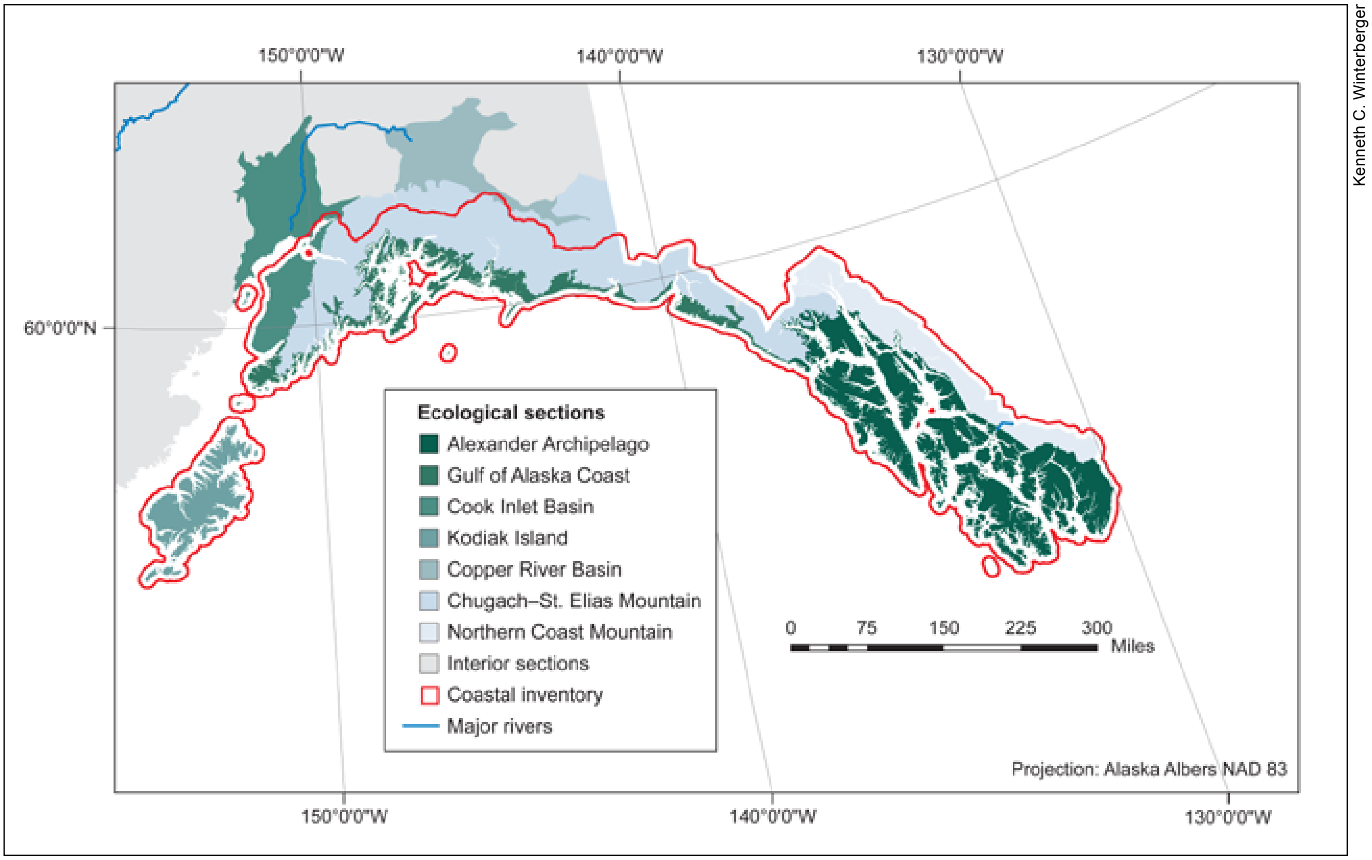


Figure 7—Ecological sections (ecoregions) in the Forest Inventory and Analysis coastal inventory unit (section boundaries based on Nowacki et al. 2002). Projection: Alaska Albers NAD 83.

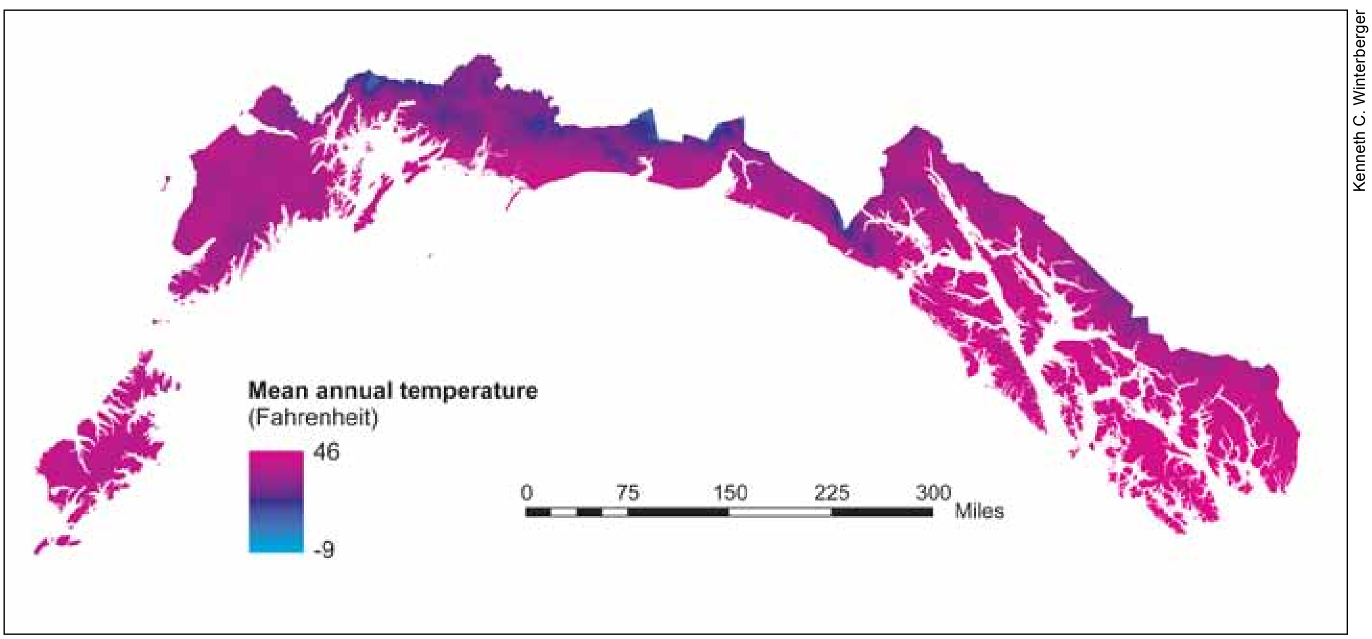


Figure 8—Mean annual temperature in the inventory unit (data are from the PRISM Climate Group 2002).

Kenneth C. Winterberger

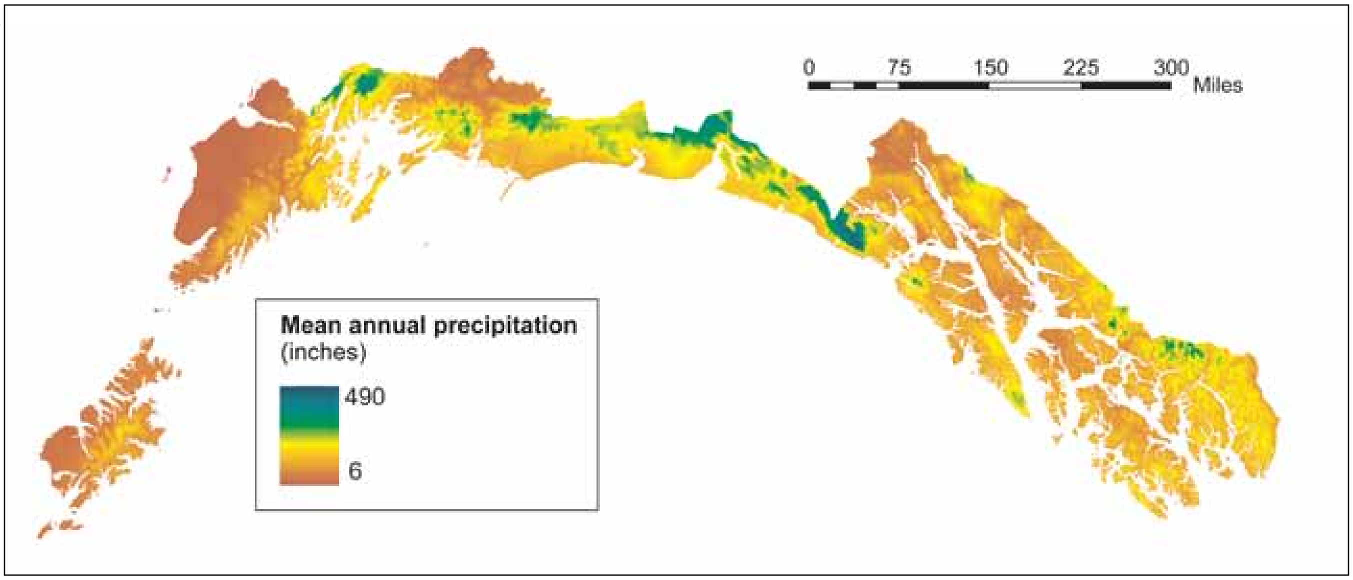


Figure 9—Mean annual precipitation in the inventory unit (data are from the PRISM Climate Group 2002). Source: Alaska Average Monthly or Annual Mean Temperature, 1961–90, Spatial Climate Analysis Service at Oregon State University (SCAS/OSU).

Four mountain ranges within the inventory unit affect temperature, precipitation, and the amount of precipitation that falls as snow. The Kenai Mountains divide the Coastal Rainforests province of Kenai Fjords and the Prince William Sound area from the boreal forests of the western Kenai. From west to east the Chugach, Saint Elias, and Coastal Mountain Ranges form the northern border of the inventory unit, with land cover of rock, ice, and alpine vegetation. The inventory unit is within a geologically active area, and subsidence and uplift following earthquakes is a significant source of disturbance. Other common types of disturbance include flooding, avalanches, and windstorms.

Population and economy—

State residents often use the phrase “Things are different in Alaska.” Alaska has the lowest population density of the 50 U.S. States, with an estimated 1 person per square mile compared to the national average of more than 80 people per square mile. It has a single major municipal area, Anchorage, founded during World War I. Most towns and villages are located either along the coast or along the limited road system. Alaska does not have counties, and internal boundaries used for political divisions and the U.S. census tend to change over time. The native flora and fauna has had relatively little impact from 20th-century development, in comparison to the native flora and fauna of other U.S. States.

The current coastal forest inventory unit contains the former southeast Alaska inventory unit (van Hees 2003) and the former south-central Alaska inventory unit (van Hees 2005b). These two areas differ fairly substantially in population and economy. The southeast area contains the census areas of Haines, Hoonah-Angoon, Juneau, Ketchikan Gateway, Prince of Wales-Outer Ketchikan, Sitka, Skagway-Yakutat-Angoon, Wrangell-Petersburg, and Yakutat. This southeast area has a population of less than 100,000 people, and growth has been slow or level for recent decades (fig. 10). The south-central area contains portions of the Anchorage, Kenai Peninsula, Kodiak Island, and Valdez-Cordova census areas. The south-central area contains about one half of the state’s population, and growth has been increasing at about 11 percent per decade (fig. 10).

The coastal inventory region of Alaska, like the rest of the state, has a rich and diverse cultural history. Native cultures in the inventory region included the Athabaskan Dena’ina on the western Kenai Peninsula and Cook Inlet region, the Koniag Alutiiq (Sugpiaq) on Kodiak Island, the Chugach Alutiiq in the Prince William Sound region, the Eyak in the Copper River Delta, and the Tlingit and Haida in southeast Alaska (Langdon 2008). Alaska Native

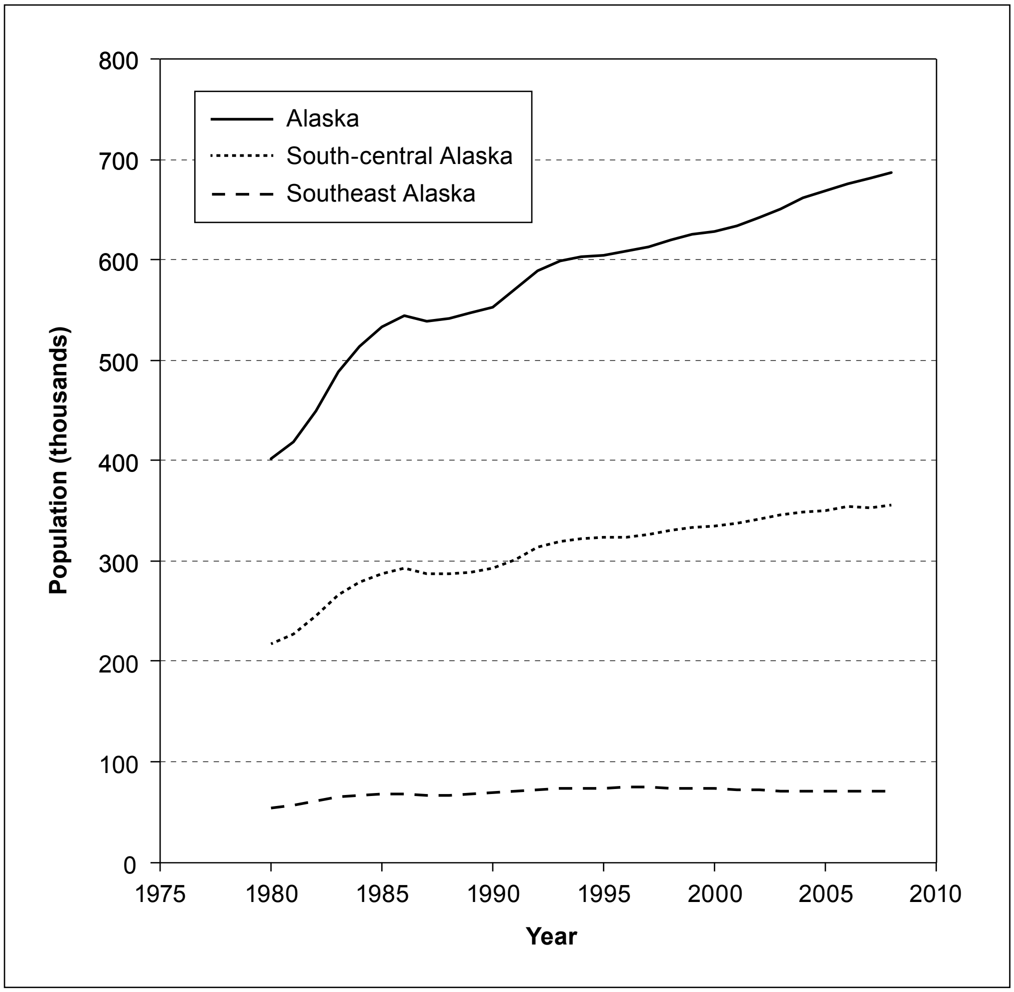


Figure 10—Population trends for the southeast and south-central census areas and for the state (U.S. Census Bureau 2009).

corporations are major forest landowners, both in the state as a whole and in the coastal inventory region.

The economy of the state is somewhat independent from that of the rest of the United States, with relatively stable employment and housing prices during the U.S. recession of 2008–2010. However, rural areas have been negatively impacted by high energy and commodity prices in recent years. Subsistence use, hunting, fishing, tourism, mining, and energy development are economic uses within the coastal inventory region. Logging, commercial fishing, and state and local government employment are important components of the economy in the southeast region. The south-central region has a more diversified economy, including more manufacturing, retail, and service industries.

Results

Smith et al. (2009) provided approximate values of 11.9 million acres of timberland and 126.9 million acres of forest land in Alaska. Using those values for the state, the 6.2 million acres of timberland in the coastal inventory unit would constitute 52 percent of timberland in Alaska, and the 15.3 million acres of forest land in the coastal inventory unit would constitute 12 percent of forest land in Alaska. Forest is defined as land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover that is not developed for a nonforest use (see "Glossary" for a detailed definition). Timberland is defined as unreserved forest land that is capable of producing at least 20 cubic feet per acre per year.

Approximately 40 percent of the coastal inventory unit is forested (fig. 11). Most of the forest in the region is found in the southeast, on the western side of the Kenai Peninsula, or in relatively thin coastal strips located between the ocean and the mountains (fig. 12). Of the 15.3 million acres of forest, 34.6 percent is reserved. Reserved land is reserved from management for wood products, and in the inventory region includes national parks and monuments, national wildlife refuges, state parks and game refuges, and wilderness areas and wilderness study areas in national forests. Additional detailed estimates for forest land and timberland by ownership, forest type, stand size class, and site class are shown in appendix 2.

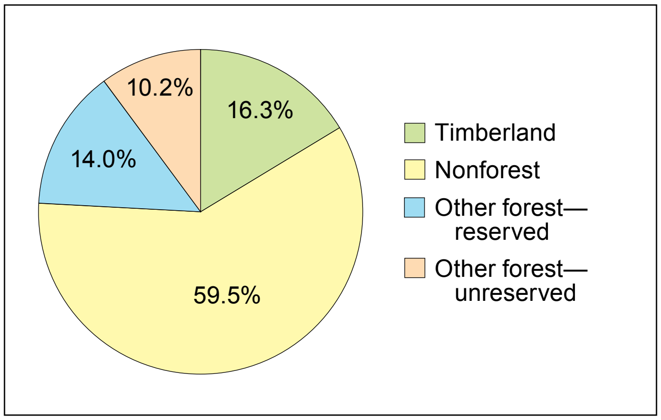


Figure 11—Percentage of area by land class category in coastal Alaska, 2004–2008.

Kenneth C. Winterberger

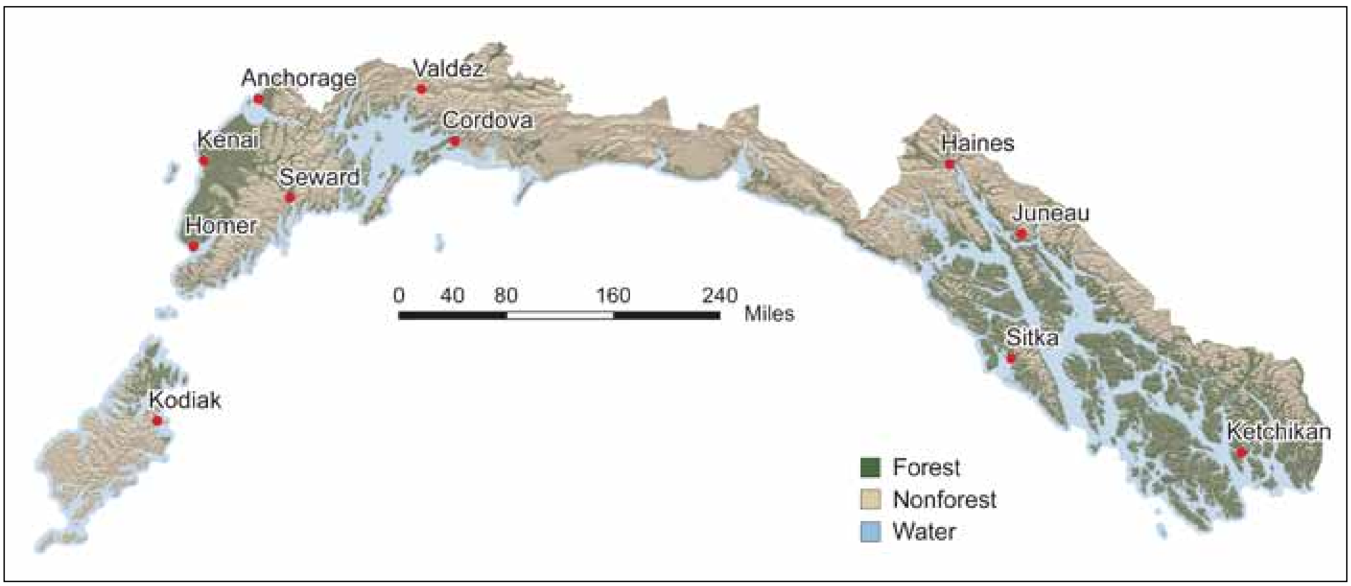


Figure 12—Approximate location of forest within the inventory unit.

When classified by the predominant tree species, western hemlock forest is the most common forest type for the inventory area, followed by mountain hemlock, yellow-cedar, Sitka spruce, and western redcedar (fig. 13). Sitka spruce and lodgepole are the forest types with the lowest proportion of area in reserve status; black spruce and aspen have the highest proportion of area in reserve status.

Almost 88 percent of forest in the coastal inventory unit is in public ownership (fig. 14). On private land, 79 percent of the forest is considered timberland. On lands owned by state and local government, 66 percent of the forest is considered timberland. On national forests, only 35 percent of forest land on national forests is timberland. The two largest national forests in the United States are found in the coastal inventory region; the Tongass National Forest in southeast Alaska, and the Chugach National Forest in south-central Alaska. Other federal land in the region includes national parks (Wrangell St. Elias, Kenai Fjords, and Glacier Bay National Parks) and national wildlife refuges (Kodiak and Kenai National Wildlife Refuges). Most of this other federal land is nonforest, and very little (5 percent) of the forest is timberland.

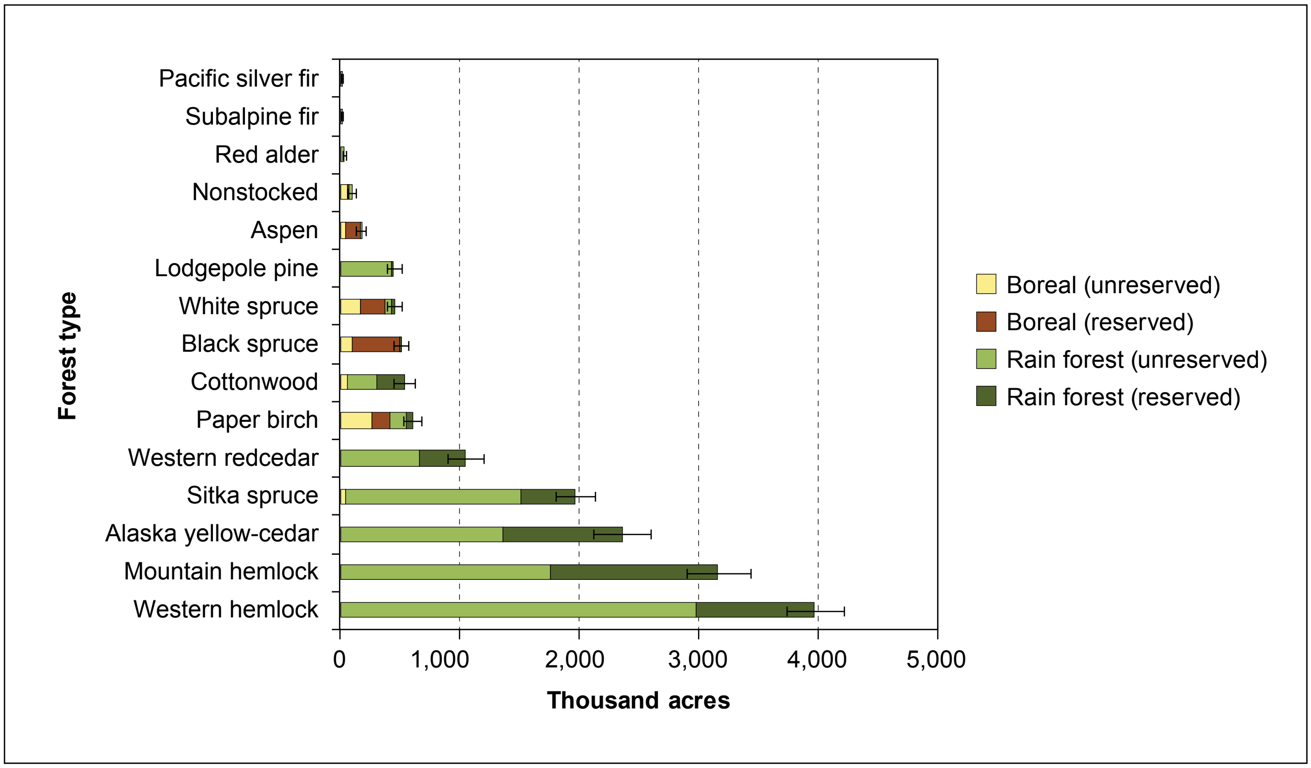


Figure 13—Forest types within the inventory area by reserve status. Lines at end of bars represent ± standard error.

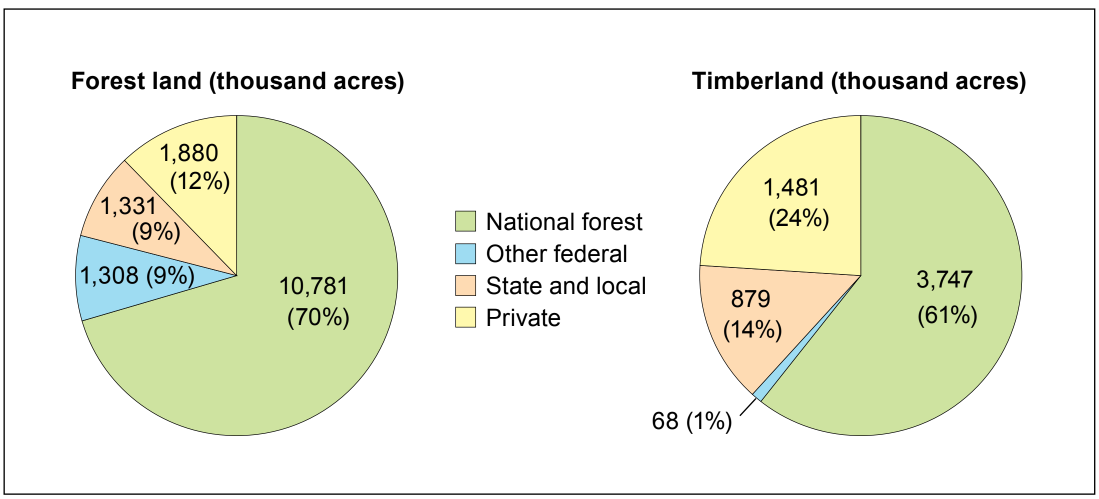


Figure 14—Timberland and forest land by owner group in the coastal inventory unit.

Numbers of growing-stock trees (see "Glossary" for definition) on timberland by diameter size class are shown in appendix 2, along with volume statistics. Much higher volumes per acre of sawtimber on timberland are found on federal land than on private land. Total volume of growing-stock trees on timberland is 29 billion cubic feet or 157 billion board feet. Western hemlock has the highest growing-stock volume on timberland, followed by Sitka spruce.

The coastal forest in Alaska is part of a larger eco-region including the coastal forests of British Columbia, Oregon, and Washington. However, even where forest types are similar, significant structural differences in the forest are noticeable. For example, yellow-cedar is not found in the coastal forests of south-central Alaska and is uncommon in coastal forests of Oregon and Washington (see chapter 4). Or, for example, western hemlock/Sitka spruce forests in Alaska show a dramatically different age class distribution than western hemlock/Sitka spruce forests in Oregon or Washington (fig. 15).

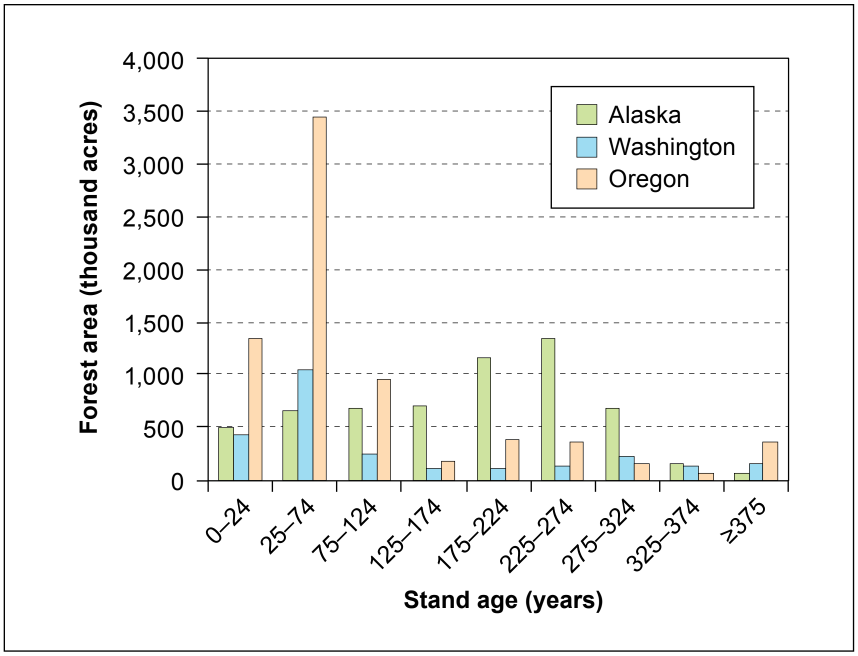


Figure 15—Distribution of western hemlock-Sitka spruce forest area in Alaska, Oregon, and Washington by age class (from Forest Inventory and Analysis data collected 2001–2008 for Oregon, 2002–2008 for Washington, and 2004–2008 for Alaska).

Interpretation

The relatively low human population density, the relatively high proportion of reserved land, and the relatively low potential productivity of forest land all contribute to the unique nature of the forests of coastal Alaska:

Estimate	Coastal Alaska	U.S. average[a]
Percentage of land that is forested	40	33
People per forested acre	2	36
Percentage of forest land that is privately owned	12	56
Percentage of forested land that is reserved	35	10
Percentage of forest land that is timberland	41	68
Percentage of timberland that is capable of producing at least 85 $ft^3 \cdot ac^{-1} \cdot yr^{-1}$	6	35
Percentage of timberland that is at least 200 years old	39	2

[a] U.S. average estimates were calculated from Smith et al. (2009).

The extent, composition, and structural characteristics of the forests in coastal Alaska are driven by a complex set of human and environmental factors. The environmental factors—soil, temperature, precipitation—control where different tree species are found, and wind, flooding, fire, insects, and disease affect succession, mortality, and regeneration. The human factors—timber harvest, development, and fire suppression—affect characteristics such as age structure, fuels, and fragmentation. In addition, unpredictable elements such as invasive species and climate change, which are driven by both environmental and human factors, can greatly affect how forests will change over time.

In coastal Alaska, the human factors have had relatively less impact on forests than in many other parts of the United States or the world. For example, as shown in figure 15, in Oregon and Washington, management has dramatically shifted the distribution of hemlock-spruce coastal forest into younger age classes. In contrast, the age class distribution of Alaskan hemlock-spruce forests more closely resembles what would be expected for coastal forests of several centuries ago, with stand-replacing disturbance relatively rare. This does not mean that human impacts have been insignificant. In the later chapters of this report, we explore some of the ways that forests in coastal Alaska are changing.

In summary, climate is the principal factor controlling where different tree species are found in coastal Alaska. Most of the inventory region has a maritime climate of high precipitation, moderate winters, and cool summers, resulting in temperate coastal coniferous rain forest. Small portions of the inventory unit, in the western Kenai and the upper Copper River region, experience less precipitation, hotter summers, and colder winters, resulting in boreal forest species. The coastal forest region, although only 10 percent of Alaska land area, contains about half of the timberland and about half of the people in the state. Relative to the rest of the United States, the coastal region contains slower growing forest, older forest, less forest in private ownership, and much more forest per capita.

Biomass and Carbon[2]

Background

Forest biomass can be defined as the dry weight of all living, or recently living, plant material within a given area of forest. Aboveground vegetation biomass is a critical determinant of net primary productivity, and therefore the carbon budget, of a forest ecosystem (Chapin et al. 2002). Forest carbon accumulates within a forest system through the process of photosynthesis, and leaves the system through the processes of respiration, decomposition, combustion (wildfire), and hydrological transport, as well as anthropogenic causes such as harvesting. Carbon makes up approximately 50 percent of forest biomass (Chapin 2002, Fahey et al. 2005). Assessment of the quantity and distribution of biomass and carbon resources using comprehensive forest inventory data is important in determining carbon stocks and monitoring the change of these stocks over time.

The forest carbon resource in coastal Alaska— Comprehensive inventory data can also be used to develop landscape- and regional-scale assessments of carbon stocks. With the emergence of international markets for carbon credits—the Chicago Climate Exchange in the United States had joined already active exchanges in Europe, Asia, and Australia—there is a critical need to quantify existing carbon stocks and evaluate possible outcomes of various alternative carbon management options under varying climatic and disturbance regimes (Leighty et al. 2006). The possibility of gaining carbon credits—where each credit equals 1 ton of carbon—could provide incentives for forest landowners to modify management practices (e.g., lengthen rotations, intensify reforestation and restoration activities) so as to increase levels of accumulated carbon beyond what would have been achieved under existing practices, thereby allowing them to manage carbon as an additional forest product (Wolfe 2008). In addition, managing to maximize forest carbon sequestration can complement other activities designed to improve forest health, maintain wildlife habitat, and increase forest productivity, including removal of hazardous fuels (reduces carbon emissions from wildfires), use of biomass for energy production (use of a renewable resource is carbon-neutral; see sidebar on page 87), site preparation to improve growth of spruce seedlings in beetle-killed areas, and planting of mixed hardwood and spruce species to enhance wildlife habitat (Cole et al. 2004, Youngblood and Cole 2003). Carbon estimates obtained from a systematic, comprehensive inventory help to establish baseline information on where carbon is currently stored, while remeasurement data can provide information on rates of sequestration across the region.

Methods

Data from the Forest Inventory and Analysis (FIA) plots, measured from 2004 to 2008, were used to develop the findings reported in this section. The sources for biomass equations used are listed in appendix 1 of this report. All calculations of carbon are based on the assumption that carbon = biomass × 0.50 (Fahey et al. 2005). The wilderness and wilderness study areas of the Chugach and Tongass are included with a 20-percent sampling intensity compared to other lands, and Glacier Bay National Park is excluded.

Findings

There are over 1.3 billion tons of biomass stored within the live trees (≥ 1 inch diameter at breast height [d.b.h.]) of coastal Alaska (table 1, figs. 16 and 17). The overwhelming majority (83 percent) of the live forest biomass in coastal Alaska is on national forest land managed by the USDA Forest Service, with most of the remainder on privately owned land (7 percent) and land managed by state and local governments (7 percent) (table 2, fig. 18).

[2] Author: Hans-Erik Andersen.

Table 1—Estimated aboveground biomass of live trees by forest type and diameter class, coastal Alaska, 2004–2008

	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	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand bone-dry tons											
Softwoods:												
Alaska yellow-cedar	8,413	1,566	5,426	791	8,439	1,127	12,217	1,654	14,955	2,033	16,136	2,266
Black spruce	2,174	313	2,513	450	1,518	358	585	168	170	68	184	93
Lodgepole pine	1,162	294	530	152	804	160	1,160	248	958	210	1,060	264
Mountain hemlock	2,747	347	4,314	739	7,287	910	10,834	1,261	16,247	2,326	16,280	2,201
Sitka spruce	4,865	1,001	3,658	556	5,109	715	7,155	919	9,271	1,267	11,093	1,566
Western hemlock	5,506	701	6,896	749	11,465	1,076	16,810	1,478	23,213	2,145	26,338	2,397
Western redcedar	1,704	306	1,537	300	3,655	608	5,402	973	6,947	1,283	9,068	1,656
White spruce	495	142	882	304	1,110	224	1,079	202	865	223	717	177
Total	27,066	1,962	25,757	1,391	39,389	1,575	55,242	2,096	72,624	3,038	80,876	3,400
Hardwoods:												
Cottonwood	987	297	832	257	1,081	308	2,031	723	2,139	553	1,819	544
Aspen	235	86	417	138	529	172	589	233	718	321	718	268
Paper birch	426	108	1,210	348	1,550	303	2,090	343	2,668	515	2,508	476
Red alder	89	77	194	148	245	151	165	102	180	141	—	—
Total	1,737	333	2,653	476	3,404	483	4,874	834	5,705	823	5,045	763
Nonstocked	—	—	—	—	3	3	—	—	—	—	—	—
All forest types	28,803	1,979	28,409	1,440	42,796	1,593	60,117	2,143	78,329	3,079	85,922	3,427

	Diameter class (inches)													
	13.0–14.9		15.0–16.9		17.0–18.9		19.0–20.9		21.0–28.9		29+		All classes	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand bone-dry tons													
Softwoods:														
Alaska yellow-cedar	18,761	3,180	15,573	2,817	16,606	2,892	9,838	1,979	24,063	5,545	19,285	5,884	169,713	23,243
Black spruce	82	60	17	19	30	33	—	—	79	86	—	—	7,352	1,180
Lodgepole pine	843	271	529	187	511	186	312	180	718	338	—	—	8,587	1,797
Mountain hemlock	19,403	2,592	21,092	3,240	16,882	2,325	14,479	2,692	45,810	7,566	38,916	10,191	214,291	26,418
Sitka spruce	12,040	1,641	12,506	1,576	12,863	1,710	11,554	1,787	48,788	7,343	95,189	19,108	234,090	30,980
Western hemlock	28,144	2,120	28,888	2,441	34,904	3,778	32,421	2,873	144,098	12,148	186,858	20,666	545,541	38,105
Western redcedar	9,297	1,792	7,588	1,717	8,551	2,622	6,909	1,752	24,118	7,241	42,595	13,573	127,371	28,138
White spruce	355	113	127	81	97	72	80	78	—	—	—	—	5,807	1,108
Total	88,924	4,016	86,321	4,460	90,444	5,086	75,594	4,542	287,674	15,252	382,844	28,487	1,312,755	42,844
Hardwoods:														
Cottonwood	2,478	807	2,004	529	1,425	364	1,266	458	4,674	2,187	3,110	2,490	23,846	6,069
Aspen	351	161	300	138	93	80	42	46	—	—	—	—	3,992	1,256
Paper birch	1,474	363	1,514	480	952	326	435	239	1,131	457	309	316	16,267	2,601
Red alder	95	99	49	45	—	—	—	—	—	—	—	—	1,016	543
Total	4,398	902	3,868	721	2,470	494	1,743	518	5,806	2,233	3,419	2,510	45,120	6,681
Nonstocked	—	—	—	—	—	—	—	—	—	—	—	—	3	3
All forest types	93,321	4,045	90,188	4,497	92,914	5,098	77,337	4,558	293,480	15,388	386,263	28,578	1,357,878	42,840

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons.

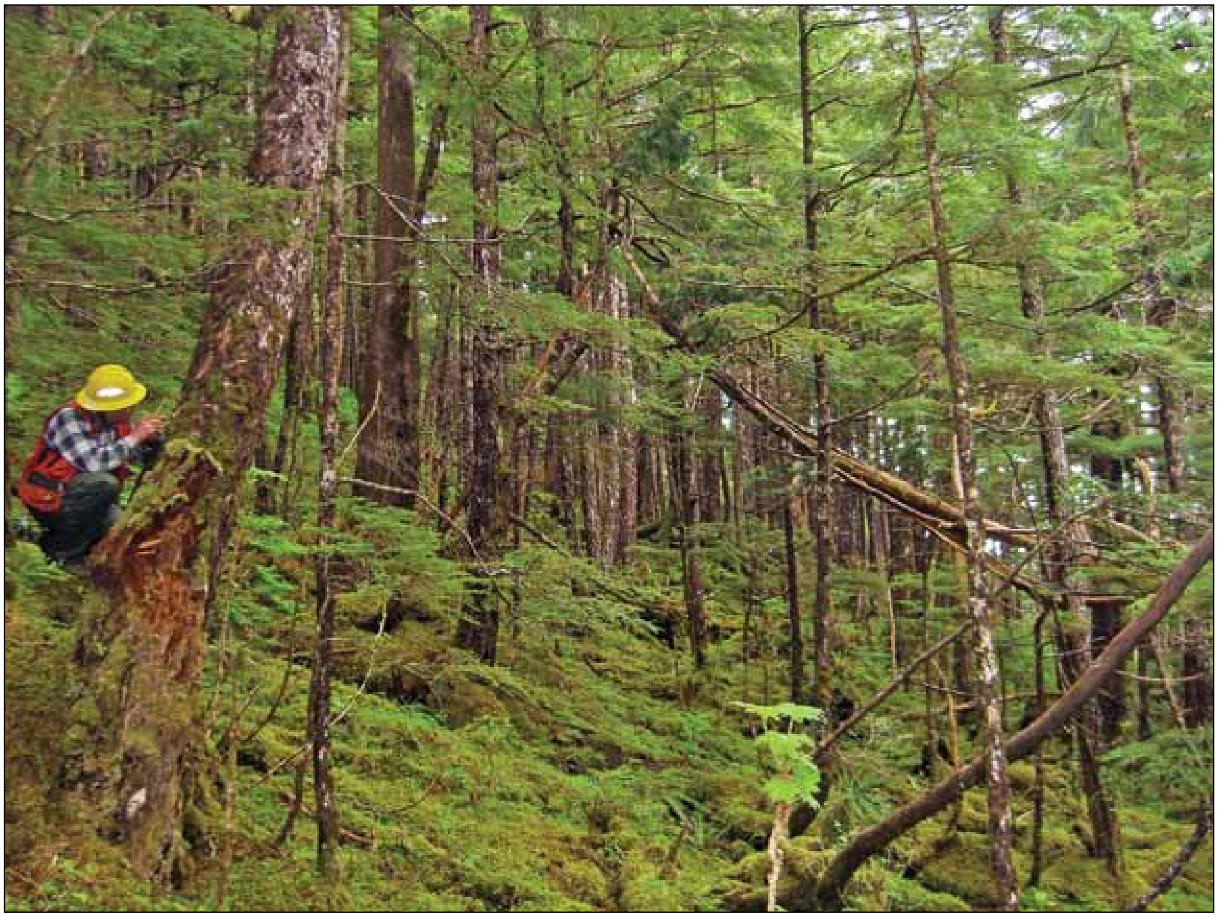


Figure 16—Significant forest carbon and biomass has accumulated in the spruce and hemlock forests of southeast Alaska.

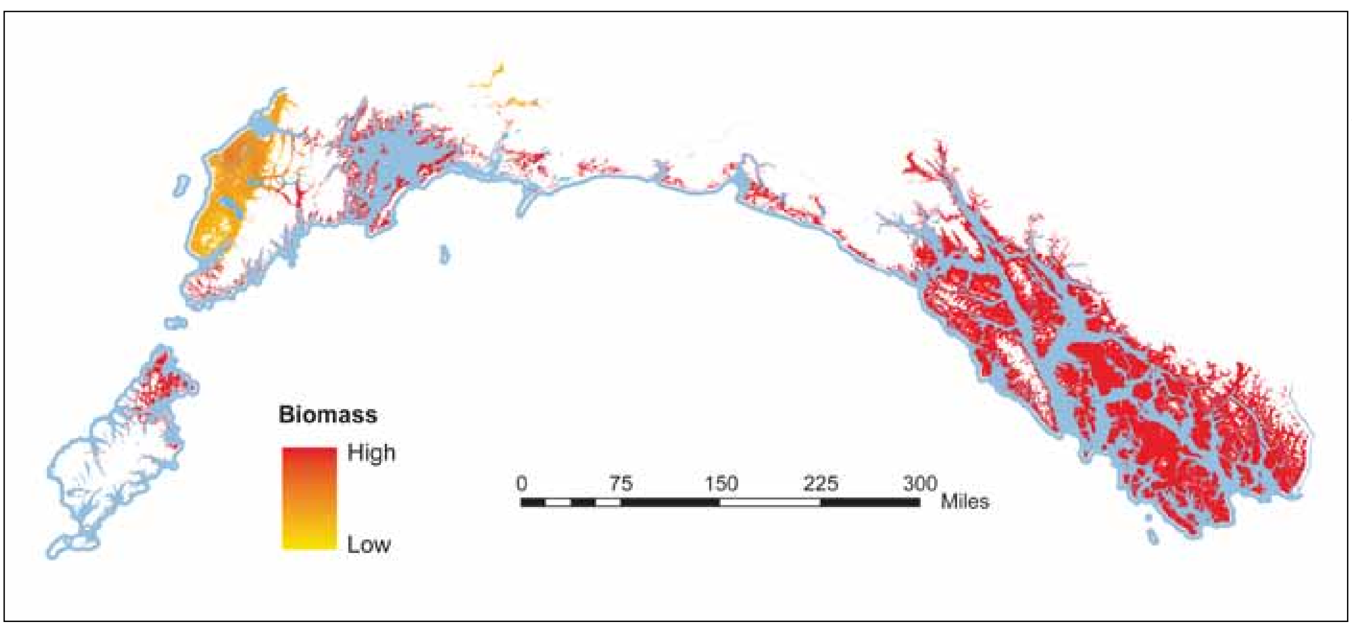


Figure 17—Distribution of forest biomass in coastal Alaska (biomass derivation procedure from Blackard et al. 2008).

Table 2—Estimated aboveground biomass of live trees by forest type and owner group, coastal Alaska, 2004–2008

	Owner group									
	National forest		Other federal		State and local		Private		All owners	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand bone-dry tons									
Softwoods:										
Alaska yellow-cedar	163,206	23,139	—	—	4,149	2,097	2,357	1,019	169,713	23,243
Black spruce	—	—	6,388	1,064	245	199	719	471	7,352	1,180
Lodgepole pine	7,114	1,544	—	—	205	166	1,268	908	8,587	1,797
Mountain hemlock	192,957	26,090	4,343	1,553	10,431	3,286	6,559	2,314	214,291	26,418
Sitka spruce	150,659	29,083	2,838	1,772	41,236	6,621	39,357	8,298	234,090	30,980
Western hemlock	485,349	37,115	3,166	2,807	29,686	7,069	27,340	6,721	545,541	38,105
Western redcedar	123,089	28,078	—	—	2,716	1,790	1,567	962	127,371	28,138
White spruce	520	340	3,248	762	480	263	1,559	684	5,807	1,108
Total	1,122,896	41,310	19,983	3,678	89,149	9,967	80,727	10,399	1,312,755	42,844
Hardwoods:										
Cottonwood	6,269	3,194	10,360	4,789	3,859	1,565	3,358	1,205	23,846	6,069
Aspen	—	—	3,734	1,245	—	—	257	165	3,992	1,256
Paper birch	18	19	8,204	1,574	2,637	1,477	5,407	1,470	16,267	2,601
Red alder	1,016	543	—	—	—	—	—	—	1,016	543
Total	7,303	3,240	22,299	5,159	6,496	2,141	9,022	1,856	45,120	6,681
Nonstocked	—	—	—	—	—	—	3	3	3	3
All forest types	1,130,200	41,092	42,282	6,114	95,645	10,008	89,752	10,418	1,357,878	42,840

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons.

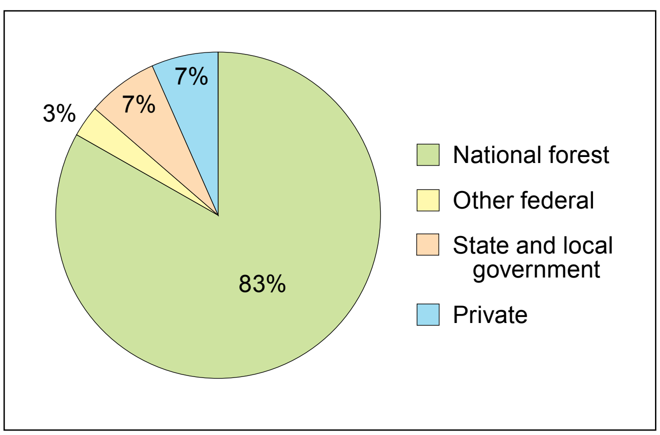


Figure 18—Aboveground live tree biomass by owner group on forest land in coastal Alaska, 2004–2008.

Almost all (97 percent) of the live tree biomass in the coastal inventory unit is within conifer forests (fig. 19). The highest average biomass levels in coastal Alaska are concentrated in the Sitka spruce (120 tons/acre), western redcedar (122 tons/acre), and western hemlock (137 tons/acre) forests of southeast Alaska (table 3). Most of the hardwood forest biomass is stored in black cottonwood and paper birch forests (fig. 19). In the northern and western areas of coastal Alaska, there are concentrations of relatively high forest biomass on Afognak Island, eastern Kenai Peninsula, and Prince William Sound, with lower average biomass levels within the white spruce and mixed-hardwood forests on the western lowlands of the Kenai Peninsula (fig. 17). Most (28 percent) of the live tree biomass for conifer forest is concentrated in trees greater than 29 inch d.b.h., whereas most (13 percent) of the live

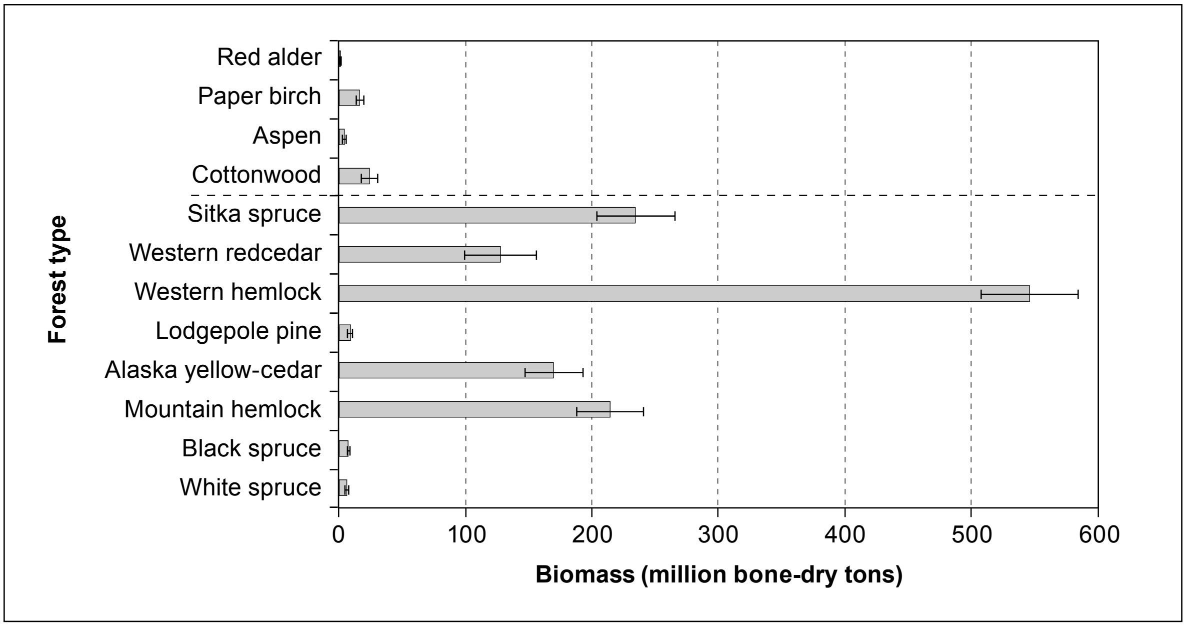


Figure 19—Aboveground live tree biomass by forest type on forest land in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

Table 3—Estimated average aboveground biomass of live trees by forest type and owner group, coastal Alaska, 2004-2008

	Owner group									
	National forest		Other federal		State and local		Private		All owners	
Forest type	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Bone-dry tons per acre									
Softwoods:										
Alaska yellow-cedar	73.1	6.3	—	—	77.4	16.3	34.7	8.9	72.1	6.1
Black spruce	—	—	15.2	1.8	10.0	3.8	13.7	5.9	14.7	1.6
Lodgepole pine	18.9	2.5	—	—	5.5	2.8	40.7	10.5	19.3	2.6
Mountain hemlock	70.3	7.0	39.4	8.4	73.2	10.9	39.6	10.0	67.8	6.1
Sitka spruce	161.4	15.1	112.3	23.3	91.7	10.6	71.7	12.7	119.6	9.6
Western hemlock	145.3	6.1	201.0	—	135.6	17.3	69.0	13.3	137.4	5.5
Western redcedar	132.1	17.4	—	—	63.2	24.5	24.0	10.5	122.5	16.3
White spruce	21.8	4.1	14.0	2.3	7.8	3.3	12.0	3.9	13.0	1.8
Total	106.0	3.8	24.8	3.9	86.5	7.3	55.4	6.2	94.5	3.0
Hardwoods:										
Cottonwood	42.6	13.6	73.8	26.4	30.5	8.6	28.4	6.2	44.8	8.9
Aspen	—	—	30.4	6.2	—	—	6.9	2.6	24.5	5.4
Paper birch	1.6	1.5	34.9	4.4	23.6	11.1	22.4	4.0	27.1	3.2
Red alder	34.0	9.4	—	—	—	—	—	—	34.0	9.4
Total	38.7	10.8	44.7	8.4	27.0	6.9	22.7	3.2	34.0	4.0
Nonstocked	—	—	—	—	—	—	0.1	0.1	0	0
All forest types	104.8	3.8	32.3	4.1	71.8	6.3	47.7	5.0	88.7	2.8

Note: Totals may be off because of rounding; data subject to sampling error; — = less than 50,000 bone-dry tons.

tree biomass in hardwood forest is in the 21.0 to 28.9-inch d.b.h. class (fig. 20). Relatively little of the total biomass in the coastal Alaska region is concentrated in the white spruce and black spruce forest types that characterize the southern extent of the boreal forest biome in Alaska (fig. 19). Most of the carbon accumulated in live (≥ 1 inch d.b.h.) and dead (≥ 5 inch d.b.h.) trees is also concentrated in western hemlock, mountain hemlock, and Sitka spruce forest types (table 4, fig. 21). A relatively high proportion of the carbon accumulated in conifer forest types is in standing dead material (snags)—especially in the white spruce type, where 47 percent of the carbon is stored in snags most likely killed by spruce bark beetle (*Dendroctonus rufipennis* [Kirby]) in south-central Alaska (table 5, figs. 22 and 23).

Interpretation

The forests of coastal Alaska represent a significant pool of stored carbon. Notably, much (24 percent) of the carbon stored in conifer forests of southeast and south-central Alaska is contained in snags—which, unlike live trees, will represent a net carbon source, as they are not photosynthetically active and are eventually emitting carbon either by burning or decomposing. As markets for carbon credits continue to emerge and requirements (and incentives) for carbon accounting become increasingly stringent at the local, state, and national levels, the comprehensive FIA inventory will serve as a useful source of information on the status and dynamics of the forest carbon resource.

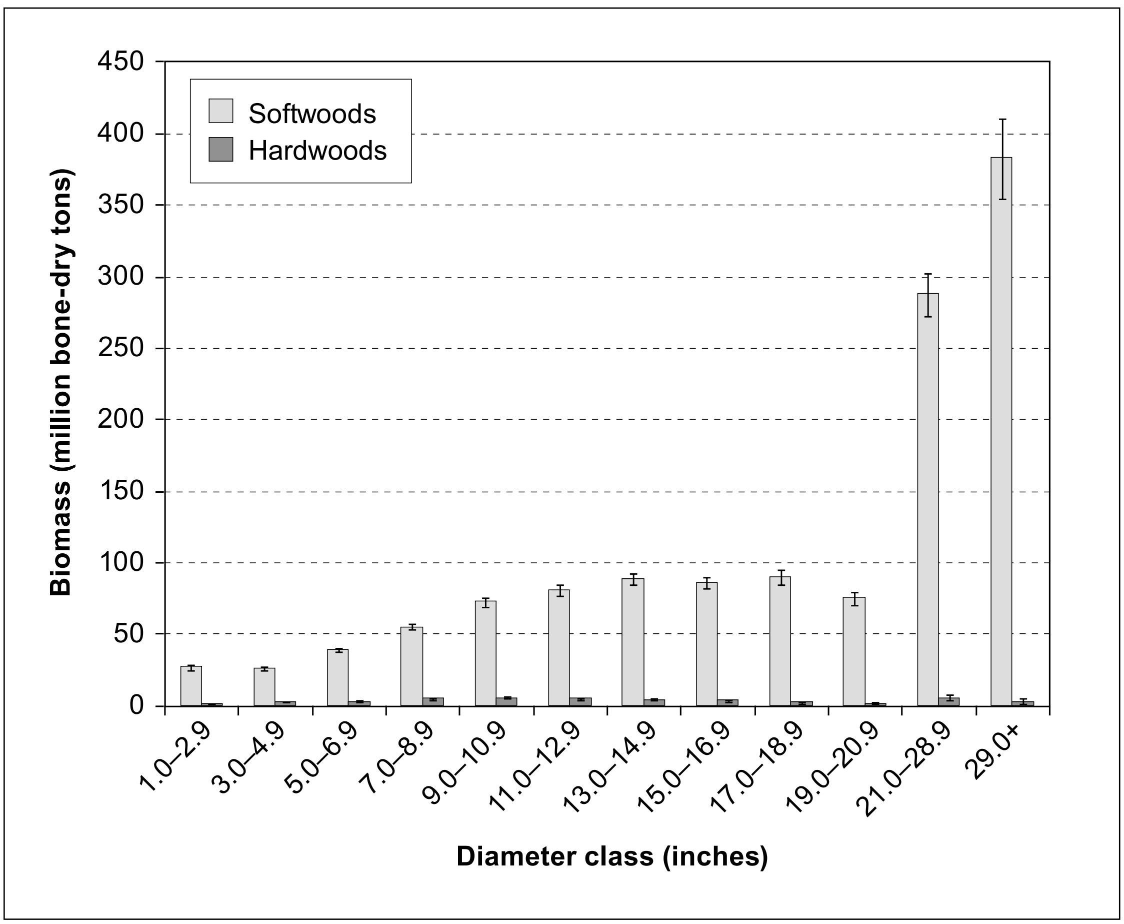


Figure 20—Aboveground live tree biomass by diameter class on forest land in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

Table 4—Estimated carbon of live trees and snags by forest type and owner group, coastal Alaska, 2004–2008

	Owner group											
	National forest				Other federal				State and local			
	Live trees		Snags		Live trees		Snags		Live trees		Snags	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand bone-dry tons											
Softwoods:												
Alaska yellow-cedar	81,603	11,570	24,145	5,025	81,603	11,570	24,145	5,025	2,075	1,049	376	189
Black spruce	—	—	—	—	3,194	532	351	167	122	99	11	10
Lodgepole pine	3,557	772	913	233	3,557	772	913	233	103	83	19	20
Mountain hemlock	96,479	13,045	13,330	2,083	98,650	13,067	13,631	2,088	5,216	1,643	949	384
Sitka spruce	75,330	14,542	13,553	3,968	76,749	14,568	14,026	4,000	20,618	3,310	2,799	728
Western hemlock	242,675	18,558	70,215	6,894	244,257	18,600	70,411	6,896	14,843	3,535	2,163	798
Western redcedar	61,544	14,039	16,320	3,129	61,544	14,039	16,320	3,129	1,358	895	374	298
White spruce	260	170	33	26	1,884	417	1,209	299	240	131	682	362
Total	561,448	20,655	138,508	7,826	571,440	20,719	141,004	7,851	44,574	4,983	7,373	1,182
Hardwoods:												
Aspen	—	—	—	—	1,867	622	622	214	—	—	—	—
Cottonwood	3,134	1,597	120	80	8,315	2,878	228	107	1,929	782	444	289
Paper birch	9	9	—	—	4,111	787	888	269	1319	738.3	792.8	368.9
Red alder	508	271	113	79	508	271	113	79	—	—	—	—
Total	3,652	1,620	233	113	14,801	3,046	1,852	355	3,248	1,071	1,237	469
Nonstocked	—	—	—	—	—	—	—	—	—	—	610	275
All forest types	565,100	20,546	138,741	7,824	586,241	20,745	142,856	7,852	47,822	5,004	9,220	1,225

	Owner group							
	Private				All owners			
	Live trees		Snags		Live trees		Snags	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand bone-dry tons							
Softwoods:								
Alaska yellow-cedar	1,179	510	268	133	84,857	11,621	24,789	5,030
Black spruce	360	236	27	22	3,676	590	388	169
Lodgepole pine	634	454	122	101	4,294	899	1,055	254
Mountain hemlock	3,279	1,157	520	241	107,145	13,209	15,100	2,136
Sitka spruce	19,679	4,149	2,705	683	117,045	15,490	19,530	4,120
Western hemlock	13,670	3,360	3,250	976	272,770	19,053	75,824	6,998
Western redcedar	783	481	184	111	63,686	14,069	16,877	3,142
White spruce	779	342	717	338	2,904	554	2,607	572
Total	40,363	5,199	7,793	1,218	656,377	21,422	156,171	7,971
Hardwoods:								
Aspen	129	83	4	4	1,996	628	625	214
Cottonwood	1,679	602	215	189	11,923	3,034	887	362
Paper birch	2703.6	734.85	851.04	275.1	8133.4	1301	2532.3	532.8
Red alder	—	—	—	—	508	271	113	79
Total	4,511	928	1,069	328	22,560	3,340	4,158	669
Nonstocked	1	1	207	172	1	1	817	325
All forest types	44,876	5,209	9,070	1,243	678,939	21,420	161,146	7,978

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons.

Table 5—Estimated average carbon of live trees and snags by forest type and owner group, coastal Alaska, 2004–2008

	Owner group											
	National forest				Other federal				State and local			
	Live trees		Snags		Live trees		Snags		Live trees		Snags	
Forest type	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
	Bone-dry tons per acre											
Softwoods:												
Alaska yellow-cedar	36.5	3.2	10.8	1.8	36.5	3.2	10.8	1.8	38.7	8.2	7.0	1.5
Black spruce	—	—	—	—	7.6	0.9	0.8	0.4	5.0	1.9	0.5	0.2
Lodgepole pine	9.4	1.3	2.4	0.5	9.4	1.3	2.4	0.5	2.8	1.4	0.5	0.4
Mountain hemlock	35.2	3.5	4.9	0.7	34.6	3.4	4.8	0.7	36.6	5.5	6.7	1.9
Sitka spruce	80.7	7.5	14.5	3.3	80.1	7.4	14.6	3.2	45.9	5.3	6.2	1.4
Western hemlock	72.7	3.1	21.0	1.6	72.8	3.1	21.0	1.6	67.8	8.6	9.9	2.9
Western redcedar	66.0	8.7	17.5	2.3	66.0	8.7	17.5	2.3	31.6	12.3	8.7	5.1
White spruce	10.9	2.0	1.4	0.8	7.4	1.1	4.7	0.9	3.9	1.6	11.1	3.0
Total	53.0	1.9	13.1	0.8	50.1	1.8	12.4	0.7	43.2	3.7	7.2	1.0
Hardwoods:												
Aspen	—	—	—	—	15.2	3.1	5.1	1.1	—	—	—	—
Cottonwood	21.3	6.8	0.8	0.6	28.9	7.8	0.8	0.4	15.3	4.3	3.5	2.0
Paper birch	0.8	0.8	—	—	16.6	2.2	3.6	0.8	11.8	5.5	7.1	2.4
Red alder	17.0	4.7	3.8	2.4	17.0	4.7	3.8	2.4	—	—	—	—
Total	19.3	5.4	1.2	0.7	21.5	3.4	2.7	0.5	13.5	3.5	5.1	1.6
Nonstocked	—	—	—	—	—	—	—	—	—	—	10.2	1.4
All forest types	52.4	1.9	12.9	0.7	48.5	1.7	11.8	0.7	35.9	3.1	6.9	0.8

	Owner group							
	Private				All owners			
	Live trees		Snags		Live trees		Snags	
Forest type	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
	Bone-dry tons per acre							
Softwoods:								
Alaska yellow-cedar	17.4	4.5	4.0	1.3	36.0	3.0	10.5	1.7
Black spruce	6.9	2.9	0.5	0.3	7.4	0.8	0.8	0.3
Lodgepole pine	20.3	5.2	3.9	1.9	9.6	1.3	2.4	0.4
Mountain hemlock	19.8	5.0	3.1	1.2	33.9	3.1	4.8	0.6
Sitka spruce	35.9	6.4	4.9	1.1	59.8	4.8	10.0	1.7
Western hemlock	34.5	6.6	8.2	2.1	68.7	2.7	19.1	1.4
Western redcedar	12.0	5.2	2.8	1.2	61.2	8.1	16.2	2.1
White spruce	6.0	2.0	5.5	2.0	6.5	0.9	5.8	1.0
Total	27.7	3.1	5.3	0.8	47.3	1.5	11.2	0.6
Hardwoods:								
Aspen	3.4	1.3	0.1	0.1	12.3	2.7	3.8	1.0
Cottonwood	14.2	3.1	1.8	1.5	22.4	4.4	1.7	0.7
Paper birch	11.2	2.0	3.5	0.9	13.5	1.6	4.2	0.7
Red alder	—	—	—	—	17.0	4.7	3.8	2.4
Total	11.4	1.6	2.7	0.7	17.0	2.0	3.1	0.5
Nonstocked	0.1	0.0	8.0	3.4	0.0	0.0	9.1	1.5
All forest types	23.9	2.5	4.8	0.6	44.4	1.4	10.5	0.5

Note: Totals may be off because of rounding; data subject to sampling error; SE = standard error; — = less than 50,000 bone-dry tons.

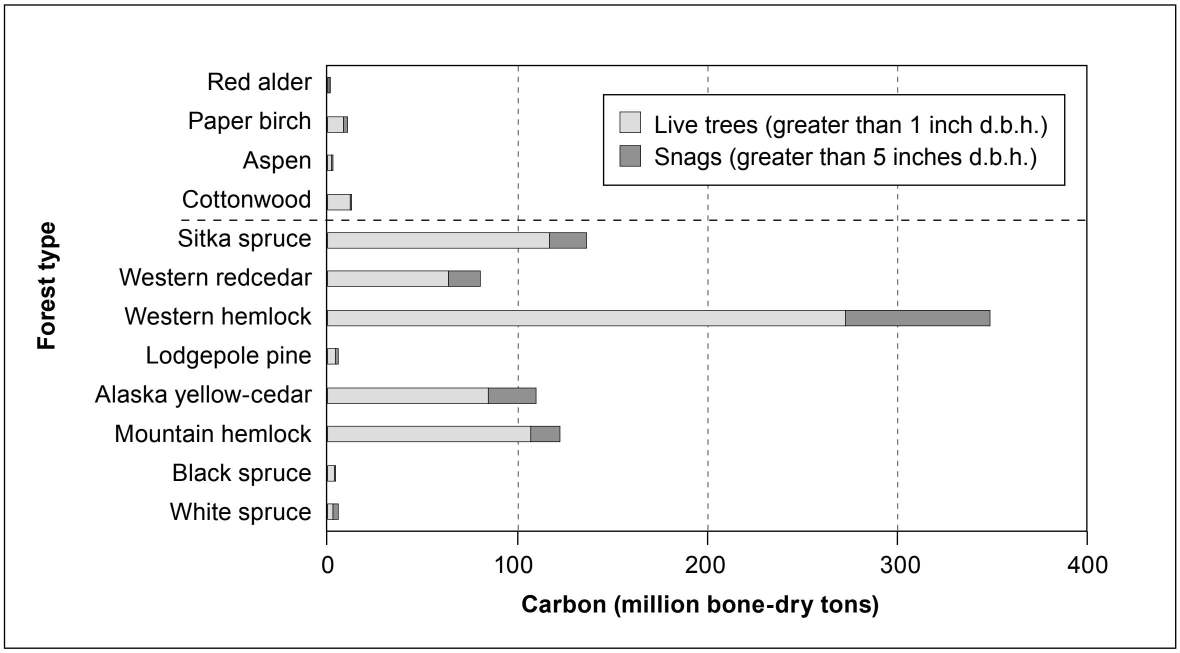


Figure 21—Carbon mass of live trees and snags by forest type on forest land in coastal Alaska, 2004–2008; d.b.h. = diameter at breast height.

Marc Much

Figure 22—A significant amount of forest carbon in coastal Alaska is stored in standing dead trees, such as these white spruce killed by bark beetles on the Kenai Peninsula.

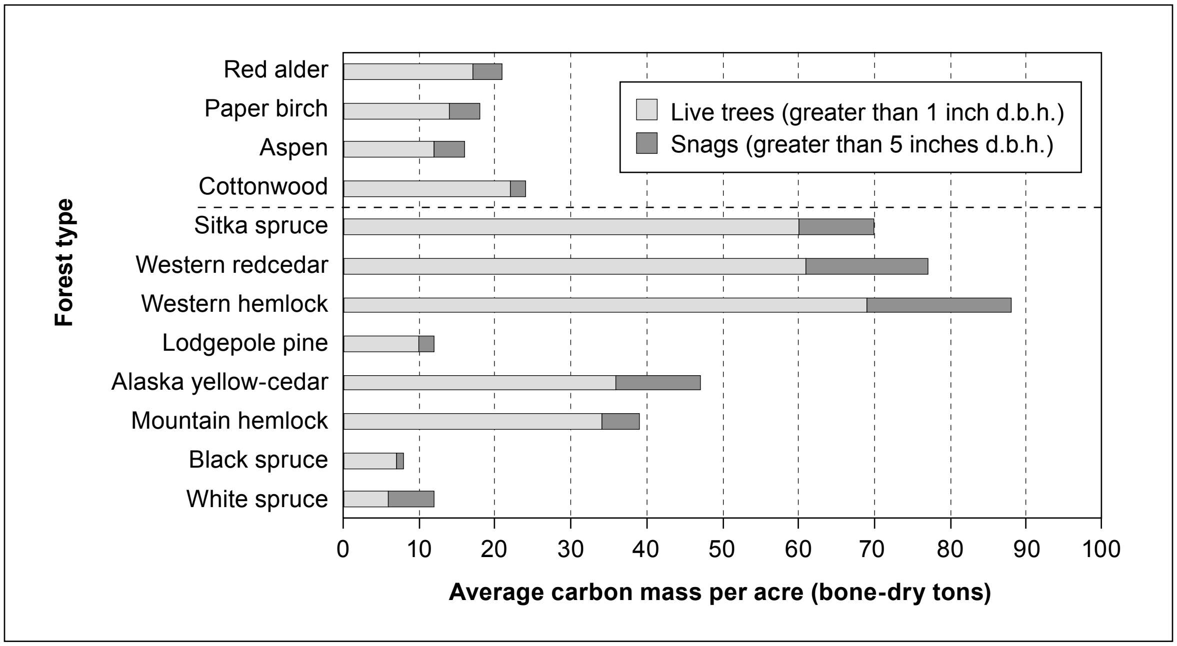


Figure 23—Average carbon mass of live trees and snags by forest type on forest land in coastal Alaska, 2004–2008; d.b.h. = diameter at breast height.

Change in Forests Between 1995–2003 and 2004–2008[3]

Background

Change in forests can be caused by a variety of natural and anthropogenic sources. It is usually not possible to attribute observed change to a single cause. Climate, plant competition, seed dispersal, herbivory, land development, mineral extraction, roadbuilding, fire, windstorms, invasive species, timber harvest, disease, flooding, earthquakes, volcanoes, and insect outbreaks can all cause change in coastal Alaska forests. Changes can occur in species composition, forest structure (e.g., vegetation density, height, or canopy layering), or in processes, such as rates of nutrient uptake or evapotranspiration.

Many of the factors that can cause change interact. For example, fire is more likely to be of high intensity if significant tree damage has previously occurred from some other cause such as insects or disease (e.g., Turner et al. 1999). Saturated soils from a climate of high precipitation can prevent trees from establishing deep root systems, making them more susceptible to windthrow. Land development often increases the probability of invasive species in many areas. Late spring freezes or summer drought can stress plants, making them more susceptible to disease. Although FIA field crews assign a general cause of death to each individual tree that dies, in many cases, it is an educated guess rather than a known cause.

Interpretation of change should incorporate the spatial and temporal context for the region being analyzed. At smaller spatial scales, forest indicators show greater fluctuation. Forest planners use the concept of "natural range of variability" to identify if a change is within expected boundaries, as any indicator will normally fluctuate in response to small-scale disturbances and regrowth. The region being reported on here is very large, incorporating the entire northern portion of the coastal temperate rain forest as well as the boreal forest region of the Kenai Peninsula. Thus changes are more likely to reflect underlying trends, and less likely to reflect small-scale disturbance or succession. However, there are some vectors of change that could be large enough to possibly impact regional trends, such as climate, harvest, windthrow, and, for the Kenai region, post-epidemic response to mortality from beetles.

[3] Author: Tara M. Barrett.

Although expansions of glaciers in the coastal Alaska region probably occurred during the Little Ice Age (760–260 BP) (Calkin et al. 2000), the last maximum glacial extent for coastal Alaska is believed to have occurred in the late Wisconsin glaciation (about 20,000 year BP). Because the glaciers would have covered most of the land that is now forest, trees had to recolonize the coastal region, and it is possible that some tree species such as yellow-cedar are still responding to the general warming trend. Overlying this long-term process is a more recent climate trend, global warming that may be related to an increase in greenhouse gases. Climate data for Alaska show that average annual temperature has increased for many parts of the state over the past 60 years. Although the 0.9° to 3.7-°F increase in the temperate coastal rain forest area (fig. 24) is less than increases in the subarctic and boreal forest regions of Alaska, this is still a substantial change. The coastal region is expected to experience additional increases in average annual temperature in the coming decades, so current change can be helpful in providing early warning of future trends.

The largest recent human-related source of disturbance to coastal forests has been timber harvests. Although timber harvest began in the region in the late 1800s to support mining and local construction, significant harvest in the coastal region did not begin until the mid-1950s. Peak levels were reached in 1989–1990, and harvest in the region has declined since then; the average annual timber volume harvested from public and private forests in Alaska decreased to 369 million board feet in the period 1997–2006 from an average annual volume of 896 million board feet in the period 1987–1996 (Brackley et al. 2009). Although those values reflect statewide estimates, a similar decline in harvest would be expected for the coastal Alaska inventory unit, particularly southeast Alaska, where most harvest takes place. Dates of initial plot measurements in southeast

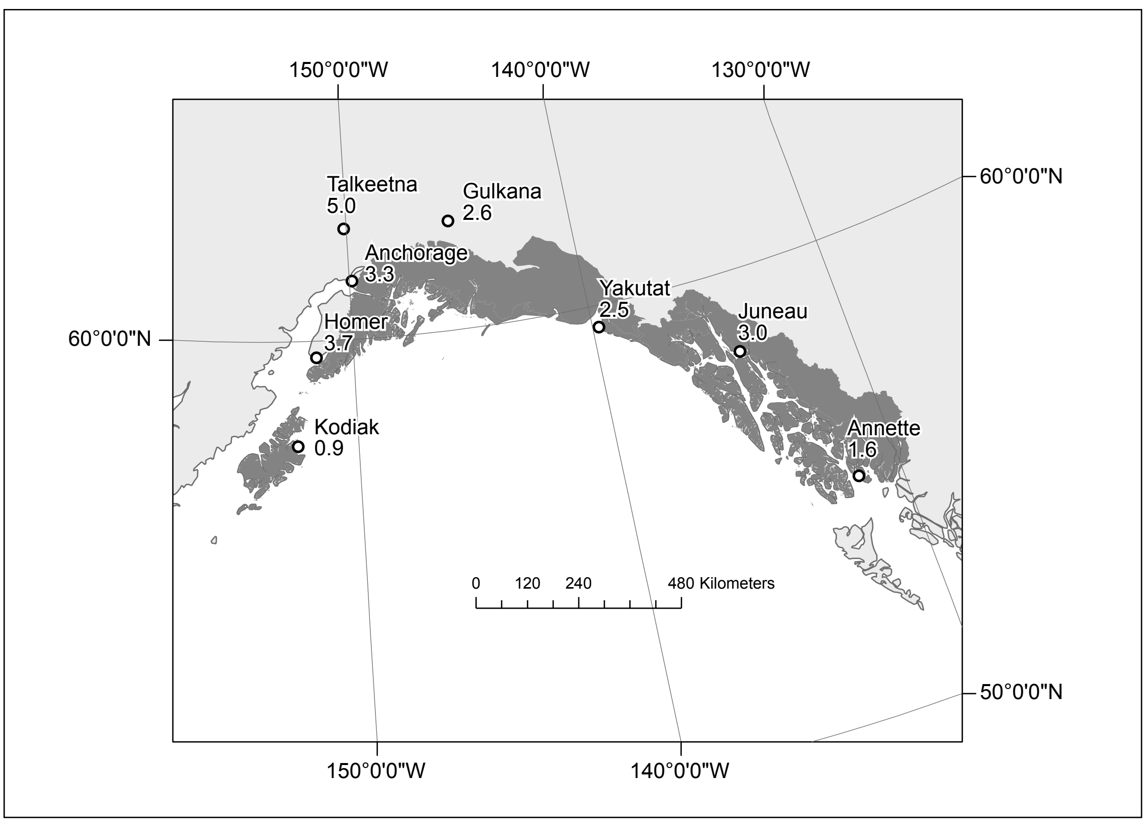


Figure 24—Change in mean annual temperature (°F) between 1954 and 2008 at long-term climate monitoring stations in southeast and south-central Alaska. Projection: Alaska Albers NAD 83.

Alaska were from 1995 to 2000 with remeasurement taking place from 2004 to 2008 (table 6). Thus the change reported could reflect ingrowth into the 5 inches d.b.h. class at the second inventory as previously harvested areas regrow.

Table 6—Number of forested plots by years of measurement, southeast Alaska

First measurement year	Second measurement year					
	2004	2005	2006	2007	2008	Total
1995	19	23	26	30	28	126
1996	33	20	34	29	21	137
1997	27	26	39	41	36	169
1998	18	36	33	22	30	139
2000	4	2	4	1	3	14
Total	101	107	136	123	118	585

One of the largest recent disturbances in the coastal region was a spruce bark beetle epidemic in the Kenai region that peaked around 1995 and that had greatly diminished by 1999 (Berg et al. 2006). Beetle epidemics in this region are thought to be linked to climate through longer warmer summers allowing the beetles to mature in 1 year instead of 2 years (Werner and Holsten 1985) and through fewer periods of severe low winter temperatures that reduce beetle populations. The first measurement dates of the south-central Alaska inventory used to estimate change in this report were made after the most recent beetle epidemic (table 7), and thus the estimates of change for south-central Alaska reported here should incorporate recovery from the previous epidemics and relatively little beetle mortality.

Table 7—Number of forested plots by years of measurement, south-central Alaska

First measurement year	Second measurement year					
	2004	2005	2006	2007	2008	Total
1999	26	19	27	27	25	124
2001	49	5	38	12	34	138
2002	13	13	9	9	16	60
2003	4	6	5	3	5	23
Total	92	43	79	51	80	345

In southeast Alaska, windthrow is an important process driving forest development (Kramer et al. 2001). Previous studies have recorded windthrow events of 2,000 to 63,000 acres in southeast Alaska (Nowacki and Kramer 1998). Ecoregions reported on here range from 0.5 million acres of forest on Kodiak Island to 10 million acres of forest within the Alexander Archipelago ecological section. Very large windthrow events, or a pulse of windthrow events clustered temporally, could cause detectable change in inventory estimates.

Methods

A set of 2,355 remeasured FIA plots, 930 of which had forested land, were used for estimates of change. All results reported in this chapter exclude Glacier Bay National Park and wilderness and wilderness study areas in national forests (see fig. 2 in chapter 1 of this report). A separate stratification was developed specifically for remeasurement analysis. Biomass and volume change estimates used initial volumes from the 1995 to 2003 inventory that were adjusted for changes in procedures and corrected for errors such as species misidentification. Biomass and volume change is calculated only from land that was defined as forest land at both periods.

No information for trees less than 5 inches d.b.h. was used in most change estimates because the microplot location, used to sample small trees, was moved between the periodic and annual inventories. Mortality and harvest rate were calculated as an arithmetic average over the remeasurement period. "Harvest" refers to trees that were cut by direct human activity and that were assumed to have been utilized. "Mortality" refers to trees that died by any other cause, and can include trees that were killed by direct human activity (such as land clearing or silvicultural purposes) but not utilized for wood. For each individual plot, the remeasurement period was adjusted from calendar time by assuming that trees grew linearly during a growing season interval of May 1 to September 1.

Statistical tests for difference were based on a one-sample t-test, where the sample consisted of the observed difference for individual plots. The t-test assumes that sample means are normally distributed, an assumption that can be violated for biomass change when the number of sampled plots is small. Numerous procedural differences occurred between the periodic and annual inventories, and, in some cases, this has restricted the types of forest attributes that can be reliably assessed for change.

Appendix 1 in this report contains additional information on procedures for both inventories, such as equations used for biomass estimates.

Results

Rates of growth, mortality, and harvest—
Overall average annual morality of trees with d.b.h. greater than 5 inches was 0.65 percent, or 1 tree out of 154 dying each year (table 8). The three species with the highest mortality rate were white spruce (1 tree out of 39 dying each year), black spruce (1 tree out of 47 dying each year), and paper birch (1 tree out of 77 dying each year). The two species with the lowest mortality rate were western redcedar (1 tree out of 457 dying each year) and yellow-cedar (1 tree out of 339 dying each year).

By species, the trees with the highest numbers of trees harvested were Sitka spruce, western hemlock, paper birch, mountain hemlock, and yellow-cedar (table 8). Overall, harvest was 23 percent of mortality by numbers of trees killed. Harvest was 57 percent of mortality for Sitka spruce and 46 percent of mortality for paper birch. Harvest was the lowest percentage of mortality for lodgepole pine (2 percent), white spruce (2 percent), and black spruce (3 percent).

Using only the 699 plots that were fully forested at both periods, a paired t-test was used to look at whether there was a change in numbers of saplings for different species on these plots. Three species showed a net increase in number of saplings: yellow-cedar, with a 23 percent increase (standard error [SE] of 11 percent, p-value of 0.0059); mountain hemlock, with a 23 percent increase (SE 10 percent, p-value of 0.0033); and Sitka spruce, with a 16 percent increase (SE of 11 percent, p-value of 0.0840). These increases are likely to be driven by trees growing across the 1-inch d.b.h. threshold on previously clearcut acres in southeast Alaska (see forest products chapter of this report).

Table 8—Average annual mortality and harvest rates between 1995–2003 and 2004–2008 of trees in coastal Alaska

		Average annual mortality			Average annual harvest			Average annual harvest and mortality		
			Percentage of live			Percentage of live			Percentage of live	
Species	Number of live trees 1995–2003	Trees	Percent	SE[a]	Trees	Percent	SE	Trees	Percent	SE
Alaska yellow-cedar	198,694,966	586,924	0.30	0.04	82,507	0.04	0.02	669,430	0.34	0.05
Black cottonwood	27,740,065	223,937	0.81	0.29	49,884	0.18	0.19	273,821	0.99	0.34
Black spruce	23,856,633	506,004	2.12	0.42	13,528	0.06	0.06	519,532	2.18	0.43
Lodgepole pine	54,749,764	411,391	0.75	0.12	6,258	0.01	0.01	417,649	0.76	0.13
Mountain hemlock	309,268,056	1,465,727	0.47	0.05	98,249	0.03	0.03	1,563,976	0.51	0.06
Paper birch	45,852,782	597,664	1.30	0.36	274,364	0.60	0.60	872,028	1.90	0.70
Sitka spruce	280,973,064	1,840,016	0.65	0.08	1,047,199	0.37	0.21	2,887,215	1.03	0.21
Western hemlock	557,201,633	3,117,581	0.56	0.04	810,335	0.15	0.05	3,927,916	0.70	0.06
Western redcedar	83,943,962	183,664	0.22	0.06	24,049	0.03	0.02	207,712	0.25	0.06
White spruce	58,620,673	1,507,347	2.57	0.47	26,779	0.05	0.03	1,534,126	2.62	0.47
Other species[b]	22,905,331	330,289	1.44	0.30	12,515	0.05	0.05	342,804	1.50	0.30
Total of all species	1,663,806,929	10,770,542	0.65	0.04	2,445,667	0.15	0.05	13,216,209	0.79	0.06

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

Note: Does not include Glacier Bay National Park or wilderness in national forests.

Note: Uses only live trees ≥ 5 inches diameter at breast height at first inventory on plots that were forested at both the first and second inventories.

[a] SE was calculated using a combined ratio estimator.

[b] Other species includes Pacific silver fir, Pacific yew, subalpine fir, quaking aspen, and red alder.

Change in carbon and biomass by species—
Net change in aboveground tree carbon per acre between the two measurement periods was not significantly different than zero over the whole inventory area. There was no significant change for the ecoregions of the Alexander Archipelego, Gulf of Alaska Coast, Cook Inlet Basin, or Kodiak Island ecological sections (see fig. 7, chapter 2 for a map of these regions). There was a significant increase for two ecoregions, the Chugach-St. Elias Mountains with an estimated 7-percent increase in carbon per forested acre, and the Northern Coast Mountains, with an estimated 8-percent increase in carbon per forested acre (table 9).

By biomass or numbers of trees, the four most common species in the coastal region are western hemlock, Sitka spruce, mountain hemlock, and yellow-cedar. None of the four showed a significant change in biomass between 1995–2003 and 2004–2008 (table 10). The next most common species, western redcedar, showed an overall biomass increase of 4.2 percent, which was significantly different from zero (p-value less than 0.01).

Of the less common species, black cottonwood, quaking aspen, and red alder all showed significant increases in biomass. Lodgepole pine showed a significant decrease of 4.6 percent (SE of 2.1 percent). The other less common species—black spruce, paper birch, and white spruce—did not show any significant change in biomass. Overall, total live tree biomass remained constant in the coastal Alaska region (0.41 percent increase, which was not significantly different from zero).

Change by type of owner—
On the Chugach National Forest, carbon and biomass in aboveground trees increased by almost 4 percent between the two inventories (table 11). For other federal ownership, estimated change was almost the same as for the Chugach National Forest, but the change was not quite significantly different from zero (p-value 0.0849, alpha = 0.05). The Tongass National Forest did not have a significant change in carbon and biomass. State and local government carbon and biomass increased significantly, by an estimated 7.6 percent. Private land estimated carbon and biomass did not show a statistically significant change.

Between the first inventory in 1995–2003 and the second inventory in 2004–2008, there was a statistically significant increase in gross cubic foot volume on timberland for the Chugach National Forest and on state-owned land (table 12). There was no statistically significant difference in volume on timberland on the Tongass National Forest, other federal land, or on private land. Although procedural differences in cull deductions prevented comparisons of net volume, current procedures show net volumes that range from 90 to 95 percent of gross volume for the various owner groups (table 12).

Table 9—Change in aboveground live tree carbon by ecoregion between 1995–2003 and 2004–2008, coastal Alaska

Ecoregion (section level)	n[a]	n_f[b]	1995–2003	2004–2008	Change	SE of change	p-value[c]
				Ovendry tons per acre			
Alexander Archipelago	631	621	50.88	50.82	(0.06)	0.64	0.93
Gulf of Alaska Coast	279	159	36.58	37.47	0.89	0.71	0.22
Cook Inlet Basin	197	158	7.54	7.70	0.09	0.18	0.60
Kodiak Island	100	33	76.68	74.78	(1.90)	4.36	0.66
Chugach-St. Elias Mountains	857	70	19.48	21.06	1.38	0.39	0.00
Northern Coast Mountains	291	60	49.68	53.49	3.81	0.99	0.00

Note: Data subject to sampling error; SE = standard error.
Note: Does not include Glacier Bay National Park or wilderness in national forests.
Note: Uses only trees ≥ 5 inches diameter at breast height at first inventory on plots that were forested at both the first and second inventories.
[a] n = number of plots in the ecoregion.
[b] n_f = number of plots with forest.
[c] p-value for test where H_0 is change = 0; H_A is change ≠ 0.

Table 10—Net change of live tree biomass by species between 1995–2003 and 2004–2008, coastal Alaska

	Biomass 1995–2003		Mortality		Harvest		Ingrowth		Survivor growth		Net change		
Species	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**$n_{species}$ [a]**
	Thousand tons												*Number*
Alaska yellow-cedar	82,836	6,319	2,485	855	1,064	811	359	47	3,651	353	525	1,332	266
Black cottonwood	8,379	1,859	121	66	50	50	90	28	1,017	89	952	265	49
Black spruce	1,881	498	205	70	3	3	221	49	134	219	147	94	54
Lodgepole pine	12,123	1,351	1,001	240	8	10	90	18	344	90	(561)	258	130
Mountain hemlock	105,414	7,795	3,589	636	421	381	464	47	4,341	458	859	970	432
Paper birch	11,651	1,754	742	193	144	144	206	90	1,046	205	377	343	104
Quaking aspen	2,765	813	221	101	—	—	70	43	312	70	162	95	28
Red alder	2,162	575	273	133	11	13	533	163	617	517	872	299	36
Sitka spruce	242,935	16,653	12,320	3,152	6,374	2,695	2,622	454	17,017	2,612	1,155	5,516	545
Western hemlock	376,590	20,677	20,067	3,298	9,025	4,897	2,724	349	22,903	2,688	(3,166)	6,243	556
Western redcedar	47,820	5,992	951	480	73	55	214	48	2,812	210	2,025	598	141
White spruce	7,706	1,009	1,394	436	9	7	410	65	1,030	406	48	434	121
Other species[b]	242	127	33	36	—	—	2	2	19	2	(12)	33	
Total	902,505	28,930	43,402	4,731	17,183	6,944	8,007	741	55,244	7,919	3,384	9,598	895

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

Note: Does not include Glacier Bay National Park or wilderness in national forests.

Note: Uses only trees ≥ 5 inches diameter at breast height at first inventory on plots that were forested at both the first and second inventories.

[a] $n_{species}$ denotes number of remeasured plots where the species occurred; sample size was 2,355 remeasured plots.

[b] Other species include Pacific silver fir, Pacific yew, and subalpine fir.

Table 11—Change in aboveground live tree carbon on forest land by owner group between 1995–2003 and 2004–2008, coastal Alaska

	Carbon time 1		Mortality		Harvest		Ingrowth		Survivor growth		Net change	
Owner	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**	**Value**	**SE**
	Thousand tons											
Chugach National Forest	22,577	3,163	671	241	—	—	135	27	1,411	350	875	410
Tongass National Forest	333,026	12,835	17,019	2,276	3,222	2,504	2,322	315	18,693	2,068	773	3,978
Other federal	11,304	1,840	911	185	—	—	314	57	1,040	223	443	212
State and local government	45,418	5,318	1,407	397	28	30	550	120	4,345	640	3,461	790
Private	38,928	5,162	1,693	446	5,342	2,405	683	148	2,492	365	(3,860)	2,529
Total	451,253	14,465	21,701	2,366	8,592	3,472	4,003	371	27,981	2,203	1,692	4,799

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

Note: Does not include Glacier Bay National Park or wilderness in national forests.

Note: Uses only trees ≥ 5 inches diameter at breast height at first inventory on plots that were forested at both the first and second inventories.

Table 12—Change in gross volume on timberland by owner group between 1995–2003 and 2004–2008, coastal Alaska

	Volume time 1		Mortality		Harvest		Ingrowth		Survivor growth		Volume time 2		Net change	
Owner	Value	SE	Value	SE	Value	SE	Value	SE	Value	SE	Value	SE	Value	SE
	Million cubic feet													
Chugach National Forest	1,623	295	51	22	—	—	7	2	113	32	1,692	301	70	35
Tongass National Forest	23,001	1,384	1,066	182	262	231	157	29	1,376	208	23,244	1,377	205	362
Other federal	188	144	11	10	—	—	—	—	23	18	200	153	12	9
State and local government	3,289	485	83	29	2	3	37	10	358	58	3,598	521	309	65
Private	3,286	496	154	44	499	220	48	12	232	37	2,913	478	(373)	232
Total	31,387	1,535	1,364	191	764	319	250	21	2,102	220	31,648	1,536	223	436

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

Note: Uses only live trees ≥ 5 inches diameter at breast height at first inventory on plots that were forested at both the first and second inventories.

Note: Does not include Glacier Bay National Park or wilderness in national forests.

Note: Gross volume does not include deductions for rotten or missing cull. In the 2004–2008 inventory, the ratio of net cubic-foot volume to gross cubic-foot volume on timberland was 91 percent on the Chugach National Forest, 90 percent on the Tongass National Forest, 95 percent on other federal land, 92 percent on state land, and 93 percent for privately owned land.

Change in forest-land area—

The biomass, volume, and carbon change estimates reported here do not reflect any increase or decrease associated with land that is deforested owing to development or natural causes or land that becomes forested through such causes as increased elevation of treeline or drying of wetlands. The alteration of the forest definition between the two inventories prevented tracking biomass changes that were due to such reversion or diversions. To try to get a rough estimate of area of land that diverted to or reverted from forest land, an experienced field crew member, working in the office and using notes taken in the field, classified every change from forest to nonforest (or vice versa) at the center of the four subplots for every plot as either (a) procedural change or (b) real change.

The results of this procedure are that an estimated 11,000 acres changed from forest to nonforest, and an estimated 55,000 acres changed from nonforest to forest. This is a net gain of 44,000 acres, out of the 10,406,000 forested acres in the remeasurement inventory. Overall, this is an increase of less than one-half of one percent for the period 1995–2003 to 2004–2008. Expressed as an annual rate, this is a net increase of 7,000 acres per year for the coastal Alaska region. Because of the very small number of plots where change was detected, and the difficulty of separating out real change from procedural change, there is a great deal of imprecision in this estimate. Plot notes where real change occurred indicate such reasons as a flood plain slowly being colonized by trees and forest creeping into muskeg.

Interpretation

Of four early-succession species (paper birch, black cottonwood, quaking aspen, and red alder), three showed significant increases in biomass, which suggests some change in biophysical conditions favorable to pioneering species (fig. 25). The increase in tree biomass in the two higher elevation ecoregions (the Chugach-St. Elias Mountain ecological section in south-central Alaska and the Northern Coast Mountain ecological section in southeast Alaska) would not be accounted for by increase in treeline elevation, as only areas defined as forest at both inventories were used in calculations of biomass change. However, it could indicate a general increase in tree density or size in higher elevation forests, which would be consistent with the increasing treeline elevation noted by Dial et al. (2007) and improving conditions for tree growth in higher elevation

Figure 25—Paper birch did not show a significant change in carbon and biomass, but it had one of the highest rates of harvest mortality. The three other hardwood species in the region (aspen, red alder, and black cottonwood) all showed a significant increase in biomass between 1995–2003 and 2004–2008.

areas. All of the changes noted in this report—an increase in biomass of pioneering species, an increase in biomass in higher elevation ecoregions, and the increase in forested area from drying wetlands—would not contribute greatly to total biomass in the region because they are areas of low biomass to begin with.

The overall stability of biomass and carbon in live trees in southeast and south-central Alaska during the period of monitoring is intriguing. The species of the coastal temperate rain-forest biome are at the northern limits of the species range. We might expect, given general trends of climate warming, that these species might be expanding in numbers and biomass. Tree ring studies suggest individual tree growth has been responding to climate trends in this region (Wiles et al. 2004).

However, the three most common species—western hemlock (fig. 26), Sitka spruce, and mountain hemlock, which together make up 80 percent of total tree biomass in the coastal region are very stable—with no statistically significant change in biomass and carbon. In contrast, two of the minor components of this biome, lodgepole pine and western redcedar, are showing trends in opposite directions,

Figure 26—Western hemlock forest near Ketchikan, Alaska. Western hemlock is the most common tree species in the temperate rain-forest biome and was found on 556 of 895 inventory plots. However, it showed no significant change in biomass between 1995–2003 and 2004–2008.

with lodgepole pine decreasing by 4.7 percent and western redcedar increasing by 4.2 percent. Overall net change in biomass and carbon was less than one half of one percent, which was not significantly different than zero.

There are three possible explanations for the apparent stability of carbon and biomass in the coastal temperate rain-forest biome. One is that there are multiple vectors of change, which can push forest change in different directions. If the biomass of harvested trees was included with net change in the remaining forest, biomass increase in the region would shift from 3.7 million tons to 15.5 million tons. Thus there is an increase in carbon and biomass in the region from increased growth that is being counterbalanced by harvesting. Carbon accounting for forests is notoriously difficult (Cornwell et al. 2009). For carbon accounting, some portion of carbon in harvested trees would likely be considered as sequestered, but there is little empirical data for carbon in dead wood, peat, soil, and water in forest ecosystems, which can contain significant amounts of carbon and where the impact of disturbance on carbon fluxes is largely unknown.

The second explanation for stability of carbon and biomass is the size of the inventory region. The common species in the region—western hemlock, Sitka spruce, and mountain hemlock—may be undergoing the same type of slow migration that is hypothesized for yellow-cedar. (See chapter 4 for additional discussion on yellow-cedar). However, because the coastal temperate rain-forest biome spans a wide range of elevation gradients and distance, tree species could be dying in some parts of their range and thriving in other parts of their range, resulting in relatively little net change for the greater temperate rain-forest biome in Alaska.

The third contributing factor is the relatively short time between remeasurements. The mean remeasurement period for stands was 8.9 years in southeast Alaska and 5.4 years in south-central Alaska. Potential growth in the coastal temperate rain-forest biome is lower than in the comparable coastal biomes of Oregon and Washington, requiring a longer period to detect increases or decreases in growth rates. In the boreal forests of the western Kenai, the main known disturbance, beetle outbreaks, had subsided before the initial measurements.

Changes in forest area could also potentially contribute to changes in tree carbon and biomass. Glacial recession in southeast and south-central Alaska has frequently been pointed to as a sign of warming climate (Larsen et al. 2007). As glaciers recede, shrub species move in, often followed by tree species. Warmer temperatures could lead to drying of wetland areas (fig. 27) and allow forest area to increase. Our ability to track forest increases and decreases was negatively impacted by procedural changes for the inventory. However, the magnitude of observed change was on the order of a 7-percent-per-century increase in forest land in the coastal region, assuming that the rate remains constant; this is not conclusive, but it suggests that glacial recession, treeline elevation increases, and other sources of forestation will take some time to have noticeable impact on total forest area or make significant contributions to biomass and carbon accumulation. Future inventory assessments may be able to detect more types of change, as the length between remeasurement increases and the number of remeasured plots doubles by 2014.

Jon Williams

Figure 27—Warmer temperatures could lead to drying of wetlands and an increase of forested areas as tree species move in, but the most recent inventory data suggest that afforestation rates are small.

Jon Williams

Chapter 3: Forest Structure and Function

Although trees are the most noticeable vegetation in forests, other life forms are also important components of forest systems. This section provides results on lichen, an important forest health indicator, from a lichen biodiversity assessment conducted by USDA Forest Service Forest Inventory and Analysis (FIA). The next section provides results on vascular plant diversity and composition, which is also a forest health indicator of FIA. The chapter concludes with a section describing some characteristics of older forests within the inventory region.

Lichen Biodiversity[1]

Background

Lichens are included among the FIA suite of forest health indicators (Jovan 2008). These organisms serve many basic and vital functions in forest ecosystems: they provide wildlife sustenance and habitat (Sharnoff and Rosentreter 1998), moderate hydrologic flux in the forest interior, and affect stand mineral budgets by enhancing inputs of important plant nutrients like nitrogen (N), calcium, and magnesium (Knops et al. 1996). Certain groups of lichen species are intimately linked to forest health. For instance, two critical functional groups of lichens in southeast Alaska include the cyanolichens and long beard-like "forage" lichens primarily from the genera *Alectoria*, *Bryoria*, and *Usnea* (see table 57 in app. 2 for species names). Cyanolichens are a specialized group of native lichens that fix N and make substantial contributions to forest fertility in N-limited stands of the Pacific Northwest (PNW) (Antoine 2004) (fig. 28). Forage lichens (fig. 29) are common nesting material for a variety of birds and rodents and are critical winter forage for southeast Alaska's big game ungulates like the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), moose (*Alces alces gigas*), and the coastal mountain goat (*Oreamnos americanus*).

[1] Author: Sarah Jovan.

Heather Root

Figure 28—*Nephroma isidiosum* (Pepper paw), an uncommon cyanolichen found in southeast Alaska.

Sarah Jovan

Figure 29—*Usnea longissima* (Methuselah's beard), a forage lichen that is popular among birds and rodents as nesting material.

Methods

Between 2004 and 2008, FIA crews surveyed for epiphytic (tree-dwelling) lichens on all phase 3 (app. 1) plots (n = 132) in southeast and south-central Alaska. Surveyors spent a minimum of 30 minutes and a maximum of 2 hours recording the abundance of each lichen species occurring within a 0.94-ac area centered on the typical FIA phase 2 plot (app. 1).

Abundance codes used in lichen community surveys. A lichen body is known as a thallus:

Code	Abundance
1	Rare (1 to 3 thalli)
2	Uncommon (4 to 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)

Results

Species richness of epiphytic lichen communities varied widely across the study area, and no prominent diversity hotspots were detected (fig. 30) (table 13). A total of 142 lichen species were recorded among all surveyed plots in southeast and south-central Alaska, which is a considerable portion (54 percent) of total diversity found across all plots surveyed in California, Oregon, and Washington (Jovan 2008). Most Alaska plots are located in a belt of temperate rain forests (n = 115) known as the Coastal Rainforest ecoregion (Nowacki et al. 2002). Although cooler, these rain forests are characterized by a wet, mild climate very similar to conditions affecting PNW rain forests to the south in the Oregon and Washington Coast Range (Bailey 1983). Overall alpha richness in Alaska rain forests was high: plots had an average of 18 lichen species, significantly higher than the average in PNW rain forests (14 species; t-test $p < 0.01$). About 65 percent of plots in Alaska rain forests contained 16 species or more compared to 45 percent of PNW rain-forest plots. Where intact forest habitat is available, the moist, maritime climate of the Pacific west coast will support a rich and complex epiphytic lichen flora. Only 19 of 115 Alaska rain-forest plots hosted a depauperate community of 10 species or fewer; most of these sites had been recently clearcut, and the remainder were young stands recovering from natural disturbance. In contrast, more than a third of PNW rain-forest plots were depauperate (27 of 73

Kenneth C. Winterberger

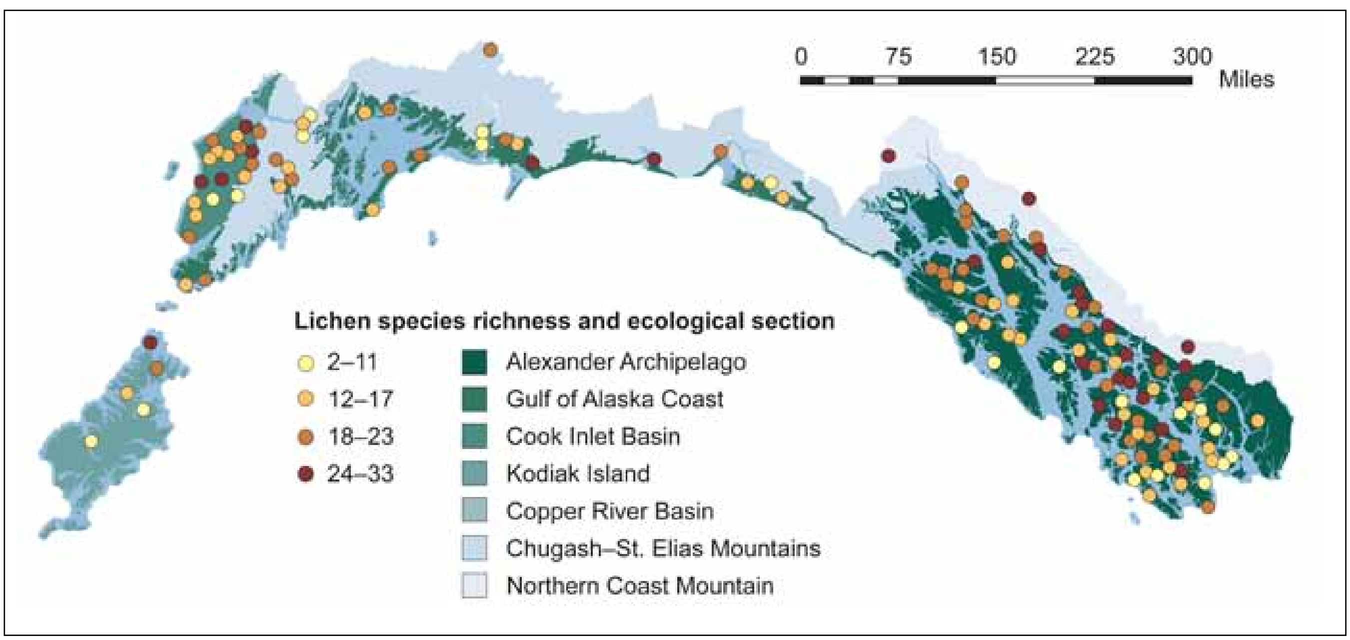


Figure 30—Forest Inventory and Analysis (FIA) plots sampled for epiphytic lichen communities. Color indicates categories of total lichen species richness (depicted plot locations are approximate). Source: USDA Forest Service, FIA program, 2004–2008 data. Ecological section boundaries from Nowacki et al. (2002).

Table 13—Summary of lichen community indicator species richness, 2004–2008

Parameter	Coastal Alaska	Alaska Range transition	Alaska coastal rain forests	Oregon and Washington Coast Ranges
Number of plots	132	17	115	73
Number of plots by lichen species richness category:[a b]				
<6 species	3	0	3	13
6–15 species	44	7	37	27
16–25 species	71	7	64	27
>25 species	14	3	11	6
Median species richness	18	17	18	15
Range of species richness per plot (Low–High)	2–33	8–28	2–33	0–32
Range of forage species richness	0–22	2–10	0–22	0–8
Range of cyanolichen species richness	0–20	0–10	0–20	0–8
Average species richness per plot (alpha diversity)	18	18	18	14
Average forage species richness	4	4	4	3
Average cyanolichen species richness	5	4	5	1
Standard deviation of species richness per plot	6	6	6	8
Species turnover rate (beta diversity)[c]	8	4	8	2
Total number of species per area (gamma diversity)	142	75	142	120

[a] Categories are based on a cumulative distribution function of plot species richness for the Southeastern U.S. gradient model.
[b] Plots with no lichens are included.
[c] Beta diversity is calculated as gamma diversity divided by alpha diversity.

plots) likely owing in large part to the landscape being more impacted by timber harvest, fire, and air quality stressors.

In both Alaska and PNW rain forests, about 39 percent of regionwide diversity consists of the ecologically important N-fixing cyanolichen and forage lichen functional groups. Unlike PNW rain forests, however, nearly all sampled Alaska rain forests contained several species from both functional groups. An average of 28 and 22 percent of species richness at Alaska rain-forest plots was composed of cyanolichens and forage species, respectively. Cyanolichens were not widely distributed in PNW rain forests and made a significantly smaller contribution to community richness (7 percent; t-test $p = < 0.0001$). Forage lichens, predominantly from the genus *Usnea*, were comparatively widespread in the PNW plots, and there was no significant difference in the contribution of forage lichens to PNW versus Alaska rain forests (t-test $p = 0.08$).

In air quality studies, most forage species are classified as N-sensitive indicator species known as oligotrophs (i.e., acidophytes) (Jovan 2008). The nonforage genera that dominate southeast and south-central Alaska's lichen communities (i.e., *Cladonia*, *Hypogymnia*, and *Platismatia*) also contain many oligotrophic species (app. 2, table 57). Abundance of cyanolichens is likewise a clean air indicator (McCune and Geiser 2009). By comparison, species positively indicating N pollution, called eutrophs (i.e., nitrophytes) were very rare. Eutrophs were detected at only about 7 percent of all surveyed sites in Alaska and were minor contributors to communities, averaging less than 0.5 percent of plot-level richness. These weedy lichens were likely primarily associated with localized natural sources of N-like guano, their natural niche, versus anthropogenic sources of N pollution that boost eutroph populations in urban and agriculturally affected forests (Jovan 2008).

The widespread abundance of pollution-sensitive species found in this preliminary analysis indicates a lichen flora characteristic of healthy forest ecosystems largely unstressed by the regional air quality issues detected by FIA biomonitoring studies in the more populated Pacific States to the south (Fenn et al. 2008, Geiser and Neitlich 2007, Jovan 2008). Pollution risks in southeast and south-central Alaska are likely in close association with point sources and urban areas, a finding corroborated by a previous large-scale lichen inventory by Geiser et al. (1998). A more intensive FIA analysis of lichen communities is underway that will allow detection of more subtle and localized pollution effects on species composition. Results will be available in 2011.

Vegetation Diversity[2]

Background

The coastal Alaska inventory encompasses extremely rugged topography in a land of dynamic geomorphic processes and climatic conditions that strongly influence the vegetation diversity of the area. Vegetation composition and structure are often assessed to determine current and potential productivity for wildlife habitat or forest products, and a site's likely response to disturbance. Some species occur in certain situations so commonly that they are used as "indicators" of certain site conditions; others are known for their value for providing wildlife food or shelter. Understanding which species grow where and with what other species can inform many management-related questions. Groups of plant species occur together across the landscape where site conditions are favorable; these groups are described as plant community types or associations.

Plant community classifications are useful communication tools for managers responsible for sustainable ecosystem management. Land managers operating within the area of the coastal Alaska inventory have several local classification systems (table 14) to reference when planning management activities or developing conservation strategies. These classifications are based on species composition data from thousands of plots in areas nested within the larger coastal Alaska inventory area and describe communities and associations in great detail, incorporating information on successional processes, indicator species, and resource management implications. With these classifications, the vegetation indicator species composition data from the forest health plots, a 1/16th subsample of the regular FIA inventory plots, can further inform us about the vegetation diversity in coastal Alaska.

The vegetation indicator is designed to provide information on regional and national scales using standard methods on permanently located plots that will be revisited in the future (Schulz et al. 2009). We can establish baseline conditions with estimates concerning species richness and species distribution that we will monitor in the future for changes beyond those expected. By comparing FIA's broader sample with the detailed local associations from areas nested within the inventory, similarities between neighboring classifications can be identified while providing a means to compare the local region with other areas of the country. These data greatly enhance the local plant association classifications by quantifying patterns of species richness and distribution that can be monitored over time, providing a measure of temporal change and successional direction.

[2] Author: Bethany K. Schulz.

Table 14—Plant community classifications and associations relevant for the coastal area inventory, ordered from southeast to northwest

Reference	Author year	Area covered	Approach
1	DeMeo et al. 1992	Ketchikan area, Tongass National Forest	Climax vegetation
2	Pawuk and Kissinger 1989	Stikine area, Tongass National Forest	Climax vegetation
3	Martin et al. 1995	Chatham area, Tongass National Forest	Climax vegetation
4	Boggs et al. 2009	Glacier Bay National Park	Existing vegetation
5	Shephard 1995	Yukatat Foreland, Tongass National Forest	Existing vegetation
6	Boggs 2000	Copper River Delta	Existing vegetation
7	Boggs et al. 2008	Kenai Fjords National Park	Existing vegetation
8	DeVelice et al. 1999	Chugach National Forest	Existing vegetation

Methods

A complete inventory of the vascular plants was taken on the forest health plots for the Vegetation Diversity and Structure (VEG) indicator (USDA FS 2008a). The FIA plot design includes four circular subplots of about 1/24th acre each (fig. 31). On each subplot, three 1-m^2 (10.76 ft^2) quadrats were established. Each vascular plant species occurring on the quadrat was recorded using plant symbols referencing the PLANTS Database (USDA NRCS 2000). The subplot was then surveyed and all vascular plant species present and their canopy covers (a measure of abundance) were recorded. Only accessible forest lands were measured; on some plots, fewer than four subplots were assessed (Schulz et al. 2009). From plot species data, species composition was summarized for each plot. Species richness was compiled for each sample unit; quadrat, subplot, and plot. Site conditions, elevation and slope, along with measures of forest structure—live basal area and stand age—were summarized for each plot.

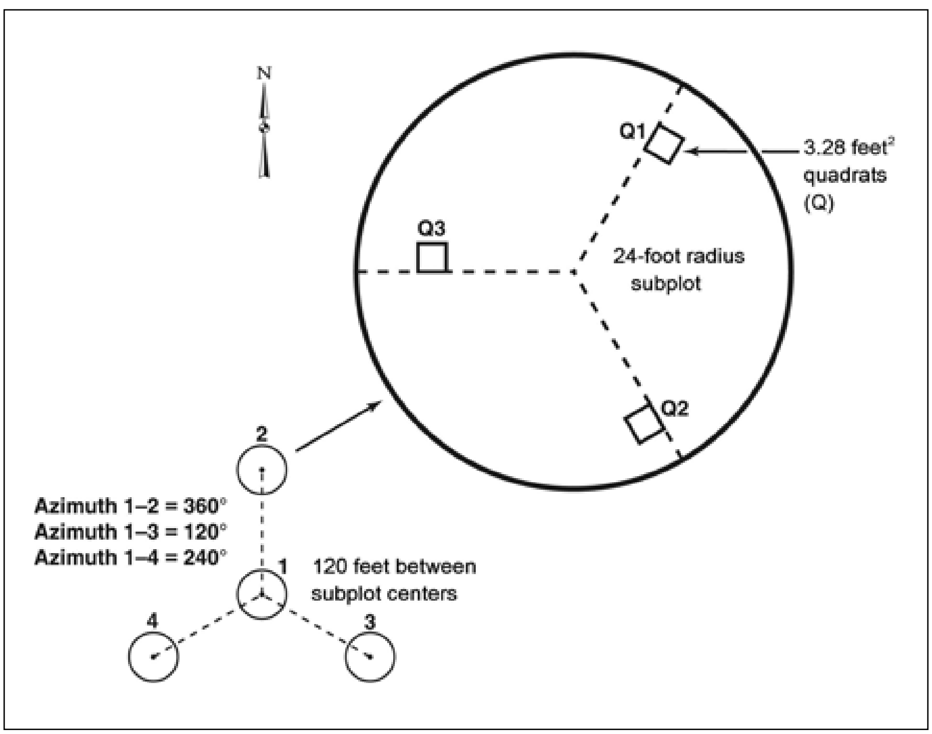


Figure 31—Forest Inventory and Analysis plot design with vegetation quadrats.

There were 135 forested plots in the forest health subsample, randomly distributed throughout the accessible forest lands of southeast and south-central Alaska. Some forested lands within the inventory area were inaccessible (wilderness areas) and could not be included in data summaries or results. To examine plant community types within the inventory area, only plots that were determined to be a single “forest type” (app. 1) that represented homogenous stands (Schulz et al. 2009, Tart et al. 2005) were considered. Plots were first grouped according to the ecological province where they occurred. Ecological provinces were determined by climatic and geomorphic characteristics and define areas with similar attributes that influence plant growth (Bailey 1995, Cleland et al. 2005). Plots were then grouped according to the forest type they were assigned by using a standard FIA computer algorithm based on tree species present (app. 1).

Each forest type within an ecological province with at least five plots was assessed (table 15). Forest types were summarized in terms of species richness, plant species composition, site conditions, and structural characteristics following procedures given in Schulz et al. (2009). Species richness was reported as average number of species per unit area and estimated at three scales: quadrat (10.76 square feet or 1 square meter), subplot area (0.0417 acre), and plot (0.167 acre).

Plant species composition data were compiled to describe the forest types in terms of the abundance and distribution of species commonly encountered. Plot-level plant species composition data were used to classify plots to locally described associations (table 14). Each classification system was unique

Table 15—Number of fully forested, single condition forest health plots per forest type by ecological province for coastal Alaska[a]

Ecological province	Forest Inventory and Analysis code	Forest type	Number of plots
Alaska Range Transition	122	White spruce (*Picea gluaca* (Moench) Voss)	1
Alaska Range Transition	703	Cottonwood (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw)	1
Alaska Range Transition	125	Black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb).	4
Alaska Range Transition	270	Mountain hemlock (*Tsuga mertensiana* (Bong.) Carrière)	1
Alaska Range Transition	901	Aspen (*Populus tremuloides* Michx)	1
Alaska Range Transition	**902**	**Birch** (*Betula papyrifera* Marsh.)	**5**
Coastal Rainforest Mountains	**270**	**Mountain hemlock**	**19**
Coastal Rainforest Mountains	122	White spruce	1
Coastal Rainforest Mountains	**271**	**Yellow-cedar** (*Chamaecyparis nootkatensis* (D. Don) Spach)	**15**
Coastal Rainforest Mountains	**301**	**Western hemlock** (*Tsuga heterophylla* (Raf.) Sarg.)	**28**
Coastal Rainforest Mountains	**305**	**Sitka spruce** (*Picea sitchensis* (Bong.) Carr.)	**10**
Coastal Rainforest Mountains	**703**	**Cottonwood**	**7**
Coastal Rainforest Mountains	281	Lodgepole pine (*Pinus contorta* Douglas ex Louden)	2
Coastal Rainforest Mountains	**304**	**Western redcedar** (*Thuja plicata* Donn ex D. Don)	**6**

[a] Only forest types in bold are included in estimates by ecological province and forest type.

to the area where it was developed; however, no attempt was made to use the plot location to limit classification to the key for that area. Instead, classification keys were used whenever the dominant tree species was included in the key, providing a better understanding of the distribution of the described forest type or association. Species and site attributes were compared to detailed descriptions of local plant associations.

Results

Over the entire inventory area, a total of 442 unique species (including some plants not identified to species) were recorded on the 135 forest health plots; 151 of those species were recorded only once. Ninety-one percent of all plants observed were identified to species—of those, 99.7 percent were native species. The average number of species on fully forested plots was 37.1, with a standard error (SE) of 1.3, and a range of 12 to 86 species. The average on subplots was 23.9 (SE = 0.57), and on quadrats the average was 8.9 (SE = 0.08).

A list of the most commonly encountered species across the entire inventory was compiled (table 16), along with their indicator properties, constancies (the percentage of visited plots where the species was recorded), and average cover when encountered. Many species were ubiquitous throughout the area—seven species were found on over 70 percent of all plots. Some individual species were indicators of site conditions (DeMeo et al. 1990, Martin et al. 1995). The 2 most common species are important deer forage and 3 of the top 12 are indicators of nutrient-rich soils. Nonnative species were recorded on the forested portions of eight plots and on the nonforest portion of two additional plots. (See “Invasive Plants in Coastal Alaska.”)

The area of the coastal Alaska inventory extended into two ecological provinces; 117 plots were within the Coastal Rainforest Mountains ecological province, and 18 were within the Alaska Range Transition province (fig. 32). Of the 135 plots visited, 101 were located entirely within single-forest-type stands. On those plots, 391

Table 16—Most common species encountered on the forest health plots of the coastal Alaska inventory

Scientific name	Common name	Indicator value[a]	Constancy	SE[b]	Mean cover	SE
			- - - - - - - - - - *Percent*	- - - - - - - - -		
Cornus canadensis L.	Bunchberry	df	79.26	0.035	5.73	0.533
Rubus pedatus Sm.	Fiveleaf bramble	df	78.52	.035	4.60	.491
Menziesia ferruginea Sm.	Rusty menziesia	hlght	76.3	.037	8.09	0.734
Vaccinium ovalifolium Sm.	Early blueberry	dwe	75.56	.037	21.59	1.756
Picea sitchensis (Bong.) Carrière	Sitka spruce	fld, sd, sspr	74.81	.037	12.49	1.623
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		74.81	.037	1.07	.115
Gymnocarpium dryopteris (L.) Newman	Western oakfern		70.37	.039	6.75	.644
Athyrium filix-femina (L.) Roth	Common ladyfern	wms, nr	67.41	.04	4.76	.746
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		65.19	.041	0.85	.108
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wdr, nr	62.96	.042	3.40	.548
Tsuga heterophylla (Raf.) Sarg.	Western hemlock	wdr	61.48	.042	33.74	2.717
Oplopanax horridus (Sm.) Miq.	Devil's club	wms, nr	59.26	.043	6.00	1.501
Blechnum spicant (L.) Sm.	Deer fern		58.52	.043	2.55	.357
Rubus spectabilis Pursh	Salmonberry	fld,sd	53.33	.043	6.82	1.211
Tiarella trifoliate L.	Threeleaf foamflower	df	53.33	.043	2.20	.221
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock	cld, dsr	53.33	.043	20.69	2.037
Coptis aspleniifolia Salisb.	Fernleaf goldthread	df	52.59	.043	4.67	.56
Lycopodium annotinum L.	Stiff clubmoss		49.63	.043	1.68	.355
Lysichiton americanus Hultén & St. John	American skunkcabbage	bf, pdr	48.15	.043	5.17	.63
Veratrum viride Aiton	Green false hellebore		42.96	.043	1.75	.2
Alnus viridis (Chaix) DC. ssp. *sinuata* (Regel) A. Löve & D. Löve	Sitka alder		40.74	.042	22.77	3.41
Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg	Deercabbage	cld, np, pdr	39.26	.042	9.10	1.093
Streptopus lanceolatus (Aiton) Reveal var. *roseus* (Michx.) Reveal	Twistedstalk		36.30	.041	2.74	.508
Clintonia uniflora (Menzies ex J.A. & J.H. Schultes) Kunth	Bride's bonnet		35.56	.041	.97	.226
Vaccinium parvifolium Sm.	Red huckleberry		35.56	.041	3.50	.618
Moneses uniflora (L.) A. Gray	Single delight		34.81	.041	.57	.128
Equisetum arvense L.	Field horsetail		34.07	.041	8.22	2.7
Chamaecyparis nootkatensis (D. Don) Spach	Alaska yellow-cedar	pdr	31.85	.04	22.27	2.358
Phegopteris connectilis (Michx.) Watt	Long beechfern		31.11	.04	2.83	.479
Vaccinium vitis-idaea L.	Lingonberry		30.37	.04	3.84	.807

[a] Indicator values: bf = bear forb; cld = cold soils; df = deer forage; dsr = deer summer range; dwe = deer winter energy; fld = flooding; hlght = high light; np = nutrient poor; nr = nutrient rich; pdr = poorly drained; sd = site disturbance; sspr = salt spray; wdr = well-drained soils; wms = water moving through soils.

[b] SE = standard error.

Kenneth C. Winterberger

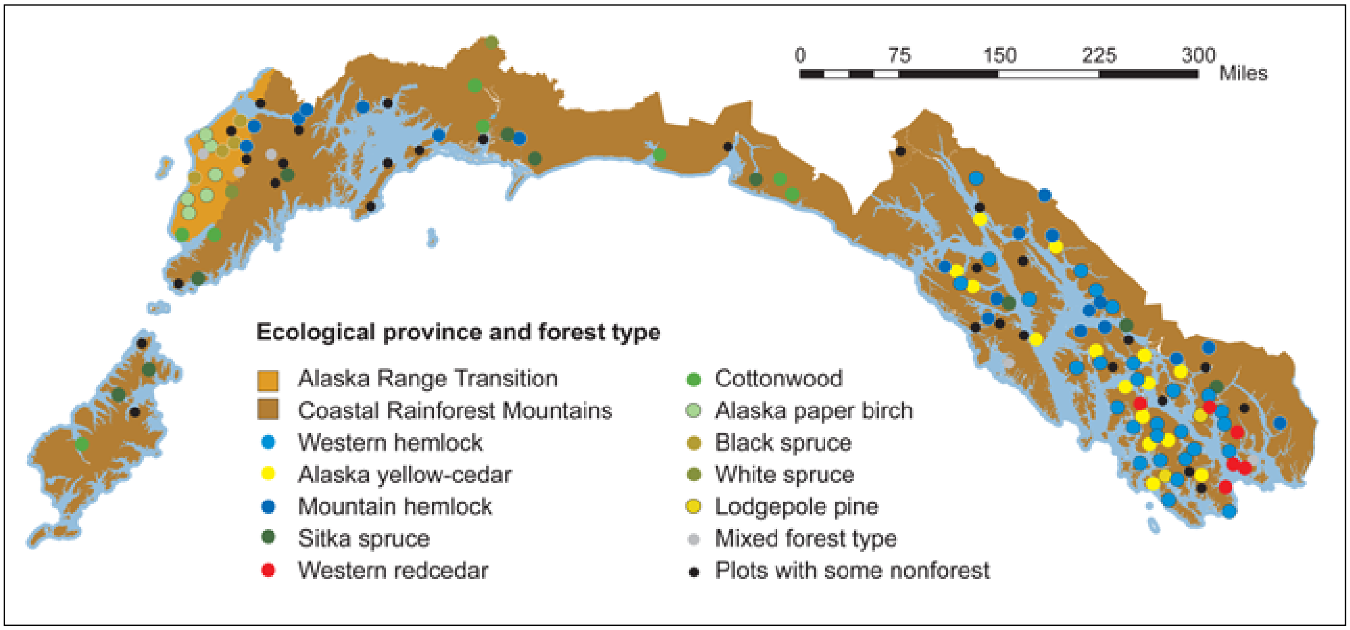


Figure 32—Distribution of forest health plots by forest type (depicted plot locations are approximate).

species were recorded, with 145 species recorded only once. The 101 plots were summarized by forest types within each ecological province, resulting in 14 ecological province/forest type combinations (table 15). One-half of the combinations were sampled with at least 5 plots; these seven forest types included 90 of the 101 plots.

Forest type species richness assessed for the standard sample areas highlighted the patterns of species-area relationships (fig. 33). The figure is arranged in order of decreasing plot species richness. Yellow-cedar, western redcedar, and mountain hemlock stands had the highest species richness; their average subplot species richness was similar to plot-level richness in western hemlock, Alaska paper birch, and Sitka spruce stands. The three scales of species richness revealed a pattern in the birch forest type suggesting a high percentage of species were evenly distributed throughout these stands; subplot alpha was about 75 percent of plot alpha, and quadrat alpha about 40 percent of the birch subplot alpha.

The plot with the greatest plot species richness (86) was a mountain hemlock forest type. The plot with the least number of species (12) was a cottonwood forest type. Both were in the Coastal Rainforest Mountains province. Interestingly, the plot with the second highest number of plot species (73) was a cottonwood forest type, the single sample of this type in the Alaska Range Transition ecological province (table 15).

Species composition of most individual plots could be classified to an association or cover type by using at least one of the local classification systems. Plot data of well-distributed forest types matched descriptions from multiple systems. The species composition of a few plots defied classification to a described association or cover type. Conversely, the forest health subsample of the FIA inventory plots did not sample every association or cover type described in each classification.

Structural (stand age and live basal area) and physical (elevation and percentage of slope) characteristics for forest types are shown in table 17. Ranges are included with average values; each forest type includes a wide range of values, but averages describe "typical" values that help us visualize where the communities occur over the wider landscape.

Summarized forest types are described below, along with a listing of plant associations matched to the plots within each type referenced to the classifications found in table 14.

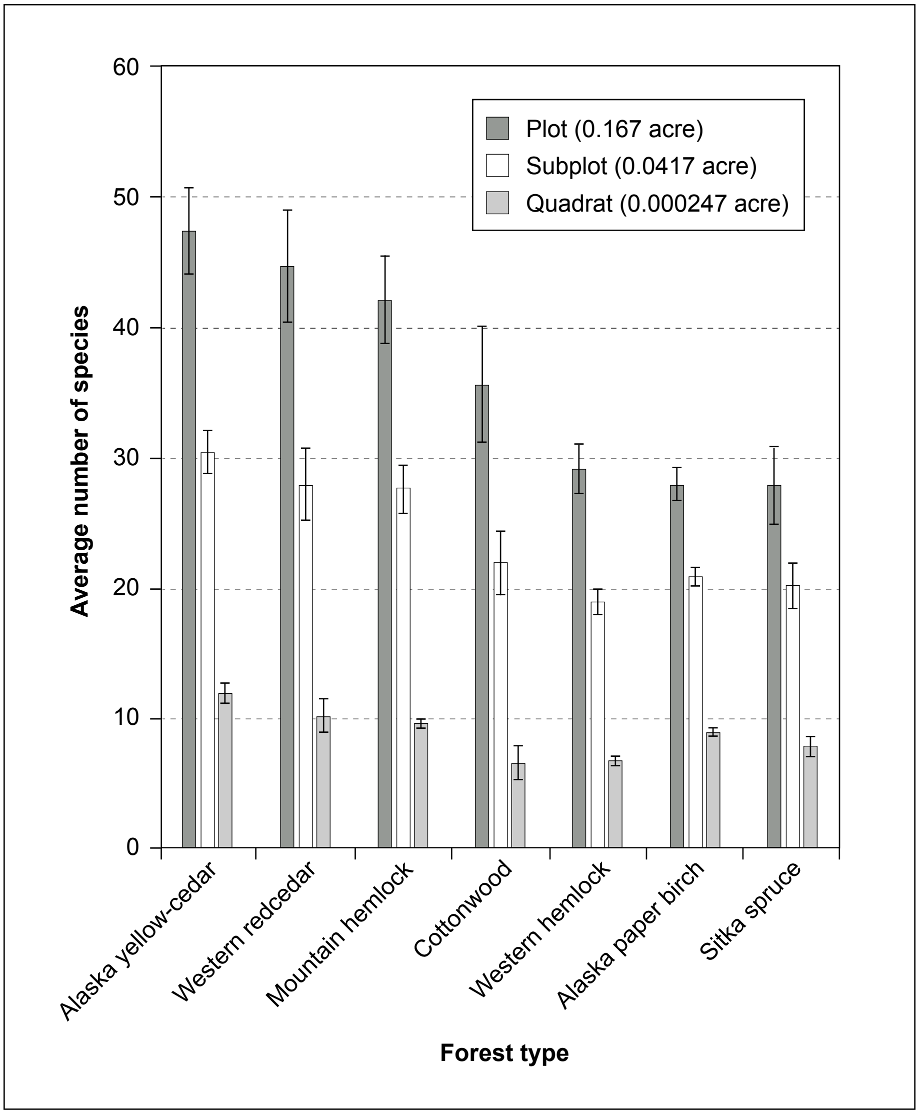


Figure 33—Average number of species per sample unit area by forest type. Lines at end of bars represent ± standard error.

Table 17—Physical and structural attributes of summarized forest community types

	Stand age		Live basal area		Elevation		Slope	
Forest type	Average (SE)	Range	Average (SE)	Range	Average (SE)	Range	Average (SE)	Range
	- - - - - - Years - - - - - -		*- - Square feet/acre - -*		*- - - - - - - Feet - - - - - - -*		*- - - - Percent - - - -*	
Western hemlock	195 (16.25)	0–369	201 (17.10)	0–350	536 (80.56)	100–1700	37 (5.60)	0–115
Mountain hemlock	213 (20.23)	48–329	124 (16.64)	9–273	1511 (131.59)	500–2700	35 (3.93)	0–65
Yellow-cedar	255 (30.68)	63–544	153 (25.46)	22–352	793 (108.57)	300–1700	33 (7.28)	0–125
Sitka spruce	95 (19.08)	26–191	150 (23.11)	0–231	420 (114.33)	100–1100	11 (3.63)	0–35
Western redcedar	138 (40.98)	15–281	183 (62.65)	4–410	300 (94.69)	100–700	16 (7.43)	0–55
Cottonwood	53 (6.16)	25–74	72 (23.66)	6–186	414 (176.22)	100–1500	9 (5.78)	0–40
Birch	74 (24.54)	25–166	62 (23.59)	6–146	460 (135.26)	100–900	13 (6.46)	0–40

Note: SE = standard error.

The **western hemlock forest type** was the most common within the inventory area. Common species present indicate a wide variety of sites, from nutrient poor to nutrient rich (app. 2, table 58). Deer forage species were common. This forest type had lower values for species richness, but had the highest basal area. Stands were often on slopes exceeding 30 percent, and were found at an elevation of about 500 feet (table 17). This species and forest type extended as far north as Prince William Sound, but the sampled forest health plots of western hemlock forest type were all located in the southern third of the inventory area (fig. 32). The best represented associations were western hemlock/blueberry (eight plots), western hemlock-western redcedar/blueberry (three plots), and mixed conifer/blueberry (three plots). The moderately productive western hemlock/blueberry association is the most abundant association in the Chatham area, is common in the Stikine and Ketchikan areas (Martin et al. 1995), and is also widespread in eastern Prince William Sound (DeVelice et al. 1999).

Western hemlock/devil's club (2, 3, 4)
Western hemlock/blueberry (1, 2, 3, 5, 6, 8)
Western hemlock/blueberry-devil's club (1, 2, 3, 5, 6, 8)
Western hemlock/blueberry/American skunk cabbage (1, 2, 3, 8)
Western hemlock-western redcedar/blueberry (1)
Western hemlock-western redcedar/blueberry-Salal (1)
Western hemlock-yellow-cedar/early blueberry (1, 2, 3)
Western hemlock-yellow-cedar/early blueberry/ American skunk cabbage (1, 2, 3)
Mixed-conifer/blueberry (1, 2, 3, 4, 5)
Mixed-conifer/blueberry/American skunk cabbage (1, 2, 4, 5)
Mixed-conifer/blueberry/deer cabbage (1, 3)
Sitka spruce-(western hemlock)/blueberry (1, 3, 8)
Mountain hemlock/early blueberry (1, 2, 4, 5)

The **mountain hemlock forest type** communities were dominated by mountain hemlock, the second most common tree species within the entire inventory area. These were some of the older stands, second only to yellow-cedar in age, but with lower live basal area than most other types. These stands were found at the highest elevations (on average, 1,500 feet or more), and slopes (35 to 40 percent) (table 17). Plant species also indicated colder, higher elevation sites, more open canopy, and a variety of microsites (app. 2, table 58). The mountain hemlock type was among the most species rich within the inventoried area (fig. 33); the single individual plot with the most species (86) was a mountain hemlock type (mountain hemlock/ blueberry). The 19 plots classified to 19 types, with the mountain hemlock/cassiope association most frequently observed. The long list of associations was partially due to different naming conventions; many plots keyed to similar associations in different classifications with different names. It also reflected the overall diversity of plant associations in the mountain hemlock forest type, which was sampled throughout the inventory area (fig. 32).

Mountain hemlock/Sitka alder (7, 8)
Mountain hemlock/cassiope (1, 3, 4, 7, 8)
Mountain hemlock/cassiope-deer cabbage (2)
Mountain hemlock/rusty menziesia/sparse (8)
Mountain hemlock/deer cabbage (7)
Mountain hemlock/devil's club (7)
Mountain hemlock/early blueberry (1, 2, 3, 4, 5, 7, 8)
Mountain hemlock/early blueberry/deer cabbage (2, 3, 4, 8)
Mountain hemlock/early blueberry-copperbush (7, 8)
Mountain hemlock/early blueberry-copperbush/ deer cabbage (1, 2, 3)
Mountain hemlock/early clueberry/Steller's cassiope (7)
Mountain hemlock/copperbush (1, 3, 5)
Mountain hemlock/copperbush-cassiope (1, 3)
Mountain hemlock-Sitka spruce/early blueberry- devil's club (1, 3, 4, 8)
Mountain hemlock-western hemlock/early blueberry/ deer cabbage (8)
Mountain hemlock-western hemlock/early blueberry- rusty menziesia (8)
Mixed-conifer/blueberry (1, 3, 5)
Mixed-conifer/blueberry/American skunk cabbage (1, 3, 5)
Sitka spruce-mountain hemlock/blueberry (1, 3, 7)

The **yellow-cedar forest type** had the highest average species richness (fig. 33), as the oldest of all forest types (table 17), and always had a mix of tree species present (app. 2, table 58). These stands were often at 800 feet elevation or higher, on slopes of about 30 percent and ranged from sea level to the mountain hemlock zone, most often on poorly drained sites (Martin et al. 1995). Common species indicated a variety of site conditions, deer forage and habitat (table 58). Yellow-cedar wood is highly valued (DeMeo et al. 1992), and its decline has been the focus of intense study (refer to yellow-cedar chapter).

The 15 plots assigned to the yellow-cedar forest type classified to nine described associations, listed below. Most common were mixed-conifer/blueberry/deer cabbage and mixed-conifer/blueberry/American skunk cabbage, with five plots each. According to Martin et al. (1995), the deer cabbage type provides better wildlife habitat, has a more open canopy, and has lower productivity, whereas the skunk cabbage type is moderately productive, but provided lower overall quality for habitat. Yellow-cedar occurred as far north as Prince William Sound, but sampled plots were all located in the southern half of the inventory area (fig. 32).

Western hemlock-yellow-cedar/early blueberry (1, 3, 4)
Mixed conifer/blueberry (1, 3, 5)
Mixed conifer/blueberry/American skunk cabbage (1, 3, 4)
Mixed conifer/blueberry/deer cabbage (1, 2, 3, 4)
Shore pine/crowberry (1, 2, 3, 4)
Mixed conifer/copperbush (3, 4)
Mixed conifer/copperbush/deer cabbage (1)
Mountain hemlock/early blueberry (1, 3)
Mountain hemlock/early blueberry/deer cabbage (2)

The **Sitka spruce forest type** plots were among both the youngest and most productive in the inventory (table 17) when the ratio of live basal area to age is considered. Sitka spruce forest type also had the lowest species richness (fig. 33). Common species (including Sitka spruce) indicated sites with a high incidence of disturbance, usually flooding or water moving through the soil on steep slopes prone to landslides, and nutrient-rich conditions (app. 2, table 58). Management implications discussed in local classifications note potential conflicts when large, highly valued Sitka spruce trees grow in riparian zones bordering salmon streams. Stands of large trees also provide critical habitat for terrestrial wildlife (DeMeo et al. 1992, Martin et al. 1995).

Pure Sitka spruce stands were uncommon, but Sitka spruce is the most ubiquitous tree species in the inventory (table 16). Only 10 plots had Sitka spruce stands, but these plots were distributed from Kodiak to Ketchikan (fig. 32). Sitka spruce stands occurred in relatively small patches generated by a site disturbance over a discrete area, landscape features that are often missed by the FIA sampling grid. Many associations were not captured in the sample of forest health plots. The 10 plots classified to 11 associations; some plots fit to several different associations owing to subtle differences in keys and different naming conventions among the classifications. DeMeo et al. (1992) acknowledged many upland types remain undescribed because of the steep, hazardous terrain they occupy.

Sitka spruce/Sitka alder (3, 4, 5, 6, 8)
Sitka spruce-red alder/salmonberry (1, 3)
Sitka spruce/blueberry (1, 3, 4, 5, 7)
Sitka spruce/blueberry-devil's club (1, 3, 5, 7)
Sitka spruce/devil's club (1, 3, 4, 5, 6, 8)
Sitka spruce/devil's club-salmonberry (1, 3, 5, 8)
Sitka spruce/moss (Bryophyte) (5, 6, 7)
Sitka spruce-cottonwood/Sitka alder (5, 8)
Sitka spruce-mountain hemlock/blueberry (1, 3, 7)
Sitka spruce-mountain hemlock/early blueberry-devil's club (7)

The **western redcedar forest type** had the second highest species richness of all the forest type communities (fig. 33). Found at lower elevations, western redcedar forest type had the second highest average basal area (table 17). This type was confined to the southern portion of the inventory area, which is the northern limit of western redcedar's range (fig. 32). The western redcedar forest type had eight species that occur on all plots (app. 2, table 58), including co-dominant western hemlock. It was distinguished by the frequent occurrence of red huckleberry and salal, which were both uncommon in other forest types (app. 2, table 58). Salal is not found north of the southern Stikine area; its range limitations are similar to western redcedar. Blueberry understories were associated with higher productivity (DeMeo et al. 1992). This forest type has the most limited range of all forest types in the Coastal Rainforest Mountain ecological province, and is only included in classifications for the Ketchikan and Stikine areas of the Tongass National Forest. Six plots were classified to six different associations.

Western hemlock-western redcedar/salal (1)
Western hemlock-western redcedar/blueberry (1, 2)
Western hemlock-western redcedar/blueberry-salal (1)
Western hemlock-western redcedar/blueberry-salal/American skunk cabbage (1)
Western hemlock-western redcedar/blueberry-American skunk cabbage (1)
Western hemlock/early blueberry/American skunk cabbage (1)

The **cottonwood forest type** plots had variable, mid-range species richness (fig. 33) and were relatively young stands (table 17). Species composition indicated recently or frequently disturbed sites (app. 2, table 58), similar to the Sitka spruce forest type. Cottonwood was found throughout the entire inventory area, but because it is not considered a climax species, this forest type was not included in classifications based on climax or potential vegetation communities. Cottonwood forest type plots were distributed from Kodiak to Yakutat (fig. 32). It is the only forest type in the Coastal Rainforest Mountains ecological province without early blueberry on the list of common species, and the only type over the entire inventory area that lacked bunchberry, the most ubiquitous species in the inventory (app. 2, table 58).

Cottonwood/Sitka alder (4, 6, 8)
Cottonwood/willow (5)
Sitka spruce-cottonwood/Sitka alder (5, 8)

The **birch forest type** was sampled in the colder Alaska Range Transition ecological province, on the western Kenai Peninsula (fig. 32). It was the second youngest forest type, and had the lowest basal area (table 17). Although the FIA forest type specified paper birch, the species observed is more likely to be Alaska paper birch (Viereck and Little 2007). The five birch forest type plots produced a species list with six species present on all plots, providing a good description of this forest type within its limited extent of the coastal inventory. Two of those species were found throughout the inventory area in other forest types (table 16); three were much less common to the other summarized forest types (fireweed, arctic starflower, and twinflower) (app. 2, table 58). The most common species list was similar to the more general Society of American Forester's description of paper birch forest cover type (Erye 1980). Birch forest types were only covered in DeVelice et al. (1999), and all plots were located to the west of the Chugach National Forest. The species composition of several individual plots did not match any cover type on the Chugach National Forest. Some plots may have occurred in stands that had been assigned to the white spruce type prior to the spruce beetle outbreak. These stands are likely to continue to change in structure and composition as the forests regenerate in the coming years.

Paper birch/bluejoint reedgrass (8)
Paper birch/rusty menziesia (8)

Interpretation

Plots were summarized by forest type within the two ecological provinces to facilitate comparisons to larger regions or other parts of the country as more FIA Vegetation Indicator data become available for analysis. The Coastal Rainforest Mountains ecological province is more thoroughly sampled than the Alaska Range Transition province, which only extends slightly into the area of the Alaska coastal inventory. Highest species richness for the inventory area is found on sites dominated by yellow-cedar, mountain hemlock, and western redcedar; the lowest species richness is found on sites dominated by Sitka spruce, birch, or western hemlock. In coastal Alaska species, richness is higher on sites that are of lower value for timber production; these stands have less overstory cover and a variety of microsites to support higher species diversity.

Reporting species richness for three standard sample areas gives a multiscale perspective of how species occupy the forest stands of each type. Although many species are ubiquitous throughout the inventory, some species and community types have limited distributions over the area. The procedures provide a standard method for assessing the differences in species richness and species and community distribution over time and space as permanent plots are remeasured.

The FIA's forest types, computed by algorithm, are roughly analogous to the Society of American Forester's forest cover types (Erye 1980), forest (tree) cover types (DeVelice et al. 1999, Shephard 1995), forest series (DeMeo et al. 1992, Martin et al. 1995, Pawuk and Kissinger 1989), alliances (Tart et al. 2005), or landcover classes (Boggs et al. 2008, 2009). The local classifications then further distinguish each forest type to more specific community types or associations. Associations are usually differentiated along gradients, such as drainage, elevation, or frequency of disturbance; the presence of certain indicator species often reflects the differences in site conditions. Authors caution that each classification is developed for a particular area; for this study, species composition data were applied to a number of classifications to assess distribution of associations across the entire inventory.

Most plots could be classified to a described plant association or community type. The opportunity to compare individual plot species composition with locally developed classifications increases our understanding of the plant association distributions within the inventory area. Each FIA-defined forest type included a wide variety of described associations and community types, indicating the greater vegetation diversity each forest type represents. Evaluation of the assembled common species list for plants indicating site conditions or habitat values along with basic stand structure and physical setting attributes revealed similarities in site characteristics and helped predict where the plant communities could be found across the inventory area.

The classification systems used differed in the types of vegetation assessed. DeMeo et al. (1992), Pawuk and Kissinger (1989), and Martin et al. (1995) all described potential or climax forest vegetation; the other authors described existing vegetation. Vegetation sampling for developing classifications usually occurred on temporary plots that would be difficult to relocate and remeasure. Although sampling methods were similar for each classification, sample plots differed in size and configuration. Therefore, it was not possible to assess or compare species richness of the plant associations based on the information provided by the classifications.

The ability to describe plant communities enhances communication between land managers planning and performing management activities. The forest plant communities described from analyses of the VEG data provide a bridge between generalized descriptions of forest types (Erye 1980, Viereck et al. 1992) and the locally relevant, detailed vegetation plant association descriptions (table 14) developed by using many more, albeit temporary, plots. The forest health grid of plots is sparse compared to the thousands of plots that were sampled for the classifications. However, the grid provides permanently established plots that can be linked via species composition data of the vegetation indicator to the detailed locally defined plant associations and community types. The standardized data collection and sampling procedures used here help to describe the distribution of the more detailed associations within the inventory area and facilitate quantified comparisons of species richness and species distribution with other regions.

Older Forests in Coastal Alaska[3]

Background

Older forests have been the subject of great controversy in the past decades. Generally, old-growth forests are characterized by old, large trees, snags, and downed logs (Franklin and Spies 1991). Additional characteristics can include diverse lichens, mosses, fungi, spatially uneven structure with occasional gaps where large trees have fallen, and large quantities of standing biomass (fig. 36). In most forest ecosystems, these old-growth characteristics only emerge many decades, even centuries, after a stand-replacing disturbance. In the United States overall, only a small proportion of the old-growth area that existed prior to European settlement remains in old-growth conditions; how small that proportion is has been a subject of considerable debate. Alaska is unique among U.S. states owing to the substantial proportion of forest that remains relatively unaffected by management activities such as land conversion, fire suppression, or timber harvest; this is true both for the coastal temperate rain forest and the boreal forests of interior Alaska.

[3] Author: Tara M. Barrett.

A Day in the Life of Alaska FIA crew[4]

Data collection for Forest Inventory and Analysis (FIA) is done quite differently in coastal Alaska than in other U.S. states. A mile or so from the coastline, it is extremely difficult, if not impossible, to access plot locations from the shore by foot. Most of our plots are accessed via a helicopter from the back deck of an 86-foot-long boat (fig. 34). We depart from Ketchikan in early June, work our way around and through the islands in southeast Alaska, out along the Gulf of Alaska, through Prince William Sound, out to Kodiak Island, and finally finish up on the Kenai Peninsula in August. Letting the boat or helicopter sit idle is expensive, so we operate 7 days a week for the full field season by keeping crews on rotating shifts. With a shift change every 5 days, and transport to and from the boat involving a complex system of helicopter, skiff, float plane, and commercial flights through southeast Alaska's changeable weather, logistics are difficult.

A Good Day

Rise and shine at 6:30 am. After a brief session of calisthenics or yoga on the heli deck, pack your lunch and field gear. Contact dispatch to make sure they have the flight schedule for the day. Check on radio repeaters and the weather. We have a full crew briefing at 8:00 am. In our briefings we go over the plan for the day, review safety and any data quality issues, and conduct the helicopter briefing. By 8:15, the first crews, packs, survival bags, and shotguns are loaded into the helicopter. All crews are out in the field by 10:30 (fig. 35). Our captain does the flight following and keeps track of crew locations in the field. By mid to late afternoon, the crews start to call back to the boat; their plots are finished and they're at their landing zone, ready for a ride back to the boat.

[4] Author: Connie Hubbard.

Brita Janson

Figure 34—Most plots have to be accessed by using a helicopter and boat.

Back on the boat, plot data are downloaded, edited, and plot writeups are done. After dinner, the next day's plan is made and posted. The schedule is e-mailed via satellite phone to dispatch, and load calculations for the helicopter are in the pilot's hand. Quality assurance staff review the plot folders for our day's work and back up our databases.

A Not-So-Good Day

Some days the weather is not so good. Rain doesn't really matter, but we need a minimum 500-foot cloud-free ceiling and a half mile of visibility, as well as less than 30 knot winds to fly. If the weather doesn't allow us to fly to the plots we planned to visit, we'll go right into plan B: identify plots at lower elevations that aren't inhibited by low clouds, or plots we can access with a skiff. Sometimes there isn't much we can do besides call it a weather day and do other things: clean firearms, catch up on writeups and checking data, plan for the next crew swap. When the weather is bad or on a rough crossing, 18 people on a small boat can feel very crowded. Personal space is limited to a bunk and a single drawer. But bad weather on the boat is better than the alternative. One time after a few weather days, we had a small break in the weather. The forecast for the late afternoon was not good, but we thought we could beat it … and we left 12 folks in the field that night. Our crews were spread between Montague, Hitchenbrook, and Hawkins Islands in Prince William Sound. We retrieved the last crew just before it got dark on the second day. With the unpredictable coastal weather, it's pretty standard for a couple of crews to spend a night out each season.

Training, Attitude, and Safety

We couldn't do FIA in Alaska without aircraft. Each crew member takes Aviation User Training, and gets to wear a bright orange Nomex flight suit, float vest, flight helmet and other personal protective equipment. Everyone is considered a crew member on each flight

Eric Straley

Figure 35—Crews carry packs, survival bags, and safety gear.

and needs to watch for other aircraft, birds, or other obstacles, as well as voice any concern about weather or other pertinent flying conditions. Crew leaders sit in the front seat and navigate to the landing zone closest to their plot by using maps, aerial photography, and satellite imagery. Landing zone selection can be a challenge, and often there is still an arduous hike to the plot. It is somewhat difficult to imagine being aboard a helicopter taking off and landing on a 20- by 20-foot deck on the back of an 86-foot boat. The mast is only about 15 feet from the tip of the rotors. Our pilots are good!

Our training is about half data collection protocols and half safety training. Many safety topics are unique to Alaska: we have bear awareness, survival training (for those unplanned nights out in the woods), firearms safety and range qualifications, aviation user training, and helicopter manager training. Many of our employees also are certified Wilderness First Responders.

Attitude is everything with Alaska FIA crews. Physical and mental challenges abound, as do the rewards for a job well done. Good attitude and flexibility are required to get the work done and have fun doing it. With the boat, helicopter, bears, firearms, rugged terrain, and remoteness of our operation, safety is our number one priority. If it can't be done safely, we don't go. We have fostered a safety culture that involves everyone at every step of the way. We look out for each other and learn to manage our many risks.

Jon Williams

Figure 36—Western hemlock forest near Hawk Mine, Alaska. Old-growth forests in the temperate rain forest of Alaska are often characterized by large trees, snags, and down logs.

Results presented here focus solely on tree-related vegetation characteristics, but it is important to recognize that old-growth forests consist of a complex web of interacting biotic and abiotic elements. Old-growth forests play an important role in sustaining quality of streams and rivers in Alaska (fig. 37). One of the primary concerns about loss of old-growth is the impact on birds, mammals, and other wildlife species. In the coastal Alaska temperate rain forest, loss of old-growth area is complicated by the isolation created by the distribution of the forest across an archipelago. Analysis of mitochondrial genetic information suggests that isolation among islands has caused some genetic divergence and endemism among mammals in southeast Alaska (Cook et al. 2001). Although concern over loss of biodiversity has often focused on fauna, other elements of old-growth forests can also be impacted by conversion to younger age structures, but the effects tend to be less well understood. For example, experience in the temperate rain forests of Oregon and Washington suggests that there are associations between fungi and old-growth conditions, but understanding and identifying those associations can be very difficult and expensive (Molina 2008).

The proportion of forest in old-growth conditions will depend on the frequency of stand-initiating disturbances. In the coastal temperate rain forest, wind is an important source of disturbance (Kramer et al. 2001). Nowacki and Kramer (1998) compiled data from case studies to provide blowdown rates for forest on southeast Chichagof Island

Misha Yatskov

Figure 37—Older forests sustain quality and quantity of water in coastal Alaska streams.

(2.6 percent per century), northeast Chichagof Island (3.4, 3.4, and 1.3 percent per century), Kuiu Island (0.9 and 3.9 percent per century), and Prince of Wales Island (7.3 percent and 14.3 percent per century, based on data from 1961 to 1972). Avalanches, insect outbreaks, and flooding also can cause stand initiation, as can timber harvest. The most recent FIA inventory data show that in the coastal temperate rain-forest region, outside of national forest wilderness, harvest occurred on an estimated 0.25 percent of forest land per year (see "change" section, chapter 2).

Most of the controversy in Alaska over harvesting old growth has focused on the temperate rain forest. However 90 percent of Alaska's forests, and 15 percent of forest in the inventory region, is in boreal forest types (see fig. 5, chapter 2). Stand-replacing disturbance such as fires or beetle outbreaks are much more common in the boreal forest, so that the resulting age distribution of forest stands is younger than in the temperate rain forest. DeVolder (1999) reported that the black spruce forests on the Kenai Peninsula have fire-return intervals ranging from 25 to 185 years, with a mean return interval of 89 years. Spruce beetle (*Dendroctonus rufipennis* [Kirby]) outbreaks on the Kenai in white, Sitka, and Lutz spruce forests have occurred on average every 52 years (Berg et al. 2006). The most recent FIA inventory data show that in the boreal forest region, harvest occurred on an estimated 0.26 percent of forest land per year (see "change" section in chapter 2).

"Old growth" is a term that has been defined in many different ways. Each definition will produce different amounts of forest land that is classified as old growth. The two national forests in coastal Alaska currently use ecological definitions described in Capp et al. (1992a 1992b). Elements in that system that are used to indicate old growth include the number of large trees per acre, the minimum diameter at breast height of large trees, the minimum age of large trees, canopy layering, number of snags, number of large pieces of down wood, and forb cover.

That system cannot be used directly with the inventory for a variety of reasons. The inventory plots are smaller than the plots used to develop the system, which affects the amount of classified old growth that would meet criteria such as minimum age or size of trees. The inventory currently does not include plant association, downed woody material, canopy layering, or forb cover on all plots, which would be necessary for using the Capp et al. classification. Instead, in this report, a single metric, stand age, is used to describe forest conditions. Most results that follow are reported as distributions across age classes. When results are presented by using a single metric, the term ''older forest'' is used to avoid confusion with existing old-growth definitions.

Methods

On each inventory plot, boundaries are delineated between stands that differ by reserved status, owner group, forest type, stand size class, regeneration status, and tree density. On most stands, three live trees that represent the plurality of the predominant stand size class are then selected and an increment borer is used to find tree age (fig. 38). For bored trees, a number of years are added to estimated age to approximate the amount of time for a tree to grow to breast height: 2 years for alder, aspen, or cottonwood; 5 years for paper birch; and 8 years for other species. For 99.7 percent of trees with measured ages, age is determined by counting rings; in 0.03 percent of cases, the bore misses the center of the tree and age is extrapolated. By using the ages of the selected trees, the field crew then assign an age to the stand. If the age of three trees were measured during the previous 1995–2003 inventory, and no change to stand age appears to have occurred, additional ages are not taken and age is computed by adding the number of years between field measurements to the previous age. Where trees are too small to bore, such as in a seedling or sapling stand, the field crew estimate an age. Tree age is subject to some measurement error, through false growth rings, absent rings, and inaccurate counting. A greater source of uncertainty in estimating stand age is the choice of which trees to select for aging, as ages can differ by very large amounts even among trees of the same size

Misha Yatskov

Figure 38—Trees are aged in the field by taking an increment bore and counting rings.

For this report, "older forest" is defined as forest that meets a minimum stand age by forest type. Although the minimum ages used for the Sitka spruce, western hemlock, white spruce, aspen, and lodgepole pine forest types correspond to tree ages described in Capp et al. (1992a, 1992b), that system refines minimum ages by plant association subseries and uses different minimum ages for Sitka spruce on the Chugach and Tongass National Forests. Although the system used here is a gross simplification of Capp et al., it has the advantage of being repeatable in future FIA inventories, which will be helpful in monitoring changes in forest characteristics over time. Minimum ages used for each forest type to define older forest were 170 years for yellow-cedar, 50 years for aspen, 100 years for cottonwood, 170 years for lodgepole pine, 160 years for mountain hemlock, 50 years for paper birch, 200 years for Sitka spruce, 160 years for subalpine fir, 180 years for western hemlock, 170 years for western redcedar, and 150 years for white spruce. Capp et al. used black spruce tree ages of 200 years as one indicator of old growth, but we did not find trees of that age and instead used the mean fire interval (89 years) plus standard deviation (43 years) from De Volder (1999) to obtain a minimum older forest stand age of 132 years. Red alder, Pacific silver fir, and subalpine fir forest types were not included in the analysis because only very small numbers of these forest types were found within the inventory region.

Because the disturbance regimes in the boreal forests on the western Kenai are substantially different from the temperate rain forests in the remainder of the inventory region, some results are presented separately for those two areas. Forests in the Alaska Range Transition ecological province (shown in fig. 6 of chapter 2) are referred to here as the boreal region, and forests in the Coastal Rainforest Mountains ecological province are referred to as the temperate rain-forest region. These ecoregion boundaries are based on Nowacki et al. (2002), and plots were assigned to regions based on best available coordinates.

Results

Based on the minimum age class definition for older forest, the temperate rain-forest ecoregion contains 8.4 million acres of older forest, which is 61.2 percent of all forest in the region. The boreal forest region on the Kenai contains 0.5 million acres of older forest, which is 31.2 percent of all forest in the region. Some 47 percent of older forest in the boreal region on the Kenai is reserved, and 35 percent of the older forest in the temperate rain-forest ecoregion is reserved (see glossary for definition of "reserved" forest land).

The age class distribution of different forest types differs substantially (fig. 39). Structural composition of older forest differs among forest types, as shown by numbers of live and dead trees per acre by diameter class (tables 18 and 19). In order of descending area, most older forest is found in the western hemlock, mountain hemlock, and yellow-cedar forest types (table 20).

The age distribution of forest also differs substantially by ownership (fig. 40). In the boreal region, 75 percent of the older forest is in public ownership. In the temperate rain-forest region, 89 percent of the older forest is in public ownership. In the temperate rain-forest ecoregion, 67 percent of federal forest land is in older forest, 35 percent of state and local government forest land is in older forest, and 34 percent of private land is in older forest. In the boreal ecoregion, 27 percent of federal forest land is in

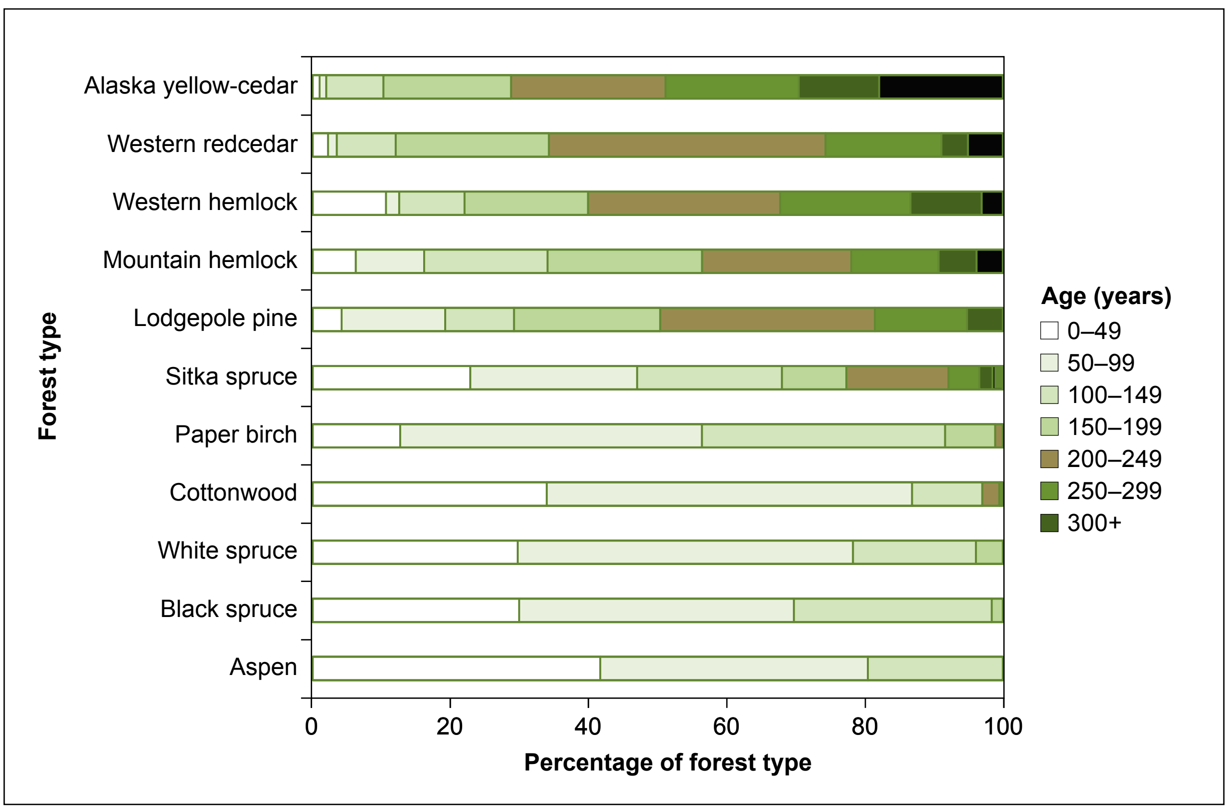


Figure 39—Percentage of forest type area by age class for coastal Alaska, 2004–2008.

Table 18—Estimated live trees per acre of older forests by diameter class and forest type, coastal Alaska, 2004–2008

Forest type	Minimum stand age	Diameter class (inches)															
		0–4.9		5.0–9.9		10.0–14.9		15.0–19.9		20.0–24.9		25.0–29.9		30.0–34.9		35.0+	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Years	*Trees per acre*															
Alaska yellow-cedar	170	581	66	144	9	60	5	22	2	6	1	2	—	1	—	1	—
Lodgepole pine	170	459	79	83	10	22	5	5	1	2	1	—	—	—	—	—	—
Mountain hemlock	160	293	26	102	5	52	4	26	2	10	1	4	1	1	—	2	1
Paper birch	50	159	36	80	9	26	3	6	1	1	—	—	—	—	—	—	—
Sitka spruce	200	193	63	74	14	40	8	14	2	9	2	8	2	7	2	6	2
Western hemlock	180	250	19	89	4	40	2	22	1	13	1	7	1	4	1	3	1
Western redcedar	170	465	39	147	9	66	7	26	5	11	2	7	2	4	1	4	1

Note: Data subject to sampling error; SE = standard error; — = less than 0.5 trees per acre were estimated. Note: Glacier Bay National Park is excluded.

Table 19—Estimated snags per acre in older forests by diameter class and forest type, coastal Alaska, 2004–2008

Forest type	Minimum stand age	Diameter class (inches)													
		5.0–9.9		10.0–14.9		15.0–19.9		20.0–24.9		25.0–29.9		30.0–34.9		35.0+	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	Years	*Trees per acre*													
Alaska yellow-cedar	170	37	3	18	2	6	1	3	1	1	—	1	1	—	—
Lodgepole pine	170	32	7	7	2	1	1	—	—	—	—	—	—	—	—
Mountain hemlock	160	13	2	6	1	3	1	2	—	1	—	1	1	—	—
Paper birch	50	27	4	13	2	2	1	—	—	—	—	—	—	—	—
Sitka spruce	200	17	4	14	4	7	2	4	1	3	1	2	1	1	1
Western hemlock	180	16	2	8	1	6	1	3	—	2	—	1	1	1	1
Western redcedar	170	52	4	19	2	9	1	3	1	1	—	1	1	1	1

Note: Data subject to sampling error; SE = standard error; — = less than 0.5 trees per acre were estimated. Note: Glacier Bay National Park is excluded.

Table 20—Area of older forest by forest type, owner group, and reserve status, coastal Alaska, 2004–2008

Forest type	Minimum stand age	U.S. Forest Service			Other public			Private	All ownerships	
		Unreserved	Reserved	Total	Unreserved	Reserved	Total	Unreserved	Area	SE
	Years	*Thousand acres*								
Alaska yellow-cedar	170	1,041	760	1,801	39	—	39	46	1,886	215
Aspen	50	—	—	—	3	82	85	10	95	29
Cottonwood	100	18	—	18	12	15	28	24	70	28
Lodgepole pine	170	231	20	251	9	—	9	23	284	55
Mountain hemlock	160	994	661	1,655	115	42	157	101	1,912	191
Paper birch	50	0	—	0	139	177	316	208	524	70
Sitka spruce	200	117	210	327	43	21	64	53	444	111
Western hemlock	180	1,680	846	2,525	104	—	104	152	2,781	227
Western redcedar	170	454	337	790	35	—	35	42	867	143
White spruce	150	—	—	—	—	5	5	12	17	14
Total		4,535	2,834	7,369	499	343	842	670	8,881	278

Note: Data subject to sampling error; data subject to sampling error; SE = standard error; — = less than 500 acres were estimated.
Note: Glacier Bay National Park is excluded.

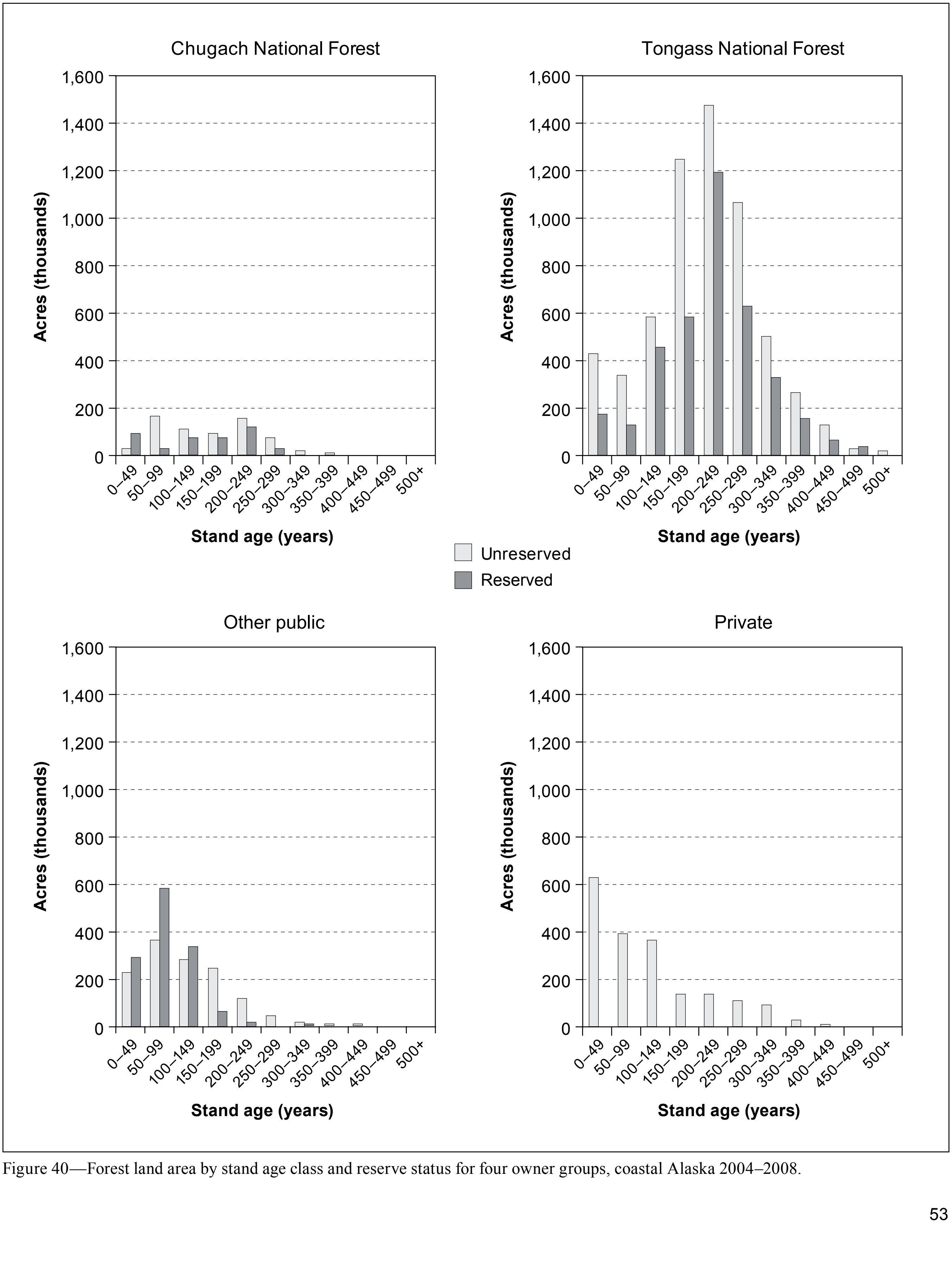


Figure 40—Forest land area by stand age class and reserve status for four owner groups, coastal Alaska 2004–2008.

older forest, 35 percent of state and local government forest land is in older forest, and 33 percent of private forest land is in older forest. Amounts of older forest by forest type, owner group, and reserve status are shown in table 20.

Older forests in the temperate rain forest ecoregion store substantial amounts of carbon. Overall, for example, the amount of carbon in live and dead trees on forest land in the Tongass National Forest is estimated at 68 tons per acre. But that same statistic increases to 75 tons per acre for older forests. The Chugach National Forest has an estimated 38 tons per acre of carbon in live and dead trees over all forest land, but 56 tons per acre in older forest. The greatest amounts of carbon per acre are found in older forest of the Sitka spruce forest type (table 21). Overall, carbon in live trees compared to carbon in snags was about a 4-to-1 ratio in older forest. Carbon content in older forests was highest in the southeast portion of the temperate rain forest. Moving westward from the Alexander Archipelago ecological section to the Gulf of Alaska Coast ecological section, carbon dropped from 53.8 to 43.5 tons per acre for the mountain hemlock forest type, from 100.0 to 75.3 tons per acre for the western hemlock forest type, and from 137.9 to 57.2 tons per acre for the Sitka spruce forest type.

Interpretation

In the temperate coastal rain forest that stretches along the west coast of North America, from Alaska through British Columbia, Washington, Oregon, and northern California, stand-replacing natural disturbance is relatively rare, and most native tree species are long-lived. The result is that absent significant human disturbance, the median stand age for most common forest types is hundreds of years of age. Outside of Alaska, the distribution of stand ages has shifted to much younger age classes throughout much of the coastal temperate rain-forest region, through forest management and harvesting. Within Alaska, large portions of the forest are in parks or wilderness, and even in unreserved land much of the forest has never been harvested. Thus Alaska has a much higher proportion of older forest than other U.S. states.

Most of the older forest on public land in the region is not reserved from being managed for wood products utilization through statute or administrative designation. However, management plans may still specify that unreserved lands be managed for purposes other than timber. In addition, logistical and economic constraints can preclude harvest of timber. A single ownership, the Tongass National Forest,

Table 21—Carbon per acre stored in live and dead trees in older forest, coastal Alaska, 2004–2008

		Carbon in live trees		Carbon in snags		Total	
Forest type	**Minimum stand age**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
	Years	*Tons per acre*					
Alaska yellow-cedar	170	40.3	3.5	12.0	2.1	52.3	5.3
Aspen	50	17.8	3.6	6.5	1.1	24.3	4.0
Cottonwood	100	56.8	27.2	3.7	2.4	60.5	26.6
Lodgepole pine	170	10.3	1.7	2.6	0.6	12.9	2.0
Mountain hemlock	160	44.6	3.7	6.9	0.8	51.5	3.9
Paper birch	50	14.5	1.7	4.8	0.8	19.3	1.7
Sitka spruce	200	86.2	9.0	21.0	4.8	107.2	12.2
Western hemlock	180	77.5	3.6	19.9	1.5	97.4	4.0
Western redcedar	170	60.8	9.4	15.5	1.7	76.3	9.8
White spruce	150	10.8	4.0	1.2	0.6	12.0	4.6
All forest		54.4	1.9	13.3	0.7	67.7	2.3

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

Note: Glacier Bay National Park is excluded.

contains 77 percent of the older forest in the coastal Alaska region.

Older forest is a substantially smaller proportion of forest land for privately owned forests than for publicly owned forest. Most of the young forest in the coastal region is in private ownership. Both of these findings about private forests are also true of most other U.S. states. Because the rotation lengths that maximize economic returns tend to be short, these trends are likely to continue in the future.

Other factors than timber harvest can alter the age distribution of coastal forests. Severe bark beetle outbreaks, such as occurred on the Kenai Peninsula in the 1980s and 1990s, can shift large areas of forest to younger age classes. There is anecdotal evidence that a rare large-area windstorm occurred in the coastal forest in the 1880s, creating a shift to younger age classes (Hennon and McClellan 2003). There is some evidence that yellow-cedar is experiencing elevated mortality that could be due to climate change (see yellow-cedar section in chapter 4 in this report). If the same methods are used to monitor stand age in future inventories, it will be possible to evaluate change in forest age distribution from these and other causes.

Walter Foss

Chapter 4: Disturbance and Stressors

There are many natural disturbances—wind, flooding, insects, fire, disease, avalanches—that affect the functioning of forest ecosystems in southeast and south-central Alaska. In this chapter, we analyze a few of the disturbances that can act as stressors on forests in the region. In the first section, dynamics of yellow-cedar (see "Common and Scientific Names") are discussed in the context of climate change. The next section describes some of the insects that affect forests in this area, followed by a short analysis of results of monitoring for invasive plants on Forest Inventory and Analysis (FIA) plots. A new postfire monitoring system being used on FIA plots on the Kenai Peninsula is described, along with the type of fire effects that will be monitored. The last section discusses hemlock dwarf mistletoe, and its host tree western hemlock, in the context of climate change.

Use of Forest Inventory Data to Document Patterns of Yellow-Cedar Occurrence, Mortality, and Regeneration in the Context of Climate[1]

Background

Yellow-cedar has great cultural and economic value but has experienced widespread mortality for about 100 years in southeast Alaska (Hennon and Shaw 1997). The tree mortality, known as yellow-cedar decline, appears as dense concentrations of dead yellow-cedar trees (fig. 41), which are readily detectable by aerial survey or other forms of remote sensing. Yellow-cedar decline occurs primarily in

[1] Authors: Paul Hennon, John Caouette, Tara M. Barrett, and Dustin Wittwer.

Dustin Wittwer

Figure 41—Yellow-cedar decline results in over 70 percent mortality of yellow-cedar, which can be detected by aerial surveys and other forms of remote sensing. Evaluating healthy yellow-cedar forests requires the use of inventory data.

unmanaged forests on wet soils where trees of various sizes and ages die and remain standing long after death. The cause of yellow-cedar decline appears to be freezing injury of shallow fine roots when they are not protected by snow in late winter or spring (Hennon et al. 2008, Schaberg et al. 2008). The U.S. Forest Service Forest Health Protection team has developed a fairly complete distribution map for yellow-cedar decline in Alaska; it occurs in more than 2,000 locations totaling over 500,000 acres (Lamb and Winton 2010). Producing maps and geographic information system (GIS) layers for healthy yellow-cedar forests has proven more difficult, however, because cedar trees are not easily distinguished from hemlocks and other trees in mixed-species forests. Thus, there is no reliable information on the current distribution of healthy yellow-cedar forests to place the decline issue into some spatial context.

Methods

We used FIA and other inventory plot data and personal field observations in selected areas to produce a coarse distribution map of yellow-cedar forests for southeast Alaska. For this coarse map, entire watersheds were designated as having yellow-cedar if yellow-cedar was present in an inventory plot or was observed there. We overlaid the map of dead cedar forests generated from the forest health detection aerial survey to determine how yellow-cedar decline fits into the general distribution of the tree.

We also analyzed FIA inventory data on the occurrence of live, dead, and regenerating yellow-cedar by elevation classes to evaluate our observations that the tree is dying at low elevations but thriving and regenerating at higher elevations in the region. We calculated ratios of live trees:dead trees and live trees:live saplings by using a 5-inch-diameter threshold to separate trees and saplings, and then charted these ratios by elevation to explore trends of how yellow-cedar populations may be changing by elevation. Results that relate numbers of yellow-cedar trees to elevation used FIA plots that were measured between 1995 and 1998; there were 625 forested plots with yellow-cedar trees in that inventory. For information about net change of yellow-cedar in the region, we used 307 of these plots that were remeasured in 2004 through 2008.

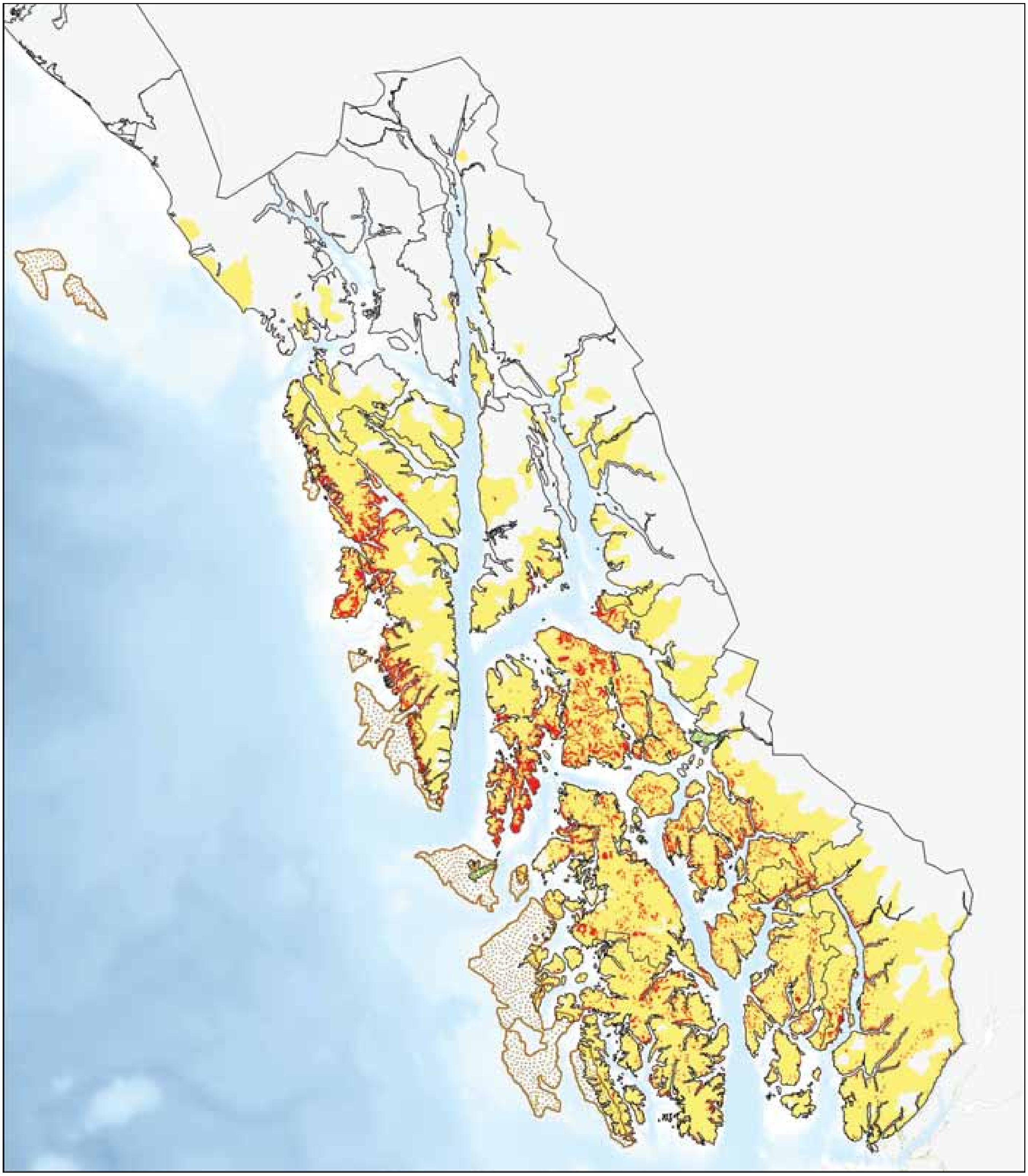
Results

The map showing the occurrence of yellow-cedar in southeast Alaska (fig. 42) is the most detailed view of yellow-cedar's natural range within the region. Yellow-cedar is present throughout most of southeast Alaska, but there are areas where it is rare or absent. For example, yellow-cedar is apparently missing from large areas in the northeastern portion of the panhandle even though there is abundant suitable habitat present in the form of bog and forested wetland complexes. This regional map of yellow-cedar is useful for a variety of purposes; for example, it has already been used to illustrate where yellow-cedar is present as a resource for bark and wood collection by Native people near each of the villages or towns. Also, we used this map as the basis for sampling in a new regionwide population genetics study for yellow-cedar.

Overlaying the yellow-cedar decline on this map indicates that the intensive mortality problem covers only part of yellow-cedar's regional distribution. Yellow-cedar decline is present in the southern and northwestern portions of the panhandle, but yellow-cedar growing in the northeastern portion of the panhandle appears to be free of the intensive mortality.

Although yellow-cedar can be found from shoreline forests to timberline in southeast Alaska, inventory data reveal that the abundance of this tree peaks at mid-elevation range (fig. 43). Tree death and regeneration of yellow-cedar show somewhat of a departure by elevation from this pattern of live trees. The ratio of dead trees:live trees was greatest at lower elevation and then diminished upslope, but the ratio of live trees:live saplings showed the opposite relationship with a greater proportion of regeneration at higher elevations (fig. 44).

Overall, change in net live tree biomass of yellow-cedar between the 1995–1998 and 2004–2008 inventories showed an increase of 0.61 percent, which was not significantly different from 0 (p-value 0.4064). Average annual mortality of trees greater than 5 inches diameter at breast height (d.b.h.) was 0.30 percent (standard error [SE] = 0.04 percent). Average annual harvest rate was 14 percent of average annual mortality, for a total tree death rate of 0.34 percent. Total



Dustin Wittwer

Figure 42—Occurrence map of yellow-cedar in southeast Alaska (yellow) from Forest Inventory and Analysis and other inventory data and several personal observations, and the distribution of yellow-cedar decline (red) mapped during forest health aerial detection surveys. Note that yellow-cedar decline occurs within most, but not all, of the range of yellow-cedar in southeast Alaska. The speckled areas along the outer west coast of the region indicate glacial refugia during the late Pleistocene Epoch (Carrara et al. 2007) and may represent the origins for yellow-cedar for subsequent Holocene migration.

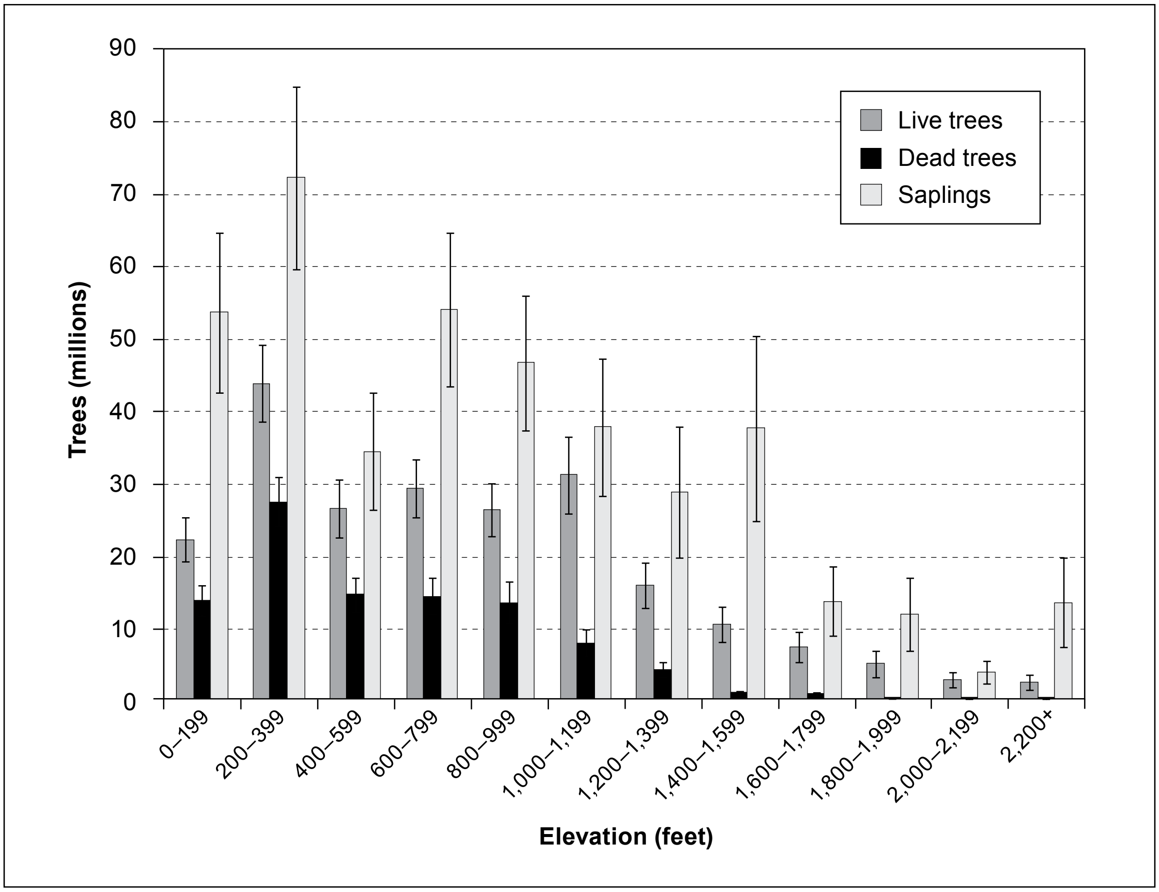


Figure 43—Numbers of yellow-cedar trees (live trees ≥ 5 inches diameter at breast height (d.b.h.), dead trees ≥ 5 inches d.b.h., and live saplings < 5 inches d.b.h.) by elevation. Lines at end of bars represent ± standard error.

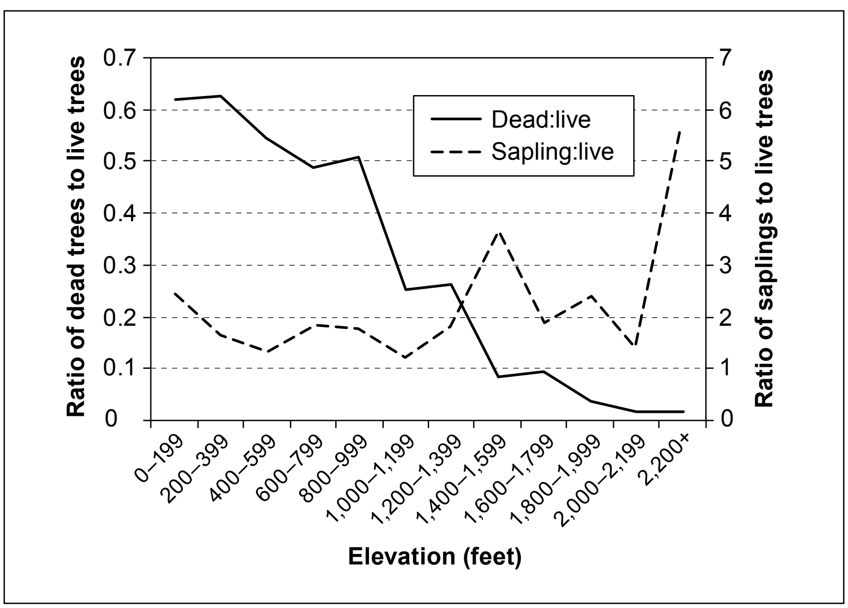


Figure 44—Ratio of yellow-cedar dead trees:live trees and live saplings:live trees for 200-foot elevation classes from Forest Inventory and Analysis inventory plot data.

number of live yellow-cedar trees ≥ 5 inches d.b.h. did not show significant change in biomass between the 1995–1998 and 2004–2008 inventories (p-value = 0.7443).

Interpretation

The general occurrence of yellow-cedar in southeast Alaska may be the result of long-term climate change in the region combined with yellow-cedar's low reproductive capacity. We hypothesize that yellow-cedar survived the late Pleistocene Epoch in forested refugia along the outer western coast of the panhandle when most of the region was covered by ice sheets (Carrara et al. 2007). Yellow-cedar likely began to colonize much of southeast Alaska during favorable climate conditions in the last 4,000 years, but our data suggest that the species is still actively migrating toward the northeast. This scenario may explain the absence or rarity of the tree in the northeast portion of southeast Alaska. The above-mentioned population genetics study based on our yellow-cedar map is designed to evaluate this hypothesis. Yellow-cedar also grows farther to the northwest in Prince William Sound. Populations are so small there that we were able to produce a map of the tree's range by observations from a boat (Hennon and Trummer 2001).

The pattern of yellow-cedar decline within the general distribution of yellow-cedar is consistent with our interpretation that seasonal snow depth is a controlling factor for yellow-cedar decline. The lowest snow zone on a regional snow map shows a remarkably close association with yellow-cedar decline (Hennon et al. 2008). Areas with more annual accumulation of snow are generally those that have healthy yellow-cedar populations. Snow protects yellow-cedar from the proximal injury leading to tree death—freezing injury of shallow-growing fine roots in late winter (Schaberg et al. 2008).

Yellow-cedar death in FIA plots is more common at low elevations. This is consistent with the same finding from aerial surveys, where the acreage of yellow-cedar decline mapped was clearly skewed toward lower elevations (Lamb and Winton 2010). The association of yellow-cedar decline with lower elevations is consistent with the role of snow in protecting yellow-cedar from the freezing scenario mentioned above.

Tree species that show different elevational patterns of occurrence among live trees, dead trees, and regeneration may be considered relatively unstable with regard to climate. More stability for a tree species would be exhibited by a pattern where live trees, dead trees, and regeneration had similar elevational trends. Yellow-cedar appears to be a species in flux, however, as our data indicate, the trees are dying at low elevation, surviving as live trees at mid elevation, and regenerating at higher elevation. Thus, under the recent-past and current climate, yellow-cedar populations appear to be shifting to higher elevations.

The relatively low rate of recent tree mortality is interesting given the large acreage of dead yellow-cedar in southeast Alaska. Our reconstruction of yellow-cedar mortality through the 1900s shows that tree death peaked during the 1970s and 1980s (Hennon and Shaw 1994). We have observed recent mortality in specific areas, despite the fairly low regional mortality rate. Although pollen records clearly show that tree species migrate over time in response to climate, little is known about the process of migration. The long-term occurrence of yellow-cedar is not well known because the species was omitted from the classic pollen profile studies conducted in the region (Heusser 1960). Spatially differentiated mortality and regeneration could occur either gradually or in pulses. If mortality is caused by the combination of low snow cover and spring freezing, both episodic events, then mortality would occur in pulses. However, yellow-cedar trees may take a long time to die after they are injured, as root damage from weather can have cumulative effects on tree growth and health (Beier et al. 2008). These possibilities suggest that monitoring needs to be long-term to capture temporal variability as well as spatial variability.

These findings can contribute to development of an adaptive strategy for the conservation and management of yellow-cedar (Hennon et al. 2008). Continued analysis of inventory plot data for yellow-cedar habitat preferences would aid in the construction of a high-resolution distribution map. A distribution map could be combined with aerial surveys of dead cedar and snow modeling to partition the landscape of coastal Alaska into areas that are unsuitable and suitable for yellow-cedar. Inventory plot data should be queried to evaluate successional trends in forests impacted by yellow-cedar decline to project the future composition and productivity of these forests. Inventory data could also be used to document the resource (e.g., diameter classes, volume) of dead yellow-cedar that might be available for salvage recovery on the roughly ½ million acres of yellow-cedar decline.

Forest Insect Pests in Coastal Alaska Forests[2]

The Alaska coastal forest occupies a vast, largely inaccessible area. Thorough disturbance detection and assessment surveys are scarce. Known disturbances include strong winds, flooding, insect outbreaks, diseases, avalanches, wildfires, ice and snow events, tree harvesting, and many others.

Because only a small percentage of coastal Alaska is accessible by roads, estimates of pest extent, distribution, and impacts are mostly made from data collected by visual observations from airplanes. The area covered during these surveys can only be a small fraction of the actual forested land acreage. Undoubtedly, the incidence of insect pests in coastal Alaska forests is much greater than the aerial surveys estimate. Much about the status of forest insect pests and other damaging agents is probably unknown. Better methods of estimating these agents are needed.

Common Forest Insect Pests in Coastal Alaska

Forest insect pests have been surveyed annually by the Forest Health Protection branch of the U.S. Department of Agriculture (USDA) Forest Service since the early 1970s. Results of these surveys have been reported in the USDA Forest Service Forest Conditions Report since 1970.

A list of the most common insect pests of major coastal tree species in Alaska is summarized in table 22. Tree species are limited to the species most commonly found in southeast Alaska, including western hemlock, Sitka spruce, mountain hemlock, red alder, western redcedar, and yellow-cedar. Other less common tree species include white spruce, black spruce, Lutz spruce, alder, aspen, birch, and willow.

Table 23 shows aerial survey estimates of the distribution of the four most commonly surveyed insect pests that occur in coastal Alaska forests.

Distribution and Damage

According to estimates in table 23, the most widespread insect pest in coastal southeast Alaska since 2003 has been the spruce aphid (see table 22 for scientific names). This defoliator has had a long history in coastal Alaska. Like many defoliators, the blackheaded budworm varies in severity of infestation and defoliation from year to year. Infestation history of this insect since 1960 is displayed in figure 45. The last major infestation occurred in 1993. The last 5 years have seen relatively low levels of infestation.

Spruce aphid has been relatively active in recent years. The infestation history of this insect is displayed in figure 46.

Not all of the insects listed in table 22 cause damage significant enough to affect consumptive or nonconsumptive forest uses. It might be argued that some actually cause positive impacts. Spruce beetles, *Ips* beetles, and other bark beetles, for example, facilitate successional dynamics when infestations levels are low. They also help maintain diverse stand structures and enhance habitat conditions for certain bird species. Not surprisingly, disturbances are a necessary part of the ecology of all natural forests.

The potential for impact (hazard) is related to feeding behavior. In this regard, the insects listed in table 22 fall within several categories depending on their feeding habits or guilds: leaf feeders (folivorous); sap-suckers; phloem feeders (phloeophagous); wood borers (xylophagous); and cone, seed and bud feeders. Insects within different guilds affect tree growth and development, stand structure and composition, and landscape patterns in different ways (table 24). Leaf feeders, for example, primarily cause reduced growth rates. Phloem feeders commonly cause mortality.

Level of impact, of course, depends on severity of infestation, timing, duration, periodicity, and other factors. Few studies have been done to determine the growth or mortality-based impacts of insect pests in Alaska coastal forests, but this kind of work has undoubtedly been done in

[2] Authors: John E. Lundquist and Mark Schultz.

Table 22—Insects common to the coastal forests of Alaska

Insect guild	Host																
	Alder (*Alnus* spp.)	Aspen (*Populus tremuloides*)	Balsam poplar (*Populus balsmifera*)	Birch (*Betula* spp.)	Black spruce (*Picea mariana*)	Cottonwood (*Populus trichocarpa*)	Fir (*Abies lasiocarpa*)	Larch (*Larix laricina*)	Lodgepole pine (*Pinus contorta*)	Lutz spruce (*Picea* X *lutzii*)	Mountian hemlock (*Tsuga mertensiana*)	Redcedar (*Thuja plicata*)	Sitka spruce (*Picea sitchensis*)	Western hemlock (*Tsuga heterophylla*)	White spruce (*Picea glauca*)	Willow (*Salix* spp.)	Yellow-cedar (*Chamaecyparis nootkatensis*)
Bark beetles:																	
Cedar bark beetle (*Phloeosinus cupressi* Hopkins, *P. sequoia* Hopkins)												X					X
Dryocoetes (*Dryocoetes affaber* [Mannerheim]; *Dryocoetes confusus* Swaine)									X	X			X	X	X		
Engravers (*Ips* sp.)					X				X	X			X		X		
Hemlock hylesinus (*Pseudohylesinus tsugae* [Swaine])															X		
Spruce beetle (*Dendroctonus rufipennis* [Kirby])					X					X			X		X		
Willow bark beetle (*Trypophloeus striatulus* [Mannerheim])																X	
Bud and shoot insects:																	
Larch budmoth (*Zeiraphera* sp.)									X								
Spruce bud midge (*Rhabdophaga swainei* Felt)						X					X			X		X	
Spruce budmoth (*Zeiraphera* spp.)											X			X		X	
Cone and seed insects:																	
Spruce cone-axis midge (*Rhabdophaga rachiphaga* [Tripp])											X					X	
Spruce seed moth (*Cydia youngana* [Kearfott])										X			X	X	X		
Yellow-cedar gall midge (*Chamaediplosis nootkatensis* Gagne and Duncan)													X	X			X
Defoliators:																	
Alder woolly sawfly (*Eriocampa ovata* [L.])	X																
Aspen leaf miner (*Phyllocnistis populiella* [Chambers])		X	X														
Birch leaf miner (*Profenusa thomsoni* [Konow], *Fenusa pusilla* Leach, *Heterarthrus nemoratus* Klug)				X													
European green alder sawfly (*Monsoma pulveratum* [Retzius])	X																
Green-striped forest looper (*Melanolophia imitate* [Walker])												X		X			X
Hemlock sawfly (*Neodiprion tsugae* [Middleton])											X			X			
Larch budmoth (*Zeiraphera* sp.)								X									
Larch sawfly (*Pristiphora erichsonii* [Hartig])								X									
Leaf beetles (*Chrysomela* spp.)			X	X		X											
Leaf blotch miner (*Phyllonorcyter nipigon* [Freeman] and *Lyonetia* sp.)	X	X	X														
Leaf roller (*Epinotia solandriana* [L.])	X	X		X		X											
Saddle-backed looper (*Ectropis crepuscularia* [Denis & Schiffermuller])												X		X			X

Table 22—Insects common to the coastal forests of Alaska (continued)

	Host																
Insect guild	Alder (*Alnus* spp.)	Aspen (*Populus tremuloides*)	Balsam poplar (*Populus balsmifera*)	Birch (*Betula* spp.)	Black spruce (*Picea mariana*)	Cottonwood (*Populus trichocarpa*)	Fir (*Abies lasiocarpa*)	Larch (*Larix laricina*)	Lodgepole pine (*Pinus contorta*)	Lutz spruce (*Picea* X *lutzii*)	Mountian hemlock (*Tsuga mertensiana*)	Redcedar (*Thuja plicata*)	Sitka spruce (*Picea sitchensis*)	Western hemlock (*Tsuga heterophylla*)	White spruce (*Picea glauca*)	Willow (*Salix* spp.)	Yellow-cedar (*Chamaecyparis nootkatensis*)
Spear-marked black moth (*Rheumaptera hastata* [L.])	X			X												X	
Spotted tussock moth (*Lophocampa maculata* [Harris])	X																
Spruce budworm (*Choristoneura* spp.)										X			X		X		
Striped alder sawfly (*Hemichroa crocea* [Geoffroy])	X																
Western blackheaded budworm (*Acleris gloverana* [Walsingham])										X	X		X	X	X		
Western hemlock looper (*Lambdina fiscellaria lugubrosa* [Hulst])																	X
Willow leaf blotch miner (*Micrurapteryx salicifoliella* [Chambers])																X	
Sap suckers:																	
Birch aphid (*Euceraphis betulae* [Koch])				X													
Eriophyid mites (*Eriophyes* sp.)	X			X												X	
Hemlock woolly aphid (*Adelges tsugae* Annand)														X			
Giant conifer aphid (*Cinara* sp.)										X			X		X		
Spruce aphid (*Elatobium abietinum* Walker)										X			X		X		
Spruce gall aphid (*Adelgis abietis* [L.]; *Adelgis cooleyi* [Gillette]; *Pineus similis* [Gillette])										X			X		X		
Wooly adelgids (*Adelges tsugae* Annand; *A. cooleyi* [Gillette]; *Pineus similis* [Gillette])										*X*			*X*		X		
Wood borers:																	
Ambrosia beetles (*Trypodendron lineatum* [Olivier], Trypodendron retusum [LeConte], *Trypodendron betulae* Swaine)		X		X						X			X	X	X		X
Bronze birch borer (*Agrilus anxius* [Gory])		X		X													
Flat-headed woodborers (*Melanophila drummondi* [Kirby], *Melanophila fulvoguttata* [Harris), *Chrysobothris trinervia* [Kirby], and *Buprestis nuttalli* [Kirby])										X					X		
Horntail (*Sirex juvencus* [L.])					X					X			X		X		X
White-spotted sawyer (*Monochamus scutellatus* [Say])					X					X				X	X		

Table 23—Estimate of area of infestation or infection of major insect pests and diseases in southeast Alaska[a]

	Year					
Insect	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
			Acres			
Blackheaded budworm	15,050	1,483	1,401	1,463	10,344	2,741
Spruce aphid	30,627	7,758	14,982	9,120	3,433	
Western balsam bark beetle		190	785	498	92	
Hemlock sawfly			155		131	

[a] Estimates from USDA Forest Service Forest Conditions Reports for Alaska Region for 2003 to 2008.

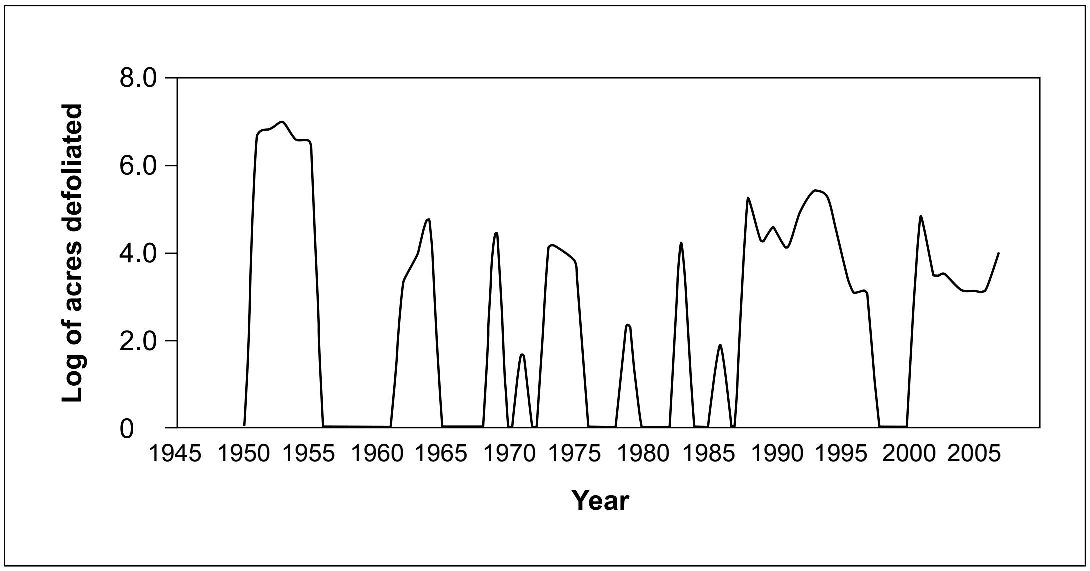


Figure 45—Log of acres of western hemlock (with or in combination with a few acres of Sitka spruce) defoliated by blackheaded budworm since 1945.

Table 24—Types of impacts associated with various insect guilds

Type of impact	Leaf feeder	Sap sucker	Phloem seeder	Wood borer	Cone, seed, bud feeder
Growth loss	x	x			
Mortality			x		
Wood degradation				x	
Reproduction losses					x
Reduced stand diversity			x		
Increased stand structural heterogeneity			x		
Decreased spatial continuity			x		
Increased spatial diversity			x		
Increased fuels	x	x	x		
Increased susceptibility to other disturbance agents	x	x	x		

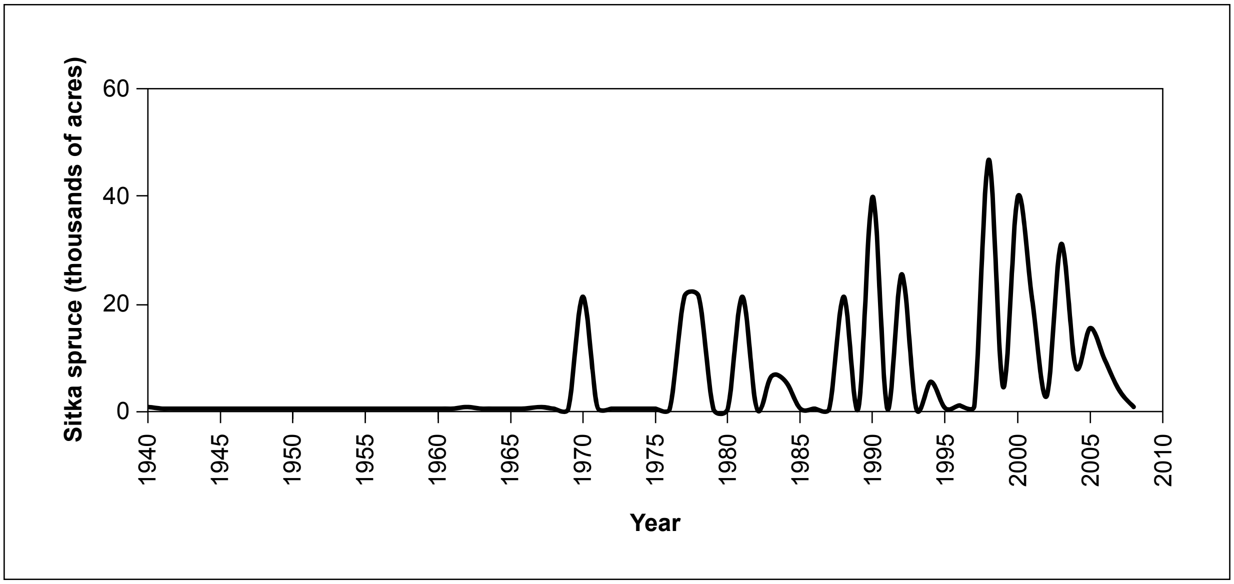


Figure 46—Acres of Sitka spruce defoliated by spruce aphid since 1940.

northern-reaching forests elsewhere. Importance depends on the management objectives defined by decisionmakers.

Increasingly it is recognized that these disturbances are best presented as a complex network where some agents interact directly with their host trees, but most concurrently or sequentially interact indirectly with other disturbances and environmental factors forming complex multipath linkages. As a consequence, predicting future outbreaks, and even explaining past outbreaks is difficult.

Previous Use of FIA Data in Forest Insect Pest Studies

Perhaps the most extensive work on predictive models using FIA data is that done on predicting spruce beetle risk and hazard. The spruce beetle (*Dendroctonus rufipennis*) is well-recognized as the most important insect pest in Alaska. It is not normally considered a coastal species, but during the 1990s, this phloem-feeding bark beetle was responsible for some of the most damaging natural biotic disturbance events ever when it killed more than 4.0 million acres of forest, mostly on the Kenai Peninsula. Much was written about the impacts of this outbreak on the remaining forests and resources (Werner 1996). Even more interesting perhaps, this outbreak spawned a number of studies that made use of FIA data ranging from sociological investigations (Flint 2004, 2006) to the wood utilization of beetle-killed trees (Boucher and Mead 2006, Schulz 2003, van Hees 2005, van Hees and Larson 1991).

Reynolds and Holsten (1994, 1996) used FIA data to develop hazard (amount of mortality expected to occur) and risk (probability of infestation) predictive models for spruce beetle on Lutz and Sitka spruce on the Kenai Peninsula. Reynolds and Holsten used expert opinions organized into a hierarchical model to estimate the relative importance of various risk factors. In developing their models, they considered the following potential risk factors: stand hazard, size and trend of spruce beetle populations in neighboring stands, daily ambient air temperature maxima in previous June, total rainfall in the past summer, and abundance of breeding materials (windthrow, right-of-way, and logging). Results indicate that infestation is a function of total stand basal area, percentage of total stand basal area infected, percentage of total spruce basal area of trees greater than 25 centimeters d.b.h., stand elevation and stand aspect. These models were subsequently presented as a user-friendly decision-support system called Sbexpert (Reynolds and Holsten 1997).

Invasive Plants in Coastal Alaska[3]

Background

The composition and structure of the Nation's forests have been influenced by a number of historical events involving introduced species. The gypsy moth (*Lymantria dispar* [L.]), chestnut blight (caused by the fungus *Cryphonectria parasitiea*), and kudzu are all examples of organisms accidentally or intentionally released in the United States with dire consequences. Most species introduced to areas where they are not native have had little apparent negative impact; some, however, become invasive as they adapt to their new environment. The impacts of invasive plant species on forested ecosystems have become even better known in the past few decades. Invasive plants can dominate habitats by competing for nutrients, water, and light, displacing native plants. By changing the composition of invaded plant communities, introduced plants can reduce the quality of wildlife habitat, alter soil chemistry, and increase the frequency and intensity of wildfires. Millions of dollars are spent annually to control invasive plants in the United States. Experience has shown that the most effective way to manage invasive plants is to prevent them from becoming naturalized at the site of introduction. Knowledge about where introduced or invasive plants have become established is essential for prioritizing management efforts.

Compared to the other 49 U.S. states, Alaska is relatively free of introduced invasive plants. For many years, it was assumed that climatic conditions limited the potential for many of the most troublesome weed pests from becoming established. However, we now know that Alaska is not immune to invasive plants. Although roadside weeds may appear to be pretty flowers to the casual observer, displays of bird vetch (fig. 47) and white sweetclover cause alarm for those who understand the damage they can cause. These species are just two examples of crops introduced by early pioneer agriculturists that have escaped and spread far beyond their initial introduction sites. Bird vetch spreads from roadsides via seeds spread by wildlife into adjacent forested areas, and white sweetclover, a nitrogen-fixing legume, has become established along glacial riverbeds, especially where roads cross rivers. Plants brought to Alaska for stabilizing disturbed areas or as ornamentals have also proved troublesome. Japanese knotweed and reed canary grass are found throughout southeast Alaska along roadsides and spreading into adjacent streams and waterways. Volunteer European bird cherry seedlings have spread away from cultivation and into wild areas in south-central and interior Alaska (Lamb and Winton 2010). The early detection of garlic mustard, spotted knapweed, and purple loosestrife have reduced or eliminated small populations, but vigilant monitoring must continue to ensure timely response to new infestations. Although many species that have become problematic in other parts of the country may never survive in Alaska's extreme climate, other species are well adapted. The invasiveness of bird vetch and European bird cherry is unique to Alaska; they do not exhibit invasive tendencies in the Lower 48 States (Carlson et al. 2008).

Tricia Wurtz

Figure 47—Bird vetch (*Vicia cracca*).

[3] Author: Bethany K. Schulz.

Introduced and invasive plants are assessed by FIA as part of both the standard field (phase 2) and forest health plots (phase 3, see app. 1) but there are some differences between methods. On all phase 2 plots, crews search for a list of 44 taxa deemed to be either important nonnative invasive species or native species known to have noxious qualities (app. 2, table 49). Plants were chosen based on expert opinion, early weed ranking efforts for Alaska (Carlson et al. 2008), likelihood of plants establishing in forests, and ease of identification in the field. Crews search nonforested portions of plots in addition to the forested portions, and are encouraged to collect other species if they appear to be introduced or displaying invasive tendencies, such as an unfamiliar plant with high canopy cover. On phase 3 plots, crews record all vascular plants present on forested portions of plots, but do not record any species on nonforested portions of plots. List-based methods on the phase 2 plots limit analyses of impact but capture invasive species on the edge of forested areas; whereas phase 3 data allow us to report the cover of introduced species relative to the native species present. This measure of impact can be compared with other regions and the rest of the Nation.

Results

Of the total 1,196 plots visited from 2004 to 2008, introduced or native noxious plants were recorded on only 19 plots (less than 2 percent), compared to some regions in the Lower 48 where 67 percent of all forested plots have at least one introduced species present (Gray and Azuma 2005; Schulz, in press). Of the eight phase 3 plots where introduced species were recorded, only one plot has a relative cover of introduced plants of 1 percent—the others were less than 1 percent.

A total of 17 species of interest were recorded. These species are summarized in table 25. Dandelion was the most frequently recorded, followed by clover and reed canary grass. Of the 17 species recorded, 14 were on the phase 2 invasive list, with 3 additional introduced species recorded in the phase 3 surveys.

A disproportionate number of plots with introduced plants were located within 500 feet of the nearest improved road (table 26, fig. 48). Of those 19 plots with introduced or invasive plants present, 45 percent had a portion of the plot occupied by a nonforested condition such as a right-of-way or developed residential area compared to only 12 percent

Table 25—Invasive and introduced plant species recorded on 1,196 plots in coastal Alaska

Number of plots	Invasive rank[a]	Scientific name	Common name
12	58	*Taraxacum officinale* G.H. Weber ex Wiggers	Common dandelion
7	53–59	*Trifolium* L.	Clover
5	83	*Phalaris arundinacea* L.	Reed canarygrass
4	44	*Plantago major* L.	Common plantain
3	32	*Matricaria discoidea* DC.	Pineapple weed
2	(nr)[b]	*Agrostis capillaris* L.	Colonial bentgrass
2	56	*Phleum pratense* L.	Timothy
1	(nr)	*Erysimum cheiranthoides* L.	Wormseed wallflower
1	54	*Crepis tectorum* L.	Narrowleaf hawksbeard
1	40	*Galeopsis* L.	Hempnettle
1	63	*Hordeum jubatum* L.	Foxtail barley
1	61	*Leucanthemum vulgare* Lam.	Oxeye daisy
1	(nr)	*Lolium arundinaceum* (Schreb.) S.J. Darbyshire	Tall fescue
1	80	*Melilotus alba* Medikus	White sweetclover
1	54	*Ranunculus repens* L.	Creeping buttercup
1	42	*Stellaria media* (L.) Vill.	Common chickweed
1	73	*Vicia cracca* L. ssp. *cracca*	Bird vetch

[a] From Carlson et al. 2008.
[b] (nr) = not ranked.

Table 26—Percentage of plots within distance classes from improved roads

Distance from improved road	All plots (n = 1,196)	Plots with at least one invasive/ introduced plant species (n = 19)
	Percent	
0–500 feet	7.5	63
More than 500 feet, less than 1 mile	19	16
One mile or more	74	21

of all sampled plots. Canary reed grass, common dandelion, and colonial bentgrass were recorded on plots more than 5 miles from improved roads, which do not include logging roads or decommissioned logging roads. Reed canary grass was once used to stabilize logging roads; dandelion and colonial bentgrass could have been introduced around homestead sites. Only 7 of the 19 plots were infested with species considered highly invasive (Invasive rank greater than 70 percent) (table 25).

Interpretation

Compared to other areas of the United States, Alaska's forest areas are, for the most part, free of potentially invasive plants. The areas where introduced plants have been found are usually not too far from the road system. To date, these species have had only a minor impact to the native plant populations.

However, although Alaska's forests have yet to be seriously affected by invasive plant species, recent observations in urban areas and along road corridors are unsettling and stress the need for continued monitoring (AKEPIC 2005, Bargeron 2009). Invasive plants are spread primarily by humans, and are commonly encountered in urban areas, but human settlements in remote areas are also prone to invasion. Birds and other wildlife can extend the reach of invasion by delivering seeds of well-established species beyond cultivated areas.

European bird cherry (fig. 49) has proven to be highly invasive in and around urban areas of Alaska. For many years this species was promoted as an ornamental species

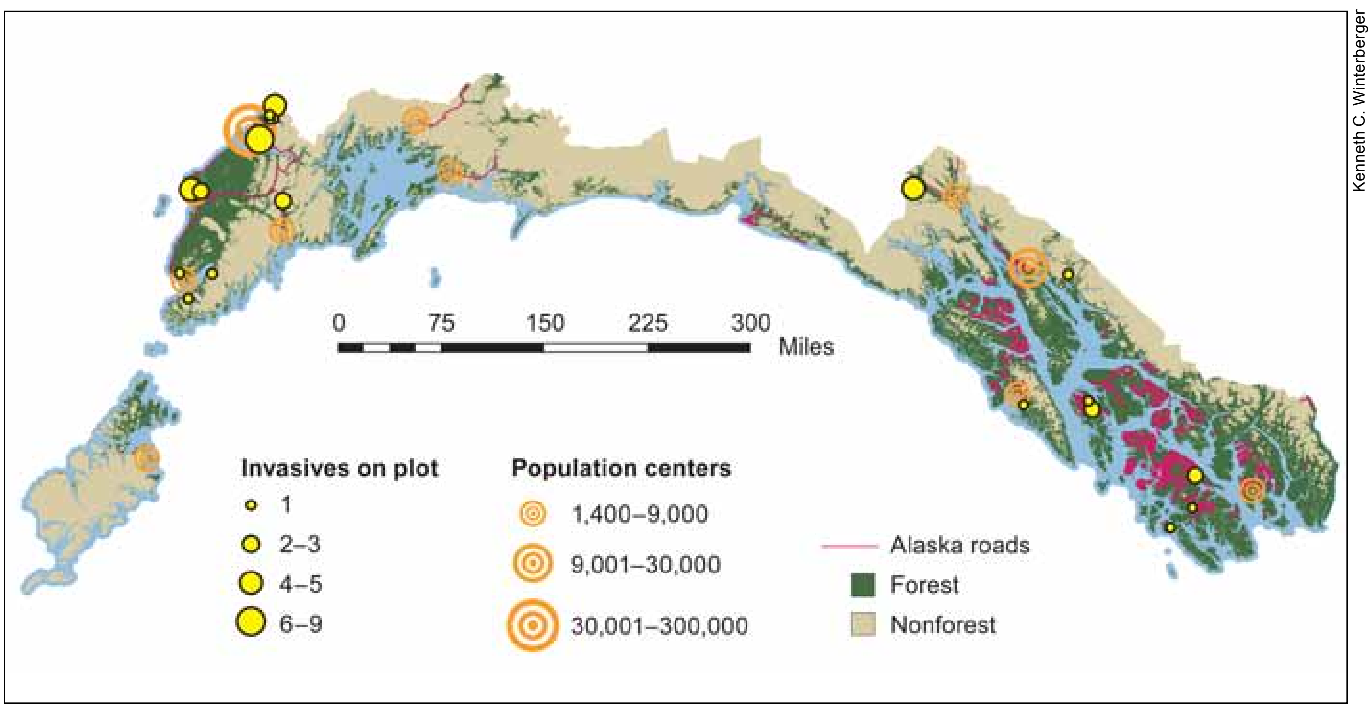


Figure 48—Forest Inventory and Analysis plots with introduced plants recorded (depicted plot locations are approximate).

Tricia Wurtz

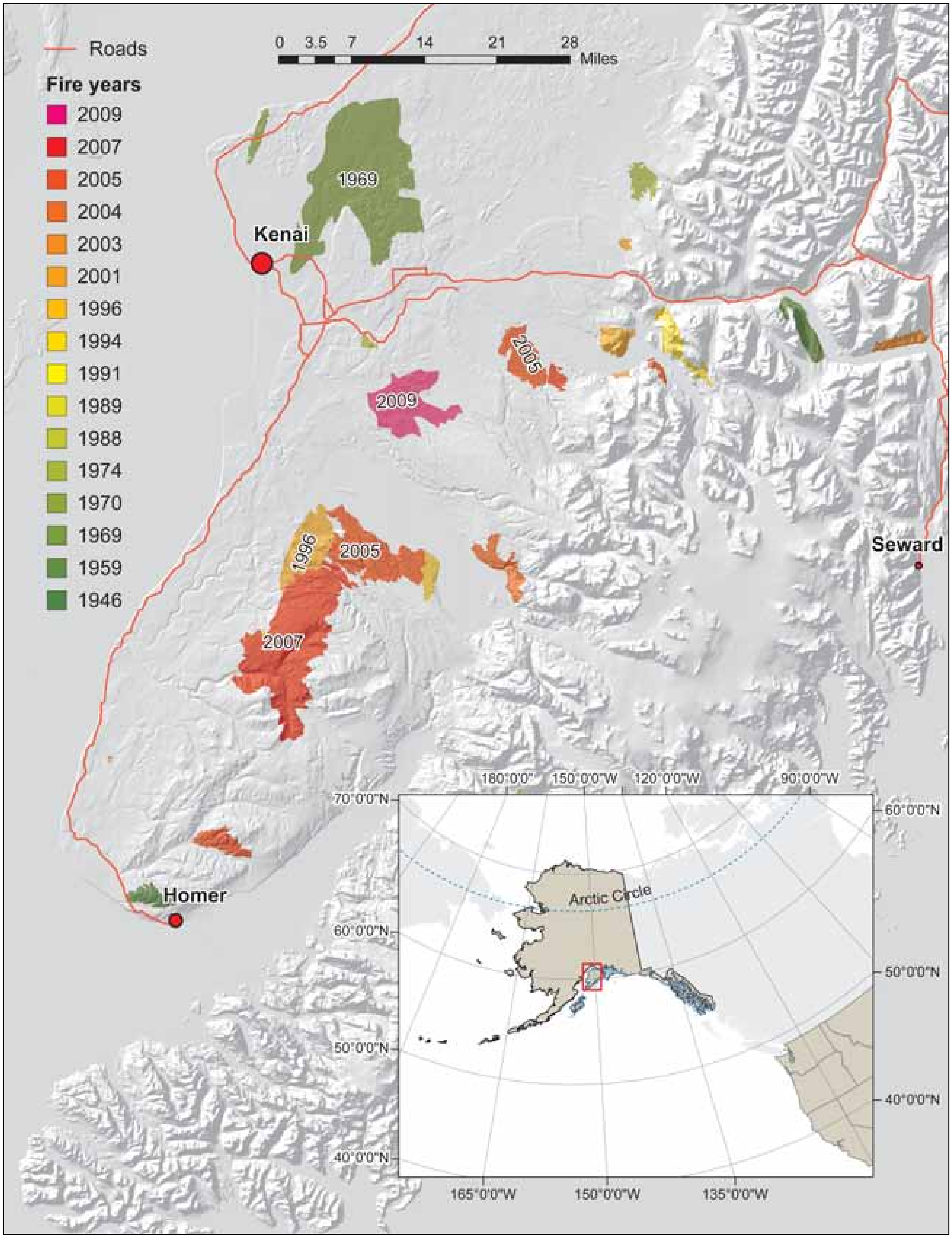
Figure 49— European bird cherry (*Prunus padus*).

with a high survival rate. Indeed, it has done very well in the region, and local birds are spreading viable seeds. In Anchorage and Fairbanks, seedlings are abundant along river and stream corridors, near parent trees, and were found in a recently burned forest stand in Anchorage. In some urban park zones, this is the only hardwood tree species found regenerating in the understory (Lamb and Winton 2010), replacing native species that moose feed on. Control efforts are underway in some areas, but this species has the potential to seriously affect Alaskan forests if they spread out of urban areas. That Alaska's coastal forests currently have a low level of invasive species means that Alaska has an opportunity to prevent establishment of many invasive species, an opportunity not available to other U.S. states where so many invasives are well-established.

The Western Kenai Peninsula: an Opportunity to Study Fire and Its Effects on Soils and Trees[4]

Most of the coastal Alaska inventory unit is part of the temperate rain-forest biome, and fire is an extremely rare event. However, for the western side of the Kenai Peninsula and the Cook Inlet region, fire is a common source of natural disturbance (fig. 50). Although wildfires are a normal part of the disturbance regime for this region, urban growth and associated infrastructure raises the risk of increasing potential loss from fire.

[4] Authors: Theresa Jain and Tara M. Barrett.



Kenneth C. Winterberger

Figure 50—Fires on the Kenai Peninsula, 1946–2009. Source: Monitoring Trends in Burn Severity database (http://mtbs.gov/). Projection: Alaska Albers NAD 83.

Understanding how the forest environment is affected by fire is helpful for predicting how the ecosystems in the Cook Inlet and western Kenai may change in the future. Fire effects include impacts on the soil as well as impacts on the trees and other vegetation. A soil's physical (appearance and mineralogy), chemical (nutritients), and biological (soil fauna) states after a fire are dependent upon the amount and duration of heating, prefire environmental conditions, landscape attributes, and fire-suppression tactics. The primary soil physical properties affected by fire are water repellency, structure stability, texture, color, temperature, and abundance of surface organic matter (Certini 2005). The chemical properties include the abundance of organic carbon, cation exchange capacity, nutrient levels and availability, and pH. However, the quantity, composition, and quality of the surface and mineral soil organic layers (leaves, needles, humic substances) are also important for influencing chemical properties. The biological properties include fungi, bacteria, soil-dwelling invertebrates, plant seed, roots, bulbs, root crowns, and other plant materials needed for sprouting or regeneration. All these components influence factors such as erosion, wildlife habitat, soil productivity, and vegetation recovery.

Soil physical properties—

Erosion is a common postfire effect because of its influence on water quality and the potential for flooding. In most circumstances, erosion does not occur unless the surface organic matter (litter, root mat) cover is less than 30 percent (Lewis et al. 2006). However, if the appropriate prefire soils exist (such as granitics), water repellency (inability for the soil to absorb water) can occur at relatively low temperatures that are quite common in wildfires (177 to 204 °C) when duration is greater than 15 minutes (Debano et al. 1976). Lewis et al. (2006) reported that grey ash is more characteristic of potential water repellency than the presence of black ash. Morever, if the overstory is killed in the fire and the forest floor is no longer present, soil temperatures can increase.

Soil chemistry—

The highest proportion of soil nutrients exist within the surface organic matter, upper mineral soil layers, and wood residue (surface and buried rotten wood). Harvey et al. (1989) reported that up to 56 percent of the nitrogen occurs within the litter and humic layers, upper mineral in the first 2 inches, and wood residue. During a fire, these components are also the most vulnerable to loss through combustion. For example, nitrogen, a nutrient that is frequently limiting in forest environments, can volatilize at 752 °F (Hungerford et al. 1991). However, nutrients such as potassium do not volatilize until temperatures exceed 1293 °F (Hungerford et al. 1991).

Soil biology—

Many organisms do not survive temperatures greater than 140 °F. Pollen, seeds, spores, lichens, and mosses do not survive above 284 °F when exposed to these temperatures for more than 30 minutes. Even lower temperatures (158 °F) can cause mortality if exposure exceeds 4 hours (Levitt 1980). Wingless insects die when exposed to temperatures greater than 104 °F. Mammals, when exposed to the temperatures directly, cannot survive when temperatures exceed 140 °F. Ninety percent of the microbial carbon in soils is volatized when exposed to temperatures of 572 °F for longer than 15 minutes (Levitt 1980).

A fire can kill vegetation two ways, through direct combustion, such as in a crown fire, or through radiant heat, which causes needle or crown scorch (red needles). Radiant heat from smoldering fires can kill roots or damage the tree cambium; this type of mortality is typically delayed and therefore a tree that appears alive after the fire can die over time. In addition, if a tree survives a fire, it sometimes can become stressed, allowing for mortality to occur from insects or disease.

How quickly a forest recovers after a fire is dependent on three survival mechanisms: whether vegetation survives a fire (e.g., ponderosa pine), recolonization either from seed banks in the soil, or transported to the site (e.g., wind, animals, floods), or sprouting new growth from roots. Each forest is different as to how it recovers after a wildfire. If a forest is able to recover quickly with much of its original plant composition, the forest is considered resilient. However, if after a wildfire, the soils no longer have seed, or an introduced species occupies the site, the forest may be less resilient (fig. 51). The level to which a forest can recover after a fire is dependent on the soils, the forest composition, and other factors that may influence how a fire burns a particular site. For example, white spruce produces large seed crops after a hot dry summer; black spruce has semi-serotinous cones that open when exposed to heat; aspen, with its copious root systems, can sprout after a fire; and birch has seeds that disperse long distances. However, all forests are unique—thus what we learn in other parts of the United States does not always transfer to Alaskan forests. Therefore, it is critical that each forest type be evaluated as to the relation between the postfire environment and how quickly a forest recovers.

The FIA program of the Pacific Northwest Research Station maintains a permanent sample of plots located on a grid throughout the United States; this provides unique information on the extent and severity of fires in forest lands as well as on postfire recovery and succession. In the Western United States, FIA has begun measuring postfire impacts on soil and vegetation the year after a fire. This information, when combined with long-term remeasurements over succeeding decades, can help us understand the trends and variation in fire effects for different forest types ranging from ponderosa pine forests of the interior West, to mixed-conifer forests of the Sierra Nevada, to the boreal forests of Alaska.

Tara M. Barrett

Figure 51—Liverworts, mosses, horsetails, and an invasive cherry seedling (*Prunus padus*, circled) sprout during the spring following the 2008 Piper Fire in Anchorage, Alaska.

In Alaska, we used postfire protocols that were first implemented on FIA plots following the 2007 Caribou Hills wildfire, a human-caused fire that burned approximately 50,000 acres on the Kenai Peninsula. This was an area that had previously been affected by a bark beetle epidemic on the Kenai Peninsula that began in the late 1980s and continued into the 1990s. Warmer temperatures had increased overwinter survival and shortened maturation time for beetles (Berg et al. 2006), and increased summer temperatures may have also caused drought stress in trees, favoring successful beetle attacks. Preliminary results from the FIA plots burned in the Caribou Hills wildfire show that most trees that had survived the bark beetle epidemic were killed by the fire (fig. 52). The Caribou Hills wildfire provides an example of how complex interacting factors determine how forests change over time in the south-central region of Alaska. Warmer temperatures encourage beetle outbreaks, increasing the abundance of dead fuel, which in turn may increase the frequency of wildfires. The frequency and extent of wildfires is also affected by the increasing development in the region. Active fire suppression in populated areas contributes to fuel buildup, and fire ignitions increase with human activities. Changes in the fire regime resulting from these interactions may potentially alter the path of succession in these areas (Kasischke et al. 2000).

Eric Straley

Figure 52—Dead white spruce and regenerating understory vegetation on the Kenai Peninsula 1 year after the 2007 Caribou Hills Fire.

The Distribution of Hemlock Dwarf Mistletoe Suggests Influences of Climate[5]

Background

Hemlock dwarf mistletoe (*Arceuthobium tsugense* [Rosendhal] G.N. Jones) is an important disease of western hemlock in old-growth forests throughout southeast Alaska (fig. 53). The disease is caused by infection from a small higher plant, which is well-adapted to life as a parasite. When intensely infected, western hemlock trees suffer significant growth loss, reduced wood quality, and higher rates of mortality. Branch infections result in abnormal growth proliferations known as "witches' brooms" that can serve as important wildlife habitat. Depending on management goals, foresters can achieve various levels of infected trees in managed stands by manipulating harvest regimes, ranging from eradication to numerous infected trees (Muir and Hennon 2007). Clearcut harvests greatly reduce or eliminate the disease, whereas retention harvests that maintain large, dispersed infected trees encourage it.

Paul Hennon

Figure 53—Western hemlock killed by hemlock dwarf mistletoe, resulting in a canopy gap in an old-growth forest. Note the numerous witches' broom infections on the branches of the dead tree.

[5] Authors: Paul Hennon, Tara M. Barrett, and Dustin Wittwer.

Hemlock dwarf mistletoe is difficult to detect during aerial surveys; thus its extent and intensity have never been adequately quantified in Alaska. We have observed that dwarf mistletoe is more common at low elevations even though the primary host, western hemlock, is rather ubiquitous at all but the highest forested elevations. We used forest inventory plots to document the broad occurrence and elevational distribution of dwarf mistletoe and then compared it to areas where western hemlock grows in coastal Alaska.

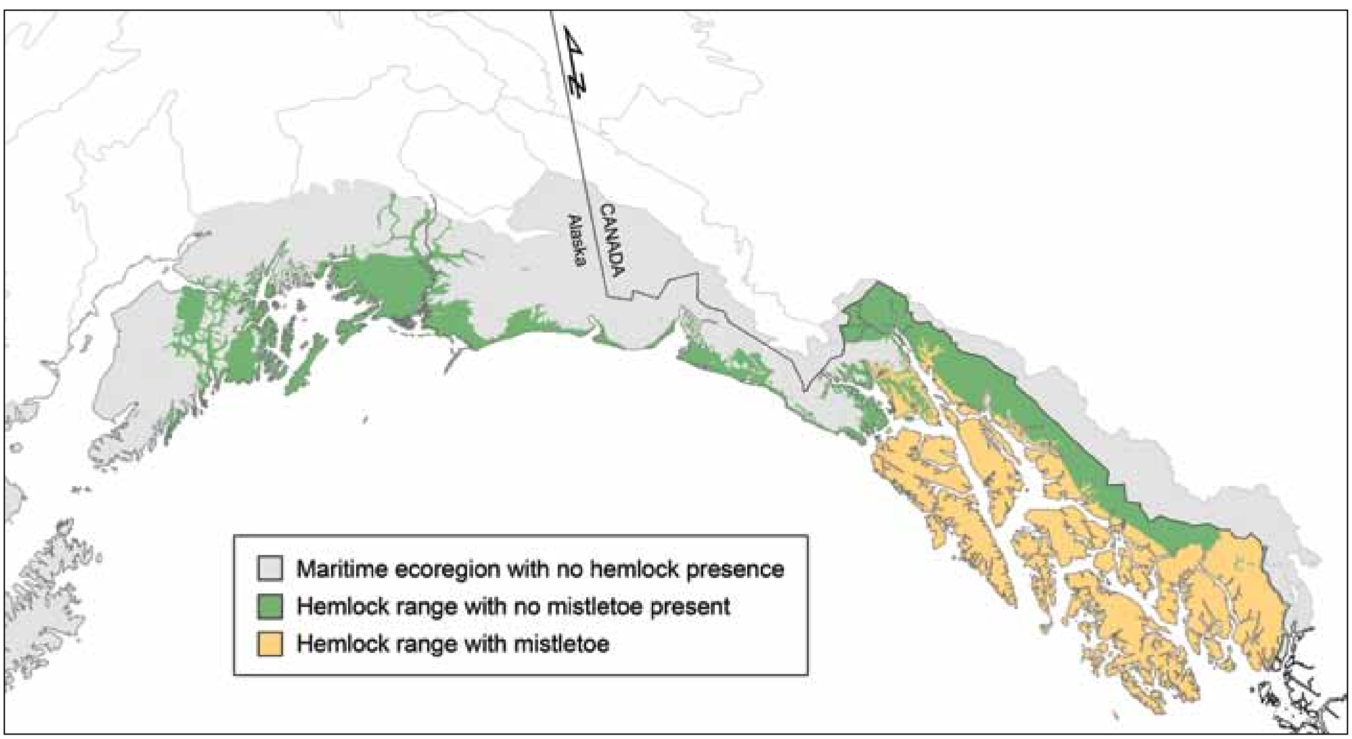
Methods

The presence or absence of mistletoe was recorded for all live trees in the 1995–2000 periodic inventory of southeast Alaska as described in appendix 1. There were 3,955 plots in that inventory, 1,278 of which were forested, and the inventory did not include wilderness on national forests or Glacier Bay National Park. Although no information on measurement accuracy exists for the inventory, it is likely that numbers of trees infected are an underestimate because field crews are more likely to miss an infected tree than note one that does not exist. Where results are reported as numbers of acres with mistletoe present, it means that at least one infected tree was recorded within forested conditions on the plot.

Results

Inventory data indicated that hemlock dwarf mistletoe is present in only part of the range of western hemlock (fig. 54). The disease occurs in most of southeast Alaska from Dixon Entrance north to Haines and Glacier Bay National Park. Western hemlock grows approximately 400 miles farther to the northwest on the coastline of the Gulf of Alaska, but the disease is completely absent in these forests.

Ignoring the inaccessible wilderness not sampled, hemlock dwarf mistletoe occurred on approximately 955,000 acres (standard error = 68,000 acres). Within the Alexander Archipelago ecoregion (Nowacki et al. 2002, fig. 6 in chapter 2), this is 14.8 percent of forest land. Mistletoe infected an estimated 7.6 percent of western hemlock trees ≥ 5 in d.b.h. in the Alexander Archipelago ecoregion. On plots where at least one tree had mistletoe, 46.0 percent



Dustin Wittwer

Figure 54—Distribution of western hemlock and hemlock dwarf mistletoe in coastal Alaska.

of western hemlock trees were infected. Hemlock dwarf mistletoe is clearly concentrated at low elevations in southeast Alaska (fig. 55). There is an apparent threshold at approximately 500 feet, above which the parasite can occur but is much less frequent. The principal host, western hemlock, is distributed well above this threshold, suggesting that some factor limits the distribution of hemlock dwarf mistletoe at higher elevations.

Interpretation

Results reflect the patchy distribution of the disease, even within the pathogen's preferred range. The elevational and regional limits for the range of the pathogen might be explained by two possible scenarios, both dealing with climate factors. First, there has been speculation that hemlock dwarf mistletoe fruits need an adequate growing season to mature to the stage where seeds can disperse. If a fall freeze comes before fruit maturation, the fruits are killed before seeds disperse, eliminating reproduction.

Second, snow, which is more abundant at higher elevation and in coastal forests around the Gulf of Alaska, may be responsible for removing dwarf mistletoe seeds from hemlock tissues during winter. Dwarf mistletoe seeds disperse from fruits in late summer but do not germinate until the following spring. Thus, they overwinter on hemlock shoots or needles, stuck to them with a viscous coating. Heavy snow, or repeated snow-rain cycles, could slough off many of these overwintering seeds. Longer growing seasons and reduced snow are among the climate change scenarios projected for coastal Alaska (IPCC 2007).

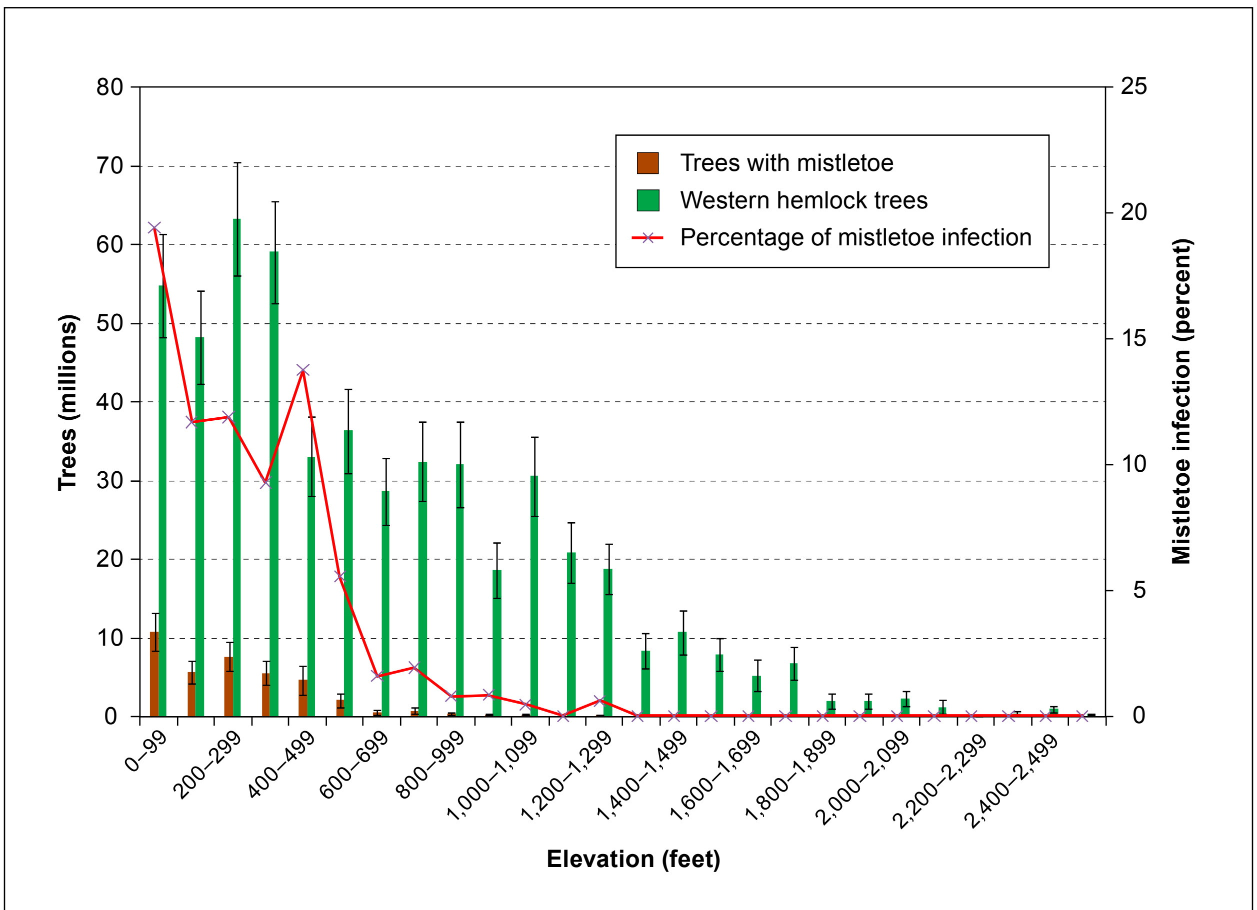


Figure 55—Occurrence of western hemlock and hemlock dwarf mistletoe by elevation in southeast Alaska. Note the drop in the percentage of infected western hemlocks above 500 feet elevation. Lines at end of bars represent ± standard error.

Thus, hemlock dwarf mistletoe is expected to increase its range and its impact on western hemlock, a tree that is also favored by a warmer climate. The FIA data provide a means to monitor the upslope spread and northwest migration of dwarf mistletoe, a process that is expected to be relatively slow. The distribution of the hemlock dwarf mistletoe disease appears to be an excellent situation to model as range expansions of the host tree and the parasite are likely to occur with climate change.

Sasha Sulia

Chapter 5: Forest Products

People benefit from the forests in southeast and south-central Alaska in different ways: forests are used for recreation and tourism, as a source of clean water, and as home to a large variety of fish and wildlife. In this chapter, we provide some analysis related to use of the forests for products. There is increasing interest in young-growth timber for wood supply in southeast Alaska, and the first section describes some of the attributes of young growth in the coastal region. The second section describes the primary forest products industry in Alaska, using a Forest Inventory and Analysis (FIA) survey of mills in the region. A new potential use, using forest biomass for energy, is briefly described in the following section. The chapter concludes with a section describing the use of coastal Alaska forests for nontimber forest products (NTFPs).

Young-Growth Timber Resource in Coastal Alaska[1]

Introduction

Timber has been harvested from the forests of coastal Alaska since before the state was purchased more than 140 years ago. Prior to the proclamation creating the Tongass and Chugach National Forests in 1907, small amounts of timber were harvested mostly for local consumption (Brackley et al. 2009, Harris and Farr 1974). Leading up to the 1940s, annual harvest volumes along coastal Alaska remained fairly low but began increasing over time. With the demand for high-quality spruce (see "Common and Scientific Names") for the manufacture of aircraft in support of World War II, annual timber harvest picked up steadily in the following decades (Hutchison 1968). The 1950s saw two important events affecting the young-growth resource: harvest levels significantly increased with the introduction of the pulp industry in southeast Alaska, and harvesting practices changed from partial harvest methods to the near exclusive use of clearcutting and even-age management (Deal et al. 2010, Harris and Farr 1974). Legislation has brought changes in ownership since the 1950s also affecting this resource: the Alaska Statehood Act of 1958 (Public Law 85-508), the Alaska Native Claims Settlement Act of 1971 (ANCSA) (Public Law 92-203), and the Alaska National Interest Lands Conservation Act (ANILCA) (Public Law 96-487) (van Hees 1987). Harvests from national forests peaked in the early 1970s, and from all forested ownerships in the late 1980s (Brackley et al. 2009). In addition to removal of trees for timber, the forests of coastal Alaska are also subject to stand-replacing events such as windthrow, wildfire, landslides, and, recently, insect infestation such as spruce bark beetle (*Dendroctonus rufipennis* [Kirby]) on the Kenai Peninsula (Campbell et al. 2005, Harris and Farr 1974). In some cases it has been decades since these young stands regenerated following harvest and other disturbances. What do they look like today? Inventory results are presented in this section that describe and estimate the current extent of young-growth forests throughout southeast and south-central Alaska (fig. 56). These forests are summarized by their estimated acreage, current tree sizes, regenerated mix of forest species types, potential productivity, and current standing volume.

Methods

Young-growth timber is defined for this report as forested stands on unreserved timberland where the majority of volume is in trees with an estimated stand age of 150 years or less. Using the 150-year age limit is useful as it includes any stand that has regenerated since significant timber harvest activities began in the region during the 1950s. Traditionally, this definition for young-growth forests has been used throughout coastal Alaska resource and planning publications and includes the tree stocking and size criteria for sawtimber stands (stands stocked with half or more of trees at least 11.0 inches diameter at breast height [d.b.h.] for hardwoods and 9.0 inches d.b.h. for softwoods) (Campbell et al. 2004, 2005; Hutchison 1968; Hutchison and LaBau 1975; USDA FS 2008a; van Hees 1988, 2003). All stand sizes—seedling (< 1.0 inch d.b.h.) and sapling (1.0 to 4.9 inches d.b.h.), poletimber (5.0 to 11.0 inches d.b.h. for hardwoods and 9.0 inches d.b.h. for softwoods), and sawtimber (> 11.0 inches d.b.h. for hardwoods and > 9.0 inches d.b.h. for soft-woods)—are reported here to provide a better assessment of

[1] Author: Glenn A. Christensen.

Kathleen Galloway

Figure 56—Young-growth stand in southeast Alaska.

the entire current young-growth resource. Results presented here are summarized by stand size for consistency with past reporting.

This report relies heavily on the stand age of young-growth forests. These young stands tend to have a less complex structure than typical old-growth, multiaged forests in the region and are predominantly even aged (Alaback 1984, Deal et al. 2010). Stand age is determined by averaging the ages of several live trees that best represent the stand's predominate size classes. Individual tree ages are determined by counting the annual growth rings of a core extracted from the tree with an increment borer and adjusted by adding the number of years required to reach breast height; see the section on old-growth forests in coastal Alaska (chapter 3) for details. Stand age is subject to error owing to measurement of tree age (from false growth rings or miscounting) or error in selection of trees that best represent the current stand.

Results

Area of young-growth timber in coastal Alaska—Throughout coastal Alaska, there are 15.3 (standard error [SE] = 0.3) million acres of forest land, with about 6.1 (SE = 0.3) million acres having a current stand age of 150 years or less. Timberland, forest land having a growth capacity of at least 20 cubic feet per acre per year and currently not set aside as reserved forest, makes up about 6.2 (SE = 0.2) million acres throughout the region. Young-growth timber stands, forested stands on timberland with a current stand-age of less than or equal to 150 years, currently makes up

47 percent, or 2.9 (SE = 0.1) million acres of these timberland acres. By region, there is 1.5 (SE = 0.1) million acres of young-growth timberland in the south-central region and 1.4 (SE = 0.1) million acres of young-growth timberland in the southeast region. These estimates include all stand sizes from seedling and sapling-sized stands to larger sawtimber-sized stands of young-growth forest (table 27).

Much (41 percent) of young-growth timberland is found on privately owned land (a total of 1.2 (SE = 0.1) million acres). The national forests manage about 34 percent and other federal or state and local governments manage the remaining 25 percent of young-growth timber acreage. Stand-age class distribution of young-growth timberland differs by ownership (fig. 57). The distribution by acre on privately owned lands is fairly even across all classes except the 10-to 30-year stand age class, which covers significantly more acres than any other age class. National forests tend to have more young-growth acreage in either the younger or the older age classes throughout coastal Alaska.

Table 27—Timberland acreage by stand-age class for south-central, southeast, and all coastal Alaska

	South-central		Southeast		Coastal	
Stand-age class	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
Years			*Thousand acres*			
< 10	119	36	105	33	223	48
10–30	122	35	357	59	480	68
31–50	212	49	282	57	494	74
51–70	245	53	57	25	302	58
71–90	256	52	92	31	348	61
91–110	223	48	73	28	297	55
111–130	149	41	238	52	387	65
131–150	163	44	200	47	363	64
> 151	394	58	2,887	143	3,281	153
All young growth	1,489	107	1,404	116	2,894	153
All classes	1,884	110	4,290	161	6,174	185

Note: SE = standard error.

About 1.5 million acres (SE = 0.1), or 51 percent, of the young growth on timberland consists of sawtimber-sized stands. A little over half of these stands (27 percent of all young-growth timberland) is found within the southeast region (about 785,000 [SE = 92,000] acres) (fig. 58). About 687,000 (SE = 80,000) acres of these sawtimber-sized

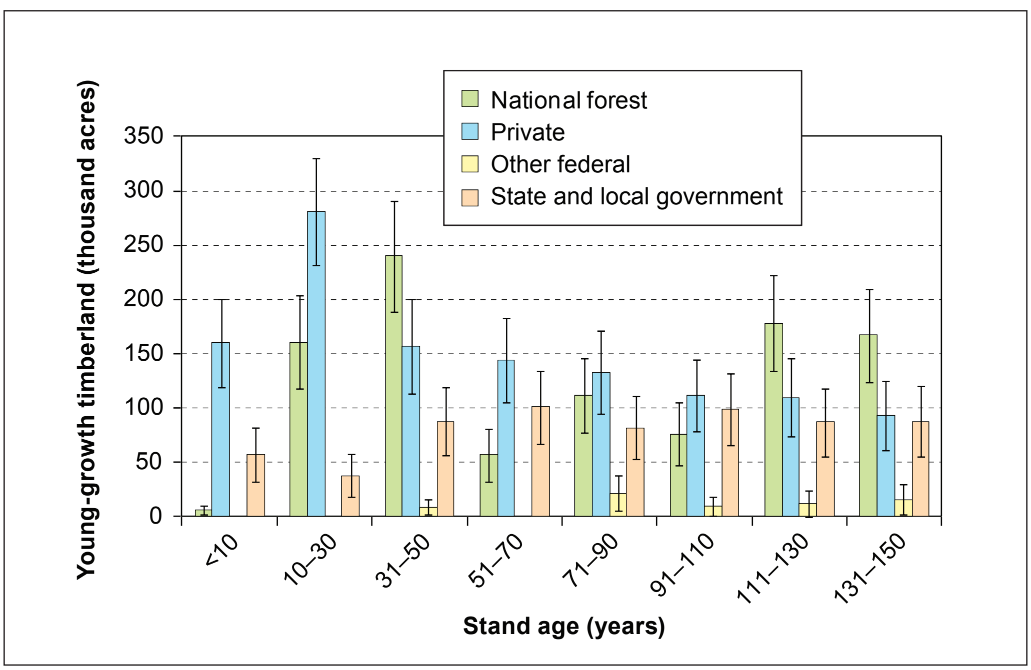


Figure 57—Estimated young-growth timberland area by owner group and stand age class in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

stands lie within the south-central region (24 percent of the young growth).

Coastal Alaska has many different forests, but Sitka spruce and western hemlock are the dominant forest types in the region (see "Forest type" in glossary). Sitka spruce young-growth makes up 36 percent, or over 1 million acres (SE = 0.1); nearly 60 percent of these stands are sawtimber size (fig. 59). Western hemlock stands are also common and make up about 27 percent (nearly 800,000 [SE = 93,000] acres) of the young-growth. These western hemlock forests currently consist of nearly 60 percent sawtimber-sized stands.

Assessment of productivity could be helpful to determine how soon these young stands could reach merchantable size and replace the older forests currently being harvested for wood products. Productivity is a measure of the annual potential for growth as measured in cubic feet per acre of wood grouped into classes (see "Site class" in glossary). Throughout coastal Alaska, highly productive stands tend to be a minor component of timberland area. About 216,000 acres (SE = 50,000) (7 percent) are in the highest productivity class (120 to 164 cubic feet per acre per year) (fig. 60), more than half (51 percent) of the young growth stands within the south-central region are in the most marginally productive class (20 to 49 cubic feet per acre per year).

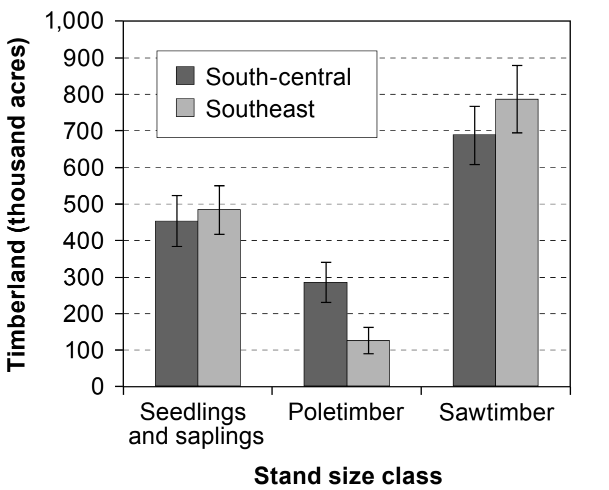


Figure 58—Estimated young-growth timberland area by region and stand size class in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

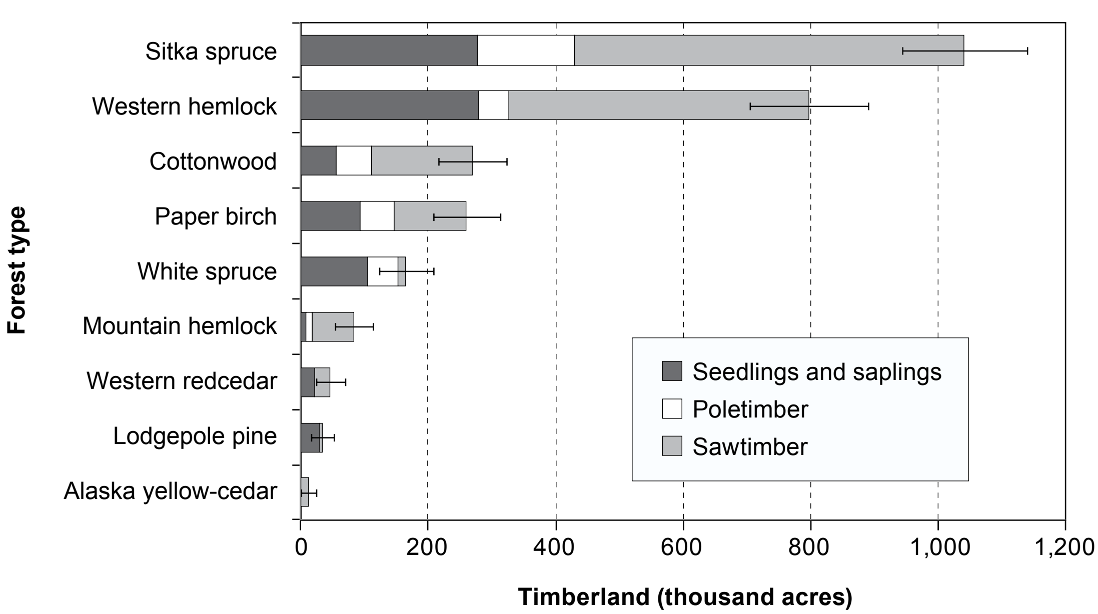


Figure 59—Estimated young-growth timberland area by forest type and stand size in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

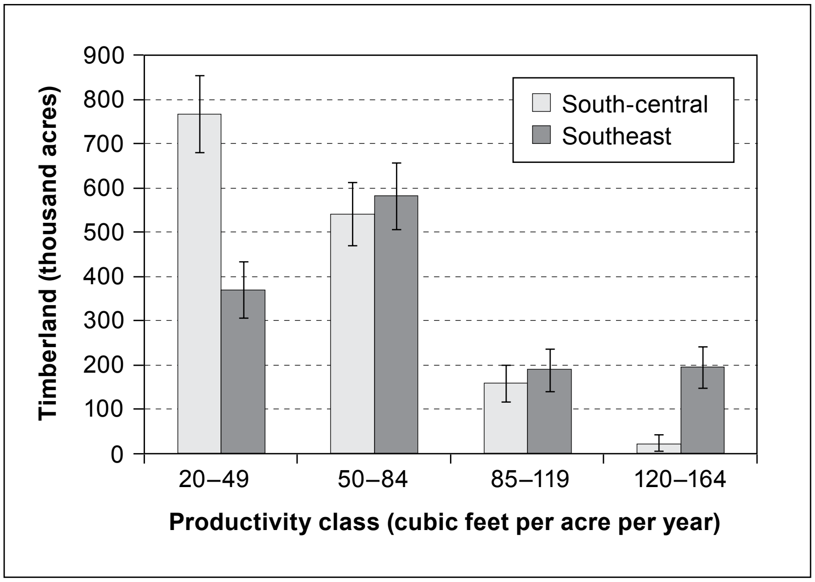


Figure 60—Estimated young-growth timberland area by region and productivity class in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

Volume of young-growth timber in coastal Alaska— The volume of wood found in the young-growth resource throughout coastal Alaska is a small portion of the total wood volume found on all timberland in the region. About 27 percent of all net cubic-foot growing-stock volume on timberland currently comes from these young-growth trees, estimated at about 8 billion cubic feet (SE = 0.8). Generally, there is a positive correlation between acreage and tree volume. A notable exception is with volume by ownership where the national forests have over half (52 percent) of all the current young-growth cubic-foot volume but only about a third (34 percent) of the young-growth acreage. As is found when evaluating acreage by forest type, most of the current volume is in Sitka spruce and western hemlock trees; together these two species make up about 83 percent of the young-growth volume. Individually, Sitka spruce is 54 percent (4.3 billion cubic feet [SE = 0.5]) and western hemlock is 29 percent (2.3 billion cubic feet [SE = 0.3]) of the young-growth volume. Figure 61 shows how this volume is distributed in softwood and hardwood trees by 2-inch diameter classes. For softwoods, the largest diameter classes (those larger than 21.0 inches) contribute about 42 percent of the softwood young-growth cubic-foot volume.

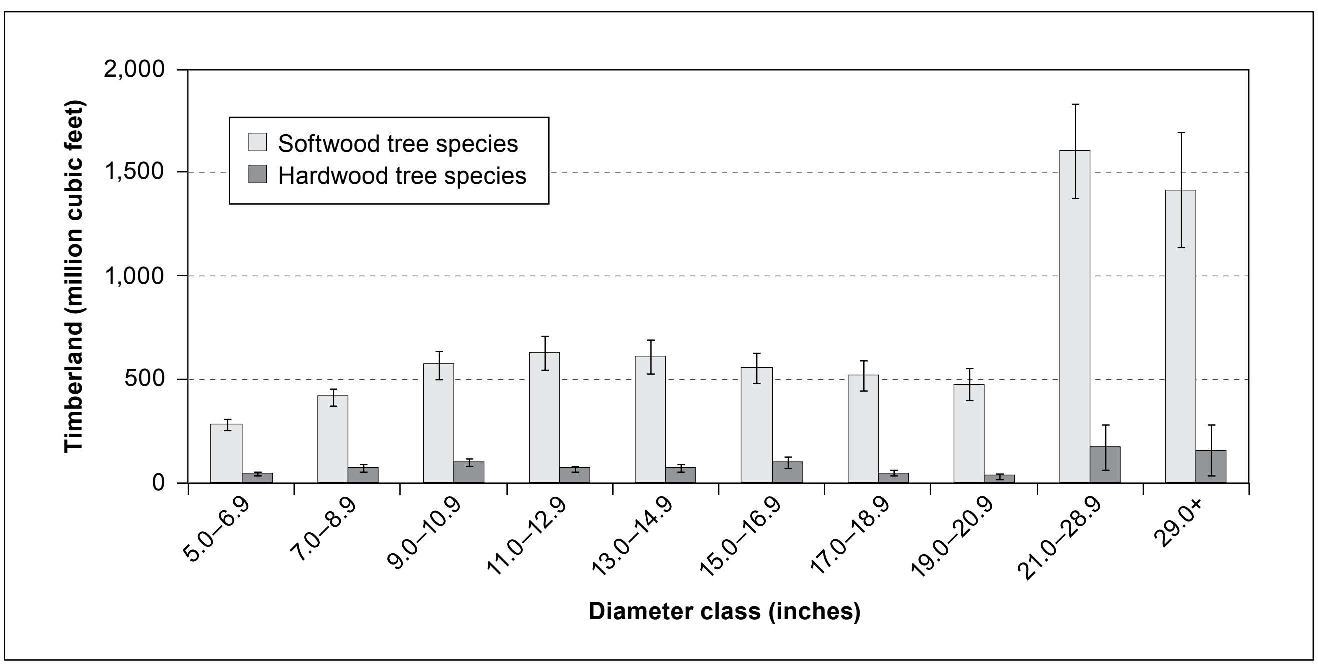


Figure 61—Estimated young-growth timberland cubic-foot volume by tree diameter class in coastal Alaska, 2004–2008. Lines at end of bars represent ± standard error.

Interpretation

The young-growth forests of coastal Alaska today are diverse and productive. Following logging or major disturbances in western hemlock or Sitka spruce forests, they respond by growing back with a postharvest regeneration that is abundant with the development of a dense new cohort of similar species (Deal 2007). These young stands have a simple structure that is uniform in tree height and diameter distribution, lacking the more complex stand structures found in old-growth stands (Deal and Tappeiner 2002). Because of these differences in stand structure and development, these stands will have a different wood product potential than the older forests currently supplying nearly all of the wood products in the region.

Overall, 41 percent of the young-growth acres falls on private ownerships, and these tend to be weighted more toward the younger age classes. These younger stands on private ownerships tend to have less overall volume, which explains why the national forests actually manage fewer overall acres of young-growth timberland but have over half (52 percent) of the current volume. Potential productivity will be helpful to determine how soon these young-growth stands could reach merchantable size and replace the older forests currently being harvested. However, larger forces such as economic and social considerations, management objectives, and public land management policy may have an even greater impact on the future of young-growth forests in coastal Alaska. Information presented here provides an initial summary of inventory results; additional analyses of these data are being compiled for forthcoming publication.

Alaska's Primary Forest Products Industry [2]

Background

Alaska's primary forest products industry provides social and economic benefits to Alaska communities by supplying wood products such as lumber and log homes, and by providing employment and income associated with land management, timber harvesting, and wood products manufacturing. Availability of timber for harvest and retention of forest products infrastructure to use timber are important issues facing Alaska's forest products industry.

In cooperation with USDA Forest Service Pacific Northwest Forest Inventory and Analysis (PNW-FIA), the Bureau of Business and Economic Research at the University of Montana conducts a periodic census of Alaska's primary forest products industry (i.e., timber processors and mill residue users). This census is the source of information presented below and provides detail on timber harvest and flow, as well as comprehensive information about the state's timber processing sectors, product volumes, sales values, and mill residue (Halbrook et al. 2009).

Results

The 2005 harvest in Alaska was 268.2 million board feet (MMBF) Scribner, but the volume processed by Alaska facilities was significantly less. Excluding raw logs that were received by Alaska mills and subsequently exported, Alaska facilities received slightly over 44.8 MMBF for processing in-state, approximately 16.7 percent of the harvest. In stark contrast to the timber harvest volume, of which national forests accounted for just 17.5 percent, the largest share (53 percent) of timber received by mills in Alaska came from national forests, followed by state and other public lands (38 percent), private and Native lands (8 percent), with Canadian imports representing about 0.5 percent of the timber received by Alaska processors. Quite unlike the industry in the Lower 48 States, Alaska's primary forest products industry almost exclusively utilizes timber harvested in-state.

Primary timber processors in Alaska produced an array of products including dimension lumber, board and shop lumber, timbers, finished house logs, log homes, log furniture, pulp chips from roundwood, cedar products, tonewood (for musical instruments), and novelty items such as bowls, spoons, and mugs. A total of 78 primary forest products facilities operated in Alaska during 2005 (fig. 62). The sawmill sector was the largest with 50 facilities, and the log home sector had 20, and eight other facilities actively purchased or used timber. During 2005, production of lumber and other sawn products was approximately 55 MMBF lumber tally, of which 89 percent was produced in

[2] Author: Todd A. Morgan.

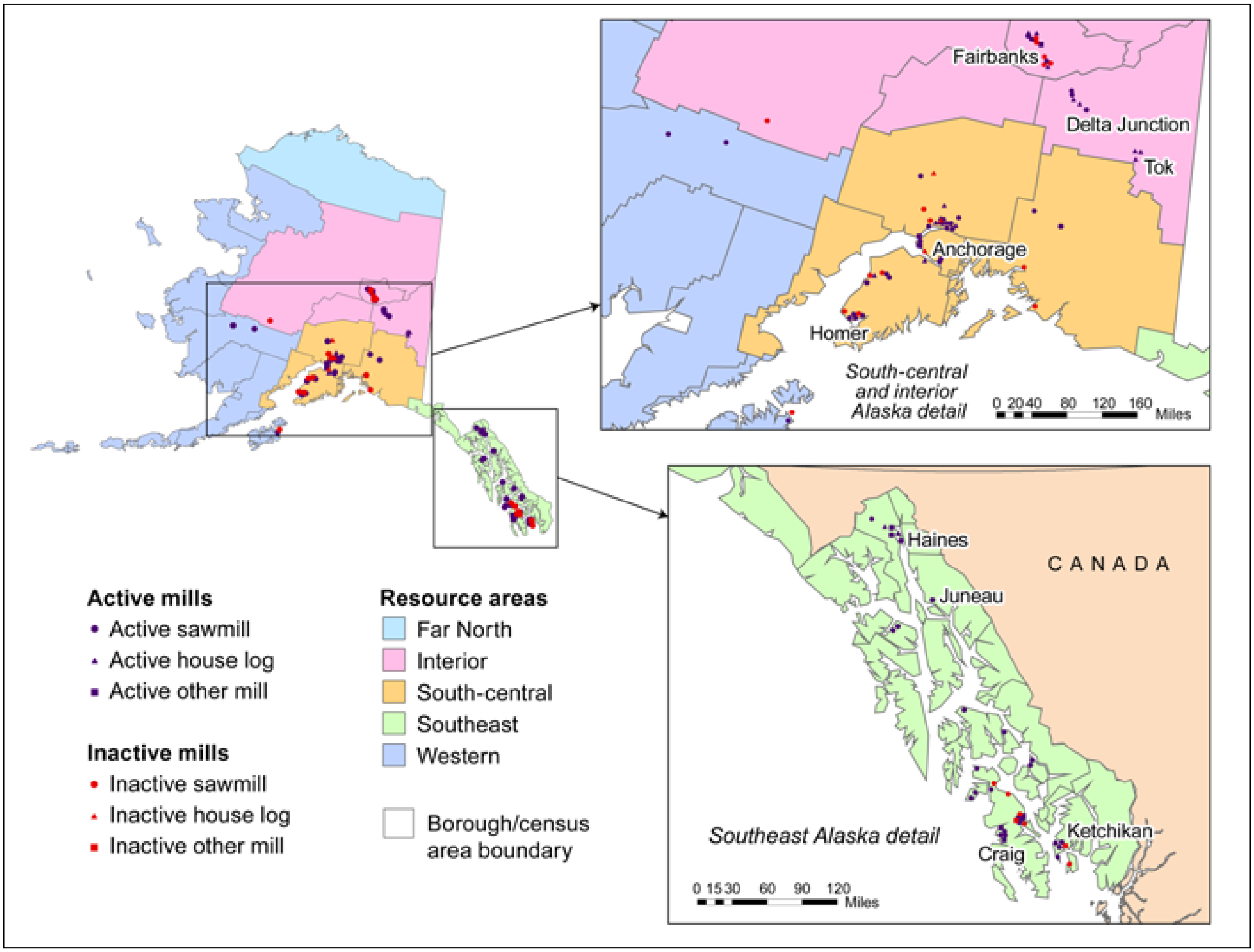


Figure 62—Alaska's resource areas and primary forest products manufacturers, calendar year 2005 (Source: Halbrook et al. 2009).

southeast Alaska. Production of house logs totaled more than 805,000 lineal feet, and pulp chip production from harvested trees exceeded 94,000 bone-dry tons.

Alaska's primary forest products sectors had product and mill residue sales of nearly $150 million during 2005. The largest share ($119 million) of sales was in the form of saw-log and pulpwood exports, primarily to Pacific Rim countries with about $10 million in sales to the Lower 48 States. Lumber accounted for about $20 million in sales, and house logs, mill residue, and other products combined accounted for slightly less than $10 million. Approximately $13 million in sales were within Alaska and consisted of a mix of products including lumber, log homes, cedar products, log furniture, tonewood, and novelty items.

Shown below are 2005 sales from Alaska's primary forest products industry sectors:

Products	**2005 sales value**
	Thousands of U.S. dollars
Saw-log and pulpwood exports	$119,171
Lumber	$20,460
House logs	$4,171
Other products[3]	$4,320
Mill residue	$1,416
Total products	$149,537

[3] Other products include cedar products, log furniture, tonewood, and novelty items.

Alaska's forest products industry employed over 3,000 workers in the 1970s. After dropping during the 1980–1982 recession, harvest and employment peaked in 1989 and 1990 at over 1 billion board feet and more than 4,600 workers. By 2005, with a 90-percent decline in national forest timber harvest and an 80-percent fall in Native/private harvest, total harvest had dropped by more than 80 percent. This precipitous decline in harvest led to a substantial loss in infrastructure with the closure of the two pulp mills in the 1990s, and forest industry employment fell to just 1,049 workers in 2005 (USDC Bureau of Economic Analysis 2007).

In addition to the steep employment declines, there was also a shift in the proportions of employment in various components of Alaska's industry. Prior to mill closures in the 1990s, approximately one-half the employment was in the logging sector. Currently, with the export of approximately 80 percent of Alaska's timber harvest, over two-thirds of the workforce is in private sector logging and forest management, and the remaining one-third is in wood products manufacturing (USDC BEA 2007).

Interpretation

Recent timber harvest levels in Alaska are on par with the mid-1950s but considerably below harvest levels seen from 1960 through 1999 (fig. 63). Changes in harvest over the last 60 years have been driven by timber output from two ownership categories: Native/private and national forests. Beginning in the 1950s with the establishment of pulp mills in the region, the annual volume of timber harvested in Alaska began to increase rapidly owing to increased harvest on national forests. Through 1973, national forests provided more than 90 percent of Alaska's timber harvest. A major shift in the ownership source of timber took place in the 1970s. The Alaska Native Claims Settlement Act of 1971 transferred ownership of approximately 44 million acres of federal land to Alaska Natives. With the shift in land ownership, the combined Native and private harvest increased from near zero prior to 1980 to a peak of 617 MMBF in 1989.

Total timber harvest volume in Alaska fell from 1,033 MMBF in 1990 to 268 MMBF in 2005. During this period, national forest harvest dropped by 90 percent

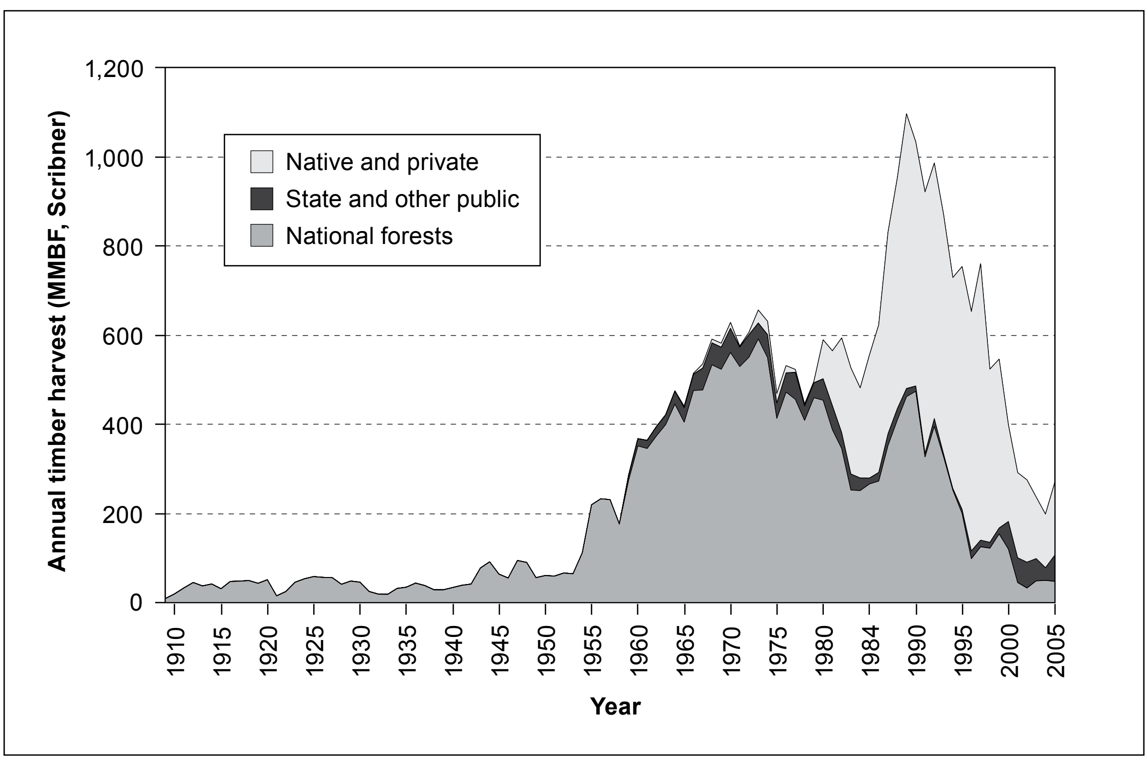


Figure 63—Alaska's timber harvest by owner group, 1909–2005. (Source: Brackley et al. 2009).

Forest Biomass as a Renewable Source of Energy in Coastal Alaska[4]

There is increasing interest in the use of forest biomass as an alternative fuel source for energy supply in rural areas of Alaska, where the ever-increasing cost of petroleum-based fuel products, specifically diesel, are putting tremendous economic pressure on these communities (Crimp et al. 2008). In coastal Alaska, the fuel supply for bioenergy production will likely be obtained as a byproduct of a range of forest management and utilization activities, including forest thinnings, sawmill operations, removal of hazardous fuels in fire-prone areas (such as the Kenai Peninsula), and habitat improvement/restoration (Nicholls and Miles 2009, Parrent 2007). Although bioenergy systems do release carbon dioxide and other products of combustion (gases and particulate matter) into the atmosphere, they offer several significant advantages over the use of fossil fuels for heating and power generation in rural Alaska: (1) forest biomass is a renewable source of fuel, and can be regrown in the near future, possibly offsetting greenhouse emissions from bioenergy production; (2) reduction of hazardous wildfire fuels near rural communities reduces risk to humans and property; and (3) managing the forest resource for sustainable, continuous biomass supply can create employment opportunities in nearby rural communities (unemployment rates in remote Native communities in southeast Alaska often reach 60 to 90 percent) (Wolfe 2008). As an example, the city of Craig in southeast Alaska has recently developed a bioenergy system that provides heat for the local school, by using a gasifier system with very low emissions, at a cost savings of $20,000 per year for the school (Peterson and Bruns 2006). Other options being considered include the use of wood pellets for home heating, electrical generation from wood biomass, use of beetle-killed spruce in the production of wood-plastic composite building materials, and export of forest biomass to foreign markets (Nicholls 2007).

Although there is tremendous potential for deriving energy from the forest biomass resource in Alaska, there are still significant obstacles to the efficient utilization of forest biomass, including prohibitive transportation costs and inadequate harvesting systems for small-diameter trees (Nicholls and Miles 2009). Another constraint on the development of bioenergy systems in rural Alaska is inadequate information on available biomass supply. Although Forest Inventory and Analysis plots can provide information on the distribution of biomass resources over large areas, the sampling intensity is not adequate to provide information on the biomass resources over smaller areas, for example, within the vicinity of a rural village. Research is currently underway to investigate how high-resolution remotely sensed data, such as airborne laser scanning, can be used in combination with FIA field plots to provide detailed information on the quantity and spatial distribution of biomass resources over smaller geographic areas (Andersen 2009).

The tree species present in coastal Alaska differ somewhat in terms of their value as a biofuel resource. For example, wood fuel heating values are as follows—western hemlock 13.9 million British thermal units (BTUs)/cord, Sitka spruce 13.4 million BTUs/cord, western redcedar 12.8 million BTUs/cord, and white spruce 13.7 million BTUs/cord (Nicholls and Miles 2009). The potential savings from converting to a wood-fired bioenergy system can be substantial. For example, at 2006 prices, the cost for biofuel (e.g., white spruce cordwood, 30 percent moisture content, $150/cord) was $16.98/million BTU, significantly lower than the cost of fuel oil ($31.70/million BTU and $3.50/gallon) (Nicholls and Miles 2009, Parrent 2007). With the cost of fossil fuels unlikely to decrease in the near future, the demand for forest biomass as an alternative fuel source for energy production in Alaska will likely continue to grow.

[4] Author: Hans-Erik Andersen.

and Native/private by about 80 percent. Numerous factors contributed to this decline, including:

- The Tongass Timber Reform Act of 1990 and Tongass timber program lawsuits
- Substantially lower timber inventories on some Native corporation lands
- Shifting markets and market conditions—especially weakness in Asian wood markets and increased competition from other producing regions
- Relatively high operating costs in Alaska

Going forward, availability of timber from Native lands and national forests will be a key factor in the retention of Alaska's forest products industry as well as the social and economic benefits provided by the industry.

Nontimber Forest Products[5]

Nontimber forest products (also known as special forest products [SFPs]) are products or services derived from the botanical and fungal resources of the forest other than timber. A precise definition of what is included as an NTFP-differs by land ownership and land management agency. In the Forest Service proposed rule on the "Sale and Disposal of National Forest System Timber; Special Forest Products and Forest Botanical Products" the following definition was given (USDA FS 2007: 59502):

> Products collected from National Forest System lands for commercial, personal, tribal, educational, or scientific purposes, including without limitation: bark, berries, boughs, bryophytes, bulbs, burls, Christmas trees, cones, ferns, firewood, forbs, fungi (including mushrooms), grasses, mosses, nuts, pinestraw, roots, sedges, seeds, transplants, tree sap, wildflowers, fence material, mine props, posts and poles, shingle and shake bolts, and rails. The term special forest products does not include sawtimber, pulpwood, non-sawlog material removed in log form, cull logs, small roundwood, house logs, telephone poles, derrick poles, minerals, animals, animal parts, insects, worms, rocks, water, and soil.

Many NTFPs are derived from vascular plant species. The FIA inventory surveys vascular plant diversity and abundance on a 1/16th-systematic subsample of all field plots. In the coastal Alaska inventory unit, this systematic subsample resulted in 135 forested plots surveyed for vegetation diversity between 2004 and 2008. Each vascular species was recorded on twelve 1-meter (3.3 foot) quadrants on each plot in the subsample (see Schulz et al. 2009 for additional detail on methods). This section of the report uses these data to provide some information on abundance of vascular plant species that are used as NTFPs.

As discussed in chapter 2, land ownership and management in Alaska's coastal inventory unit includes federal, state, local, and private entities. Each owner or land management agency has their own policies and regulations regarding the harvest of NTFPs. On most federal and state lands, uses of NTFPs are separated into noncommercial use and commercial use. In their interim SFP resource management policy, the Alaska Region of the Forest Service provides the following category of uses (USDA Forest Service 2000: 1):

> NON-COMMERCIAL USE—this category includes:
>
> Subsistence Use—Customary and traditional uses by rural residents, as defined in ANILCA Title VIII, for direct personal or family use or consumption, barter, sharing, or customary trade that does not constitute a significant commercial enterprise.
>
> Personal Use—Gathering of small quantities of materials for personal or family use or consumption; not intended for selling or resale. This includes cultural and traditional use by nonrural residents.
>
> Other Non-Commercial Use—This includes collections of plants by non-commercial entities for research not directed toward development of a commercial product. Educational use is also considered non-commercial when the class or workshop is affiliated with a college, university, Tribe or other recognized organization. The class

[5] Author: Lisa K. Crone.

instructor may be compensated for his/her time in gathering and preparing the materials for the classroom, either by the organization or by the students.

COMMERCIAL USE —Materials harvested for the primary purpose of sale, resale, or use in a manufacturing process resulting in a product that will be sold or used for business activities. Research collections directed at development of a commercial product are also treated as commercial use.

The order of priority for harvesting NTFPs on national forest lands in Alaska are subsistence use, personal use, educational and noncommercial research use, and commercial use. Permits are not required for subsistence and personal use unless there is a specific local impact to be mitigated, but permits are required for educational, noncommercial research, and commercial use. Noncommercial research and educational use can be authorized through an administrative use permit or free-use permit. The procedures for obtaining a commercial permit are much more extensive and must comply with national, regional, forest, and district direction, while also allowing for adequate review by tribes and interested groups or individuals. Fees are charged for commercial permits with the fees determined by the specific NTFP resources requested, the amounts allowed for harvest, and the locations of harvests. The primary areas of consideration for commercial NTFP harvest are areas where planned management activities such as timber harvest, road and trail construction, etc., would otherwise damage or destroy the product. Areas of known traditional subsistence and personal use are prioritized for subsistence and personal use.

The national parks and national wildlife refuges in Alaska have their own regulations concerning NTFP harvest (which can differ by specific national park or wildlife refuge). Woolwine (2003) provided a brief summary of their general policies.

On general state-owned lands[6] managed by the Division of Mining, Land and Water (DMLW), the harvesting of a small number of wild plants, mushrooms, berries, and other plant materials for personal, noncommercial use is generally allowed with no permit required (Alaska DNR 2009). For commercial harvest of NTFP on these lands, a permit is required. A limited NTFP commercial harvest permit may be obtained from the DMLW for many NTFP resources, without public review. The specific product and species allowed under this type of permit, as well as their quantity limits, harvest seasons and required harvest methods, are included in the *Alaska Non-Timber Forest Products Harvest Manual for Commercial Harvest on State-Owned Land* (Alaska DNR 2008). Any commercial harvest activities or quantities not specifically addressed in that manual must be applied for and authorized through the state's standard Land Use Permit, including all associated public review periods. All commercial use permits have fees, which are determined by the specific products and quantities harvested.

Pilz et al. (2006) provided an excellent overview of NTFP resources and their uses in Alaska. Included in their list of products currently being produced in the state are crafts, artwork, dyes, floral greenery, berries and other wild fruits, syrups, teas, flavorings, edible and medicinal plants, native seeds, edible mushrooms, and medicinal fungi. They also include a table that lists plants with documented historical or contemporary subsistence use in Alaska, and another table that lists NTFP resources that customers have inquired about for commercial harvest at ranger districts of the Chugach or Tongass National Forests since 1995. In table 60 (app. 2) plants that were found in at least one phase 3 FIA plot in the Alaska coastal inventory unit that also appear in one or both of the Pilz et al. (2006) tables are listed along with their subsistence uses and their intended commercial use/parts harvested as listed in the Pilz et al. (2006) tables. Moss and mushrooms are not inventoried in the FIA plots, so they are not included in this table.

---

[6] These lands do not include state parks, nor land managed by other state agencies such as the University of Alaska, Alaska Mental Health Trust, Department of Transportation and Public Facilities, or the Alaska Railroad. Pilz et al. (2006) provided a discussion of NTFP regulations for some of the state parks in the region.

The frequency attribute in the table indicates the percentage of plots on which these species were found using FIA vegetation survey methods (Schulz et al. 2009) and provides an indication of how common these plants are in southeast and south-central Alaska forests.

Table 60 indicates that many of the plants that were inquired about for commercial harvest on the Chugach and Tongass, also have documented subsistence or traditional uses. Schroeder (2002) wrote that the Alaska National Interest Lands Conservation Act has made federal agencies "loath to encourage commercial exploitation of nontimber forest products where conflict with existing subsistence uses might result." Lee (2002) noted the importance of nonmonetary exchange networks centered on fish, game, and wild plants in maintaining links between rural and urban Alaska Natives, with the gathering and processing of NTFP contributing to the development and maintenance of social ties needed for long-term cultural sustainability. Through oral interviews, Newton and Moss (2005) documented the manner in which many important NTFP subsistence resources were traditionally collected and used by the Tlingits.

Many Alaska Native tribes and organizations in southeast and south-central Alaska have expressed concern over the commercial harvest of NTFP on national forest lands in the Alaska Region. Some of these concerns are captured by Mater (2000) who summarized tribal comments on the Alaska Region's draft SFP policy.

Some tribal groups submitted lists of the species or plants they wanted excluded from commercial harvest, whereas others were opposed to any commercial use of NTFP. These concerns were addressed in the regional interim SFP resource management policy (USDA FS 2000) through the prioritization of uses, as well as an explicit guideline that local tribes must be directly notified of any proposed commercial SFP resource harvest activities within their use areas. Through the consultation process, tribal officials may identify any possible areas of conflict with traditional uses such as traditional gathering areas or traditional-use plants associated with the harvest. Because of its cultural and spiritual significance to Alaska Natives, commercial harvest of devil's club is not allowed on the Tongass. Other NTFP resources with special restrictions for commercial harvest from the Tongass include red and yellow-cedar bark, moss and lichens, and burls. Requests for bioprospecting[7] and medicinal plant harvests were also of concern to Alaska Native tribes and organizations. Scoping for these requests, whether they are requesting commercial or administrative permits, must involve Alaska Native tribes and organizations.

There have been very few commercial permits issued in the Alaska Region over the past 5 years. On the Chugach National Forest, there were two permits issued in calendar year 2004, for 300 tree transplants (trees that are dug up and replanted elsewhere for purposes such as landscaping) and 100 pounds of mushrooms. There were no commercial permits issued on the Chugach for calendar years 2005 through 2008. Table 28 lists the number of commercial permits and harvest quantities for the Tongass National Forest for calendar years 2004 through 2008.

To date, most NTFP resources in the coastal inventory region of Alaska have been harvested at sustainable levels. However, the continued involvement of Alaska Natives and other stakeholder groups, in designing NTFP management policies (including inventory and monitoring) is essential for both sustaining these resources and ensuring their contribution to the social, cultural, and economic well-being of individuals, tribes, businesses, groups, and communities in the region.

---

[7] The Tongass National Forest Interim Special Forest Products Resource Management Policy document, available online at http://www.fs.fed.us/r10/tongass/projects/sfp/, gives the following definition of the term bioprospecting: "This activity involves the sampling of small amounts of plants, animals and microorganisms (often from soil). The samples are used in laboratory testing for compounds that might be active for use in cancer drugs or other medical cures, as well as potential microorganisms for use in environmental cleanup."

Table 28—Nontimber forest products commercial permits and harvest quantities on the Tongass National Forest, 2004–2008

Year	Number of permits	Products and quantities
2004	2	20 Christmas trees, 20 lbs of other plants, 15 lbs of bark, 39 lbs of foliage, 20 lbs of nuts and seeds, 20 gal of fruit and berries
2005	6	44 Christmas trees, 2,400 lbs of limbs and boughs, 30 lbs of bark, 64 lbs of foliage, 20 lbs of nuts and seeds, 55 gal of fruit and berries, 10 roots
2006	1	400 lbs of limbs and boughs
2007	2	50 lbs of fruit and berries, 400 lbs of limbs and boughs
2008	2	40 lbs of fruit and berries, 60 lbs of limbs and boughs, 20 lbs of foliage

Source: Timber Information Management database, Alaska Region, USDA Forest Service.

Emily Bernhardt

Chapter 6: Concluding Remarks

We hope this report has provided a better understanding of status and change of Alaska's coastal forests, 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 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 Alaska's coastal forests. Some possible areas of future work may include more comprehensive analysis and reporting of issues such as carbon dynamics; forest productivity; climate-related disturbances and ecosystem resiliency; and forest health issues such as risk from disease, insects, and invasives.

We expect that researchers from the Pacific Northwest Research Station, U.S. Forest Service, as well as researchers and analysts from other organizations 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 Forest Inventory and Analysis (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 southeast and south-central Alaska, the next report should be written in 2015, after all FIA plots have been visited and the first full cycle of data collection is completed.

Glossary

abiotic—Pertaining to nonliving factors such as temperature, water, and mineral soil.

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. (March 21, 2008).

bioenergy—Renewable energy made available from materials derived from biological sources. http://en.wikipedia.org/wiki/Bioenergy. (March 21, 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 FS 2006).

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 inches × 12 inches × 1 inch = 144 cubic inches). http://www.ccffa-oswa.org/B.html. (March 21, 2008).

bole—Trunk or main stem of a tree (USDA FS 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).

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 FS 2006).

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

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).

cyanolichens—Lichen species containing cyanobacteria, which fix 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.

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 differ on abnormally formed trees (USDA FS 2006).

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. 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 FS 2006).

ecological region (ecoregion)—A defined geographic region that is similar in climate, geology, or other environmental attributes. This report uses ecoregions defined by Nowaki et al. (2002) and arranged by the hierarchical classification of Cleland et al. (1997). The hierarchical classification divides Alaska into three broad ecological divisions (Marine, Subarctic [boreal], and Tundra [arctic]). Divisions are subdivided into ecological provinces, which are further subdivided into ecological sections.

ecological section (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. (March 21, 2008).

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).

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

federal forest land—Public lands owned by the U.S. government (USDA FS 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 FS 2006).

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 FS 2006).

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

forestation—The process of nonforest land (e.g., shrubland, wetland, grassland, cropland) becoming forested as conditions change and trees are planted or naturally regenerate.

greenhouse gas—A gas, such as carbon dioxide or methane, that contributes to potential climate change. http://www.epa.gov/OCEPAterms/gterms.html. (March 21, 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 FS 2006).

hardwood—Tree species belonging to the botanical subdivision Angiospermae, class Dicotyledonous, usually broad leaved and deciduous (USDA FS 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. (March 21, 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).

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. (March 21, 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 FS 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 FS 2006).

mean annual increment (MAI)—A measure of the produc-tivity 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).

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 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).

mortality—The death of trees from natural causes, or subsequent to incidents such as storms, wildfire, or insect and disease epidemics (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 species—Plant species that were native to Alaska prior to Russian and Euro-American settlement. For vascular plants, these are the species that are not present on the USDA Natural Resources Conservation Service list of nonnative species (see nonnative species) (USDA NRCS 2000).

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).

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

nonnative species—Plant species that were introduced to Alaska subsequent to Russian and Euro-American settlement. For vascular plants, nonnative species are those on the USDA Natural Resources Conservation Service (USDA NRCS 2000) list of nonnative species.

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).

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

owner group—A variable that combines owner classes into the following groups: Forest Service, other federal agency, state and local government, and private. Differing categories of owner group on a plot require different conditions (USDA FS 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 a corporation, partnership, club, or trust; or a public agency. An ownership has control of a parcel or group of parcels of land (USDA FS 2006).

pathogen—Parasitic organism directly capable of causing disease (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 FS 2006).

public land—An ownership group that includes all federal, state, county, and municipal lands (USDA FS 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 feet sampling unit for the phase 3 Vegetation Indicator (USDA FS 2006).

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/glossar2.htm. (March 21, 2008).

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 FS 2006).

richness—The number of different species in a given area, often referred to at the plot scale as alpha diversity and at the region 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 recovery, 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 owing 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 FS 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 for softwoods of 7 inches (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 FS 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 FS 2007).

site class—A classification of forest land based on its capacity to grow wood.

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 DWM. Standing dead material shorter than 4.5 feet are considered stumps (USDA FS 2007).

stand—An area of relatively homogenous forest, often distinguished from surrounding forest by similarity in species composition, size, density, or structure.

stand age—Average age of the trees (plurality of all live trees not overtopped) in the predominant stand size class of the condition.

state land—An ownership class of public lands owned by states or lands leased by states for more than 50 years (USDA FS 2006).

stocked/nonstocked—In the Forest Inventory and Analysis Program, a minimum stocking value of 10 percent live trees is required for accessible forest land (USDA FS 2007).

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).

timberland—Forest land that is producing or capable of producing >20 cubic feet per acre per year of wood at culmination of MAI. Timberland excludes reserved forest lands (USDA FS 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 FS 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 MAI without regard to reserved status (USDA FS 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. 2009).

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. (March 21, 2008).

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).

Wilderness First Responder—An individual trained to respond to emergency situations in remote settings, with certification typically obtained through an 80-hour training course.

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-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. (March 21, 2008).

Common and Scientific Names[1]

Common name	Scientific name
Trees:	
Alaska paper birch[2]	*Betula neoalaskana* Sarg.
Barclay's willow	*Salix barclayi* Anderss.
Black cottonwood	*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.)
Brayshaw	
Black spruce	*Picea mariana* (Mill.) Britton, Sterns & Poggenb.
European bird cherry	*Prunus padus* L.
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Lutz spruce[3]	*Picea X lutzii* Little
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Pacific silver fir	*Abies amabilis* (Douglas ex Louden) Douglas ex Forbes
Pacific yew	*Taxus brevifolia* Nutt.
Paper birch	*Betula papyrifera* Marsh.
Ponderosa pine	*Pinus ponderosa* P. & C. Lawson
Quaking aspen	*Populus tremuloides* Michx.
Red alder	*Alnus rubra* Bong.
Sitka spruce	*Picea sitchensis* (Bong.) Carrière
Subalpine fir	*Abies lasiocarpa* var. *lasiocarpa* (Hook.) Nutt.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Western mountain ash	*Sorbus sitchensis* M. Roemer
Western redcedar	*Thuja plicata* Donn ex D. Don
White spruce	*Picea glauca* (Moench) Voss
Yellow-cedar, Alaska yellow-cedar	*Chamaecyparis nootkatensis* (D. Don) Spach
Vines:	
Kudzu	*Pueraria montana* (Lour.) Merr.

Common name	**Scientific name**
Shrubs:	
American red raspberry	*Rubus idaeus* L.
Blueberry	*Vaccinium* L.
Bog Labrador tea	*Ledum groenlandicum* Oeder
Bog laurel	*Kalmia polifolia* Wangenh.
Common juniper	*Juniperus communis* L.
Common snowberry	*Symphoricarpos albus* (L.) Blake
Copperbush	*Elliottia pyroliflorus* (Bong.) S.W. Brim & P.F. Stevens
Devil's club	*Oplopanax horridus* (Sm.) Miq.
Early blueberry	*Vaccinium ovalifolium* Sm.
Highbush cranberry	*Viburnum edule* (Michx.) Raf.
Japanese knotweed	*Polygonum cuspidatum* Sieb. & Zucc.
Kamchatka rhododendron	*Rhododendron camtschaticum* Pallas
Red currant	*Ribes triste* Pallas
Red elderberry	*Sambucus racemosa* L.
Red fruit bearberry	*Arctostaphylos rubra* (Rehd. & Wilson) Fern.
Red huckleberry	*Vaccinium parvifolium* Sm.
Russet buffaloberry	*Shepherdia canadensis* (L.) Nutt.
Rusty menziesia	*Menziesia ferruginea* Sm.
Salal	*Gaultheria shallon* Pursh
Salmonberry	*Rubus spectabilis* Pursh
Scotch broom	*Cytisus scoparius* (L.) Link
Siberian peashrub	*Caragana arborescens* Lam.
Sitka alder	*Alnus viridis* (Chaix) DC. ssp. *sinuata* (Regel) A. Löve & D. Löve
Stink currant	*Ribes bracteosum* Dougl. ex Hook.
Sweetgale	*Myrica gale* L.
Thimbleberry	*Rubus parviflorus* Nutt.
Trailing black currant	*Ribes laxiflorum* Pursh
Willow	*Salix* L.
Subshrubs:	
Alaska bellheather	*Harrimanella stelleriana* (Pallas) Coville
Alpine bearberry	*Arctostaphylos alpina* (L.) Spreng.
Alpine clubmoss	*Lycopodium alpinum* L.
Black crowberry	*Empetrum nigrum* L.
Bog blueberry	*Vaccinium uliginosum* L.
Bog rosemary	*Andromeda polifolia* L.
Bunchberry dogwood	*Cornus canadensis* L.
Cloudberry	*Rubus chamaemorus* L.
Dwarf bilberry	*Vaccinium caespitosum* Michx.
Fiveleaf bramble	*Rubus pedatus* Sm.
Hemlock dwarf mistletoe	*Arceuthobium tsugense* (Rosendahl) G.N. Jones
Lapland cornel	*Cornus suecica* L.
Lingonberry	*Vaccinium vitis-idaea* L.
Liverleaf wintergreen	*Pyrola asarifolia* Michx.
Mountainheath	*Phyllodoce* Salisb.
Nagoonberry	*Rubus arcticus* L.
Partridgefoot	*Luetkea pectinata* (Pursh) Kuntze
Running clubmoss	*Lycopodium clavatum* L.

Common name	Scientific name
Sidebells wintergreen	*Orthilia secunda* (L.) House
Small cranberry	*Vaccinium oxycoccos* L.
Stiff clubmoss	*Lycopodium annotinum* L.
Tree groundpine	*Lycopodium dendroideum* Michx.
Twinflower	*Linnaea borealis* L.
Forbs/herbs:	
Alfalfa	*Medicago* L.
Alpine mountainsorrel	*Oxyria digyna* (L.) Hill
American skunkcabbage	*Lysichiton americanus* Hultén & St. John
Arctic starflower	*Trientalis europaea* L.
Beachhead iris	*Iris setosa* Pallas ex Link
Bird vetch	*Vicia cracca* L. ssp. *cracca*
Bride's bonnet	*Clintonia uniflora* (Menzies ex J.A. & J.H. Schultes) Kunth
Bride's feathers	*Aruncus dioicus* (Walt.) Fern.
Brightgreen spleenwort	*Asplenium trichomanes-ramosum* L.
Broadpetal gentian	*Gentiana platypetala* Griseb.
Bull thistle	*Cirsium vulgare* (Savi) Ten.
Butter and eggs	*Linaria vulgaris* P. Mill.
Canadian burnet	*Sanguisorba canadensis* L.
Canada thistle	*Cirsium arvense* (L.) Scop.
Claspleaf twistedstalk	*Streptopus amplexifolius* (L.) DC.
Clover	*Trifolium* L.
Common chickweed	*Stellaria media* (L.) Vill.
Common cowparsnip	*Heracleum maximum* Bartr.
Common dandelion	*Taraxacum officinale* G.H. Weber ex Wiggers
Common groundsel	*Senecio vulgaris* L.
Common ladyfern	*Athyrium filix-femina* (L.) Roth
Common mare's-tail	*Hippuris vulgaris* L.
Common plantain	*Plantago major* L.
Common tansy	*Tanacetum vulgare* L.
Common yarrow	*Achillea millefolium* L.
Creeping buttercup	*Ranunculus repens* L.
Deer fern	*Blechnum spicant* (L.) Sm.
Deercabbage	*Nephrophyllidium crista-galli* (Menzies ex Hook.) Gilg
Dwarf fireweed	*Chamerion latifolium* (L.) Holub
European stickseed	*Lappula squarrosa* (Retz.) Dumort.
False lily of the valley	*Maianthemum dilatatum* (Wood) A. Nels. & J.F. Macbr.
Fernleaf goldthread	*Coptis aspleniifolia* Salisb.
Field horsetail	*Equisetum arvense* L.
Fireweed	*Chamerion angustifolium* (L.) Holub
Garlic mustard	*Alliaria petiolata* (Bieb.) Cavara & Grande
Green false hellebore	*Veratrum viride* Ait.
Hairy catsear	*Hypochaeris radicata* L.
Hairy rockcress	*Arabis hirsuta* (L.) Scop.
Heartleaf twayblade	*Listera cordata* (L.) R. Br. ex Ait. f.
Hempnettle	*Galeopsis* L.
Horsetail	*Equisetum* L.
Kamchatka fritillary	*Fritillaria camschatcensis* (L.) Ker-Gawl.

Common name	Scientific name
Largeleaf avens	*Geum macrophyllum* Willd.
Ledge stonecrop	*Rhodiola integrifolia* ssp. *integrifolia* Raf.
Licorice fern	*Polypodium glycyrrhiza* D.C. Eat.
Little yellowrattle	*Rhinanthus minor* L.
Long beechfern	*Phegopteris connectilis* (Michx.) Watt
Lyrate rockcress	*Arabis lyrata* L.
Meadow hawkweed	*Hieracium caespitosum* Dumort.
Monkshood	*Aconitum delphiniifolium* DC.
Mouseear hawkweed	*Hieracium pilosella* L.
Narrowleaf hawksbeard	*Crepis tectorum* L.
Narrowleaf hawkweed	*Hieracium umbellatum* L.
Nootka lupine	*Lupinus nootkatensis* Donn ex Sims
Northern groundcone	*Boschniakia rossica* (Cham. & Schlecht.) Fedtsch.
Northern maidenhair	*Adiantum pedatum* L.
Northwestern twayblade	*Listera caurina* Piper
Orange hawkweed	*Hieracium aurantiacum* L.
Ornamental jewelweed	*Impatiens glandulifera* Royle
Oxeye daisy	*Leucanthemum vulgare* Lam.
Perennial sowthistle	*Sonchus arvensis* L.
Pineapple weed	*Matricaria discoidea* DC.
Prostrate knotweed	*Polygonum aviculare* L.
Red baneberry	*Actaea rubra* (Ait.) Willd.
Roundleaf sundew	*Drosera rotundifolia* L.
Scentbottle	*Platanthera dilatata* (Pursh) Lindl. ex Beck
Scottish licorice-root	*Ligusticum scoticum* L.
Shepherd's purse	*Capsella bursa-pastoris* (L.) Medik.
Single delight	*Moneses uniflora* (L.) Gray
Slender bog orchid	*Platanthera stricta* Lindl.
Small twistedstalk	*Streptopus streptopoides* (Ledeb.) Frye & Rigg
Spotted knapweed	*Centaurea biebersteinii* DC.
Spreading woodfern	*Dryopteris expansa* (K. Presl) Fraser-Jenkins & Jermy
Sticky tofieldia	*Tofieldia glutinosa* (Michx.) Pers.
Subalpine fleabane	*Erigeron peregrinus* (Banks ex Pursh) Greene
Swamp gentian	*Gentiana douglasiana* Bong.
Sweetclover, white	*Melilotus alba* Medikus
Sweetclover, yellow	*Melilotus officinalis* (L.) Lam.
Tansy ragwort	*Senecio jacobaea* L.
Threeleaf foamflower	*Tiarella trifoliata* L.
Threeleaf goldthread	*Coptis trifolia* (L.) Salisb.
Twistedstalk	*Streptopus lanceolatus* (Aiton) Reveal var. *roseus* (Michx.) Reveal
Violet	*Viola* L.
Western brackenfern	*Pteridium aquilinum* (L.) Kuhn
Western columbine	*Aquilegia formosa* Fisch. ex DC.
Western oakfern	*Gymnocarpium dryopteris* (L.) Newman
Western salsify	*Tragopogon dubius* Scop.
Wild chives	*Allium schoenoprasum* L.
Wormseed wallflower	*Erysimum cheiranthoides* L.
Yellow marsh marigold	*Caltha palustris* L.

Common name	Scientific name
Grass-like plants:	
Bluejoint	*Calamagrostis canadensis* (Michx.) Beauv.
Cheatgrass	*Bromus tectorum* L.
Colonial bentgrass	*Agrostis capillaris* L.
Foxtail barley	*Hordeum jubatum* L.
Orchardgrass	*Dactylis glomerata* L.
Pacific reedgrass	*Calamagrostis nutkaensis* (J. Presl) J. Presl ex Steud.
Quackgrass	*Elymus repens* (L.) Gould
Reed canarygrass	*Phalaris arundinacea* L.
Rush	*Juncus* L.
Ryegrass	*Lolium* L.
Sedge	*Carex* L.
Smooth brome	*Bromus inermis* Leyss.
Tall cottongrass	*Eriophorum angustifolium* Honckeny
Tall fescue	*Lolium arundinaceum* (Schreb.) S.J. Darbyshire
Timothy	*Phleum pratense* L.
Tufted bulrush	*Trichophorum caespitosum* (L.) Hartman
Water whorlgrass	*Catabrosa aquatica* (L.) Beauv.

[1] Scientific names are from the USDA PLANTS database at http://plants.usda.gov. (January 2000).
[2] Alaska paper birch, Kenai paper birch, and western paper birch are not recorded as different species by FIA and are included together as "paper birch" in this report.
[3] On the Kenai Peninsula, Sitka spruce and white spruce hybridize as Lutz spruce. The FIA field crew classify each individual Lutz spruce tree to whichever of the two species it most resembles.

Acknowledgments

John Cauoette, one of the authors of this report, died unexpectedly in the autumn of 2010. John's energy and enthusiasm contributed much to this report and to other forest research in southeast Alaska, and he will be greatly missed by his colleagues.

We wish to acknowledge the Pacific Northwest Research Station Forest Inventory and Analysis (FIA) field crew for collecting the high-quality field data on which this report was based: Stacey Allen, Nicole Amato, Gerald Bednarczyk, Kristen Bednarczyk, Zachary Bergen, Tina Boucher, Allan Braun, Will Bunten, Brandon Burke, Janelle Cossey, Erica Engle, Water Foss, Kathleen Galloway, Marion Glasser, Walter Grabowiecki, Richard Hannah, Connie Hubbard, John Kelley, Ann Klinefelter, Ray Koleser, Nicholas Lisuzzo, Marc Much, Brendt Mueller, Laura Mujica-Crapanzano, Eric Murphy, Shawn Osborn, Pierre Parisien, Elizabeth Patterson, Ben Pfohl, Andrew Richards, Eric Straley, Sasha Sulia, Andy Tasler, Chris Teutsch, Steve Trimble, Julie Vorachek, Jonathan Williams, and Mikhail Yatskov. In addition, many other people contributed significantly to this report. We greatly appreciate all the work done by Jane Reid and Kevin Dobelbower, who compiled the data that were the foundation for this report. We thank Ron Wanek and Kurt Campbell who provided troubleshooting for data issues, Chuck Veneklase who programmed the field data recorder, and Dale Weyermann and Elena Graham for geographic information system support. We appreciate the help from Olaf Kuegler, who contributed substantially on stratification and statistical issues. We thank Bill van Hees, Ray Koleser, and George Breazeale, who all contributed substantially to the Alaska inventory. We appreciate the efforts of Sue Willits and Sally Campbell in supporting FIA in Alaska over the past decade, and for providing review comments.

Thanks also to the other reviewers that provided helpful comments on a draft version of this report: Phyllis Adams, Keith Boggs, Tina Boucher, Roger Burnside, Bob Deal, Rob Develice, Mike McClellan, Carol McKenzie, Amy Miller, Barb Schrader, and Lori Winton. We thank Carolyn Wilson, Keith Routman, Lynn Sullivan, and Ann Pruszenski for helping to prepare the report for publication.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.3048	Meters
Miles	1.609	Kilometers
Acres	.405	Hectares
Board feet	.0024	Cubic meters
Cubic feet	.0283	Cubic meters
Cubic feet per acre	.06997	Cubic meters per hectare
Square feet	.0929	Square meters
Square feet per acre	.229	Square meters per hectare
Ounce	28349.5	Milligrams
Gallon	3.79	Liters
Pound	.453	Kilograms
Pounds per cubic foot	16.018	Kilograms per cubic meter
Tons per acre	2.24	Megagrams per hectare
Degrees Fahrenheit	.56(°F – 32)	Degrees Celsius
British thermal units (Btu)	.000293	Kilowatt hours
Pounds per cubic foot	.016	Grams per cubic centimeter

References

Alaback, P. 1984. Secondary plant succession following logging in the Sitka spruce-western hemlock forests of southeast Alaska: implications for wildlife management. Gen. Tech. Rep. PNW-GTR-173. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 26 p.

Alaska Department of Natural Resources [DNR]. 2008. Alaska non-timber forest products harvest manual for commercial harvest on state-owned land. Anchorage, AK: Division of Mining, Land and Water. 41 p. http://dnr.alaska.gov/mlw/ntfp/pdf/soa_ntfp_harvestmanual_04022008.pdf. (August 24, 2009).

Alaska Department of Natural Resources [DNR]. 2009. Generally allowed uses on state land. Anchorage, AK: Division of Mining, Land and Water. 2 p. http://dnr.alaska.gov/mlw/factsht/gen_allow_use.pdf. (September 8, 2009).

AKEPIC Alaska Exotic Plant Information Clearinghouse [AKEPIC]. 2005. Invasive plants of Alaska. Anchorage, AK: Alaska Association of Conservation Districts Publication. 294 p.

Alemdag, I.S. 1984. Total tree and merchantable stem biomass equations for Ontario hardwoods. Inf. Report PI-X-46. Chalk River, ON: Petawawa National Forestry Institute, Canadian Forestry Service, Agriculture Canada. 54 p.

Andersen, H.-E. 2009. Using airborne light detection and ranging (LIDAR) to characterize forest stand condition on the Kenai Peninsula of Alaska. Western Journal of Applied Forestry. 24(2): 95–102.

Antoine, M.E. 2004. An ecophysiological approach to quantifying nitrogen fixation by *Lobaria oregana*. The Bryologist. 107: 82–87.

Azuma, D.L.; Dunham, P.A.; Hiserote, B.A.; Veneklase, C.F. 2004. Timber resource statistics for eastern Oregon, 1999. Resour. Bull. PNW-RB-238. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 42 p.

Bailey, R.G. 1983. Delineation of ecosystem regions. Environmental Management. 7: 365–373.

Bailey, R.G. 1995. Description of the ecoregions of the United States. Fort Collins, CO: U.S.Department of Agriculture, Forest Service, Rocky Mountain Research Station. http://www.fs.fed.us/land/ecosysmgmt/index.html. (April 14, 2010).

Bargeron, C. 2009. Early detection and distribution mapping system. Tifton, GA: Center for Invasive Species and Ecosystem Health, The University of Georgia. http://www.eddmaps.org/alaska/. (October 6, 2009).

Bechtold, W.A.; Patterson, P.L. 2005. The enhanced Forest Inventory and Analysis Program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Ashville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

Beers, T.W.; Miller, C.I. 1964. Point sampling: research results, theory, and applications. Purdue University Resource Bulletin 785. West Lafayette, IN: Purdue University. 56 p.

Beier, C.M.; Sink, S.E.; Hennon, P.E.; D'Amore, D.V.; Juday, G.P. 2008. Twentieth-century warming and the dendroclimatology of declining yellow-cedar forests in southeastern Alaska. Canadian Journal of Forest Research. 38: 1319–1334.

Berg, E. 2009. Permafrost on the Kenai lowlands. Refuge notebook. Soldatna, AK: U.S. Fish and Wildlife Service, Kenai National Wildlife Refuge. http://kenai.fws.gov/overview/notebook/2009/november/13nov2009.htm. (March 8, 2010).

Berg, E.E.; Henry, J.D.; Fastie, C.L.; DeVolder, A.D.; Matsuoka, S.M. 2006. Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: relationship to summer temperatures and regional differences in disturbance regimes. Forest Ecology and Management. 227(3): 219–232.

Blackard, J.; Finco, M.; Helmer, E.; Holden, G.; Hoppus, M.; Jacobs, D.; Lister, A.; Moisen, G.; Nelson, M.; Riemann, R.; Ruefenacht, B.; Salajanu, D.; Weyermann, D.; Winterberger, K.; Brandeis, T.; Czaplewski, R.; McRoberts, R.; Patterson, P.; Tycio, R. 2008. Mapping U.S. forest biomass using national forest inventory data and moderate resolution information. Remote Sensing of Environment. 112: 1658–1677.

Boggs, K. 2000. Classification of community types, successional sequences, and landscapes of the Copper River Delta, Alaska. Gen. Tech. Rep. PNW-GTR-469. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 244 p.

Boggs, K.; Klein, S.C.; Grunblatt, J.G.; Streveler, P.; Koltun, B. 2008. Landcover classes and plant associations of Glacier Bay National Park and Preserve. Natural Resource Technical Report NPS/GLBA/NRTR-2008/093. Fort Collins, CO: National Park Service. 255 p.

Boggs, K.; Klein, S.C.; Flagstad, L.; Boucher, T.; Grunblatt, J.; Koltun, B. 2009. Landcover classes, ecosystems and plant associations of Kenai Fjords National Park. Natural Resource Technical Report NPS/KEFJ/NRTR—2009/136. Fort Collins, CO: National Park Service. 246 p.

Boucher, T.V.; Mead, B.R. 2006. Vegetation change and forest regeneration on the Kenai Peninsula, Alaska following a spruce beetle outbreak. Forest Ecology and Management. 227: 233–246.

Brackett, M. 1973. Notes on tariff tree volume computation. Resource Management Report No. 24. Olympia, WA: State of Washington, Department of Natural Resources. 26 p.

Brackley, A.M.; Haynes, R.W.; Alexander, S.J. 2009. Timber harvests in Alaska: 1910–2006. Res. Note PNW-RN-560. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

Bruce, D. 1984. Volume estimators for Sitka spruce and western hemlock in coastal Alaska. In: Inventorying forest and other vegetation of the high latitude and high altitude regions. Proceedings of an international symposium. Bethesda, MD: Society of American Foresters: 96–102.

Calkin, P.E.; Wiles, G.C.; Barclay, D.J. 2000. Holocene coastal glaciations of Alaska. Quaternary Science Reviews. 20(1-3): 449–461.

Campbell, S.; van Hees, W.W.S.; Mead, B. 2004. Southeast Alaska forests: inventory highlights. Gen. Tech. Rep. PNW-GTR-609. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Campbell, S.; van Hees, W.W.S.; Mead, B. 2005. South-central Alaska forests: inventory highlights. Gen. Tech. Rep. PNW-GTR-652. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.

Capp, J.; Van Zee, B.; Alaback, P.; Boughton, J.; Copenhagen, M.; Martin, J. 1992a. Ecological definitions for old-growth forest types in south-central Alaska. R10-TP-28b. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. On file with: Tara Barrett, Forestry Sciences Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99507.

Capp, J.; Van Zee, B.; Alaback, P.; Boughton, J.; Copenhagen, M.; Martin, J. 1992b. Ecological definitions for old-growth forest types in southeast Alaska. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region; final report; R10-TP-28a. On file with: Tara Barrett, Forestry Sciences Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99507.

Carlson, M.L.; Lapina, I.V.; Shephard, M.; Conn, J.S.; Densmore, R.; Spencer, P.; Heys, J.; Riley, J.; Nielsen, J. 2008. Invasiveness ranking system for non-native plants of Alaska. R10-TP-143. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 218 p.

Carrara, P.E.; Ager, T.A.; Baichtal, J.F. 2007. Possible refugia in the Alexander Archipelago of southeastern Alaska during the late Wisconsin glaciation. Canadian Journal of Earth Sciences. 44: 229–244.

Certini, G. 2005. Effects of fire on properties of forest soils: a review. Oecologia. 143: 1–10.

Chapin, F.S.; Matson, P.; Mooney, H. 2002. Principles of terrestrial ecosystem ecology. New York: Springer. 436 p. Chapter 6.

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G.; King, T.; Russell, W.E. 1997. National hierarchical framework of ecological units. In: Boyce, M.S.; Haney, A., eds. Ecosystem management: applications for sustainable forest and wildlife resources. New Haven, CT: Yale University Press: 181–200.

Cleland, D.T.; Freeouf, J.A.; Keys, J.E.; Nowacki, G.J.; Carpenter, C.A.; McNab, W.H. 2005. Ecological subregions, sections and subsections for the conterminous United States. [Map on CD-ROM]. 1:3,500,000. Washington, DC: U.S. Department of Agriculture, Forest Service.

Cole, E.; Youngblood, A.; Newton, M. 2004. Effects of competing vegetation on juvenile white spruce (*Picea glauca* [Moench] Voss) growth in Alaska. Annals of Forest Science. 60: 573–583.

Cook, J.A.; Bidlack, A.L.; Conroy, C.J. 2001. A phylogeographic perspective on endemism in the Alexander Achipelago of southeast Alaska. Biological Conservation. 97(2): 215–227.

Cornwell, W.K.; Cornelissen, J.H.C.; Allison, S.D.; Bauhus, J.; Eggleton, P.; Preston, C.M.; Scarff, F.; Weedon, J.T.; Wirth, C.; Zanne, A.E. 2009. Plant traits and wood fates across the globe: rotten, burned or consumed? Global Change Biology. 15(10): 2431–2449.

Crimp, P.; Colt, S.; Foster, M. 2008. Renewable power in rural Alaska: Improved opportunities for economic development. In: Proceedings of the arctic energy summit, Anchorage, AK. Anchorage, AK: Institute of the North. http://www.iser.uaa.alaska.edu/Publications/AES_Crimp_Colt_Foster.pdf. (April 14, 2010).

Deal, R.L. 2007. Management strategies to increase stand structural diversity and enhance biodiversity in coastal rainforests of Alaska. Biological Conservation. 137: 520–532.

Deal, R.L.; Heithecker, T.; Zenner, E.K. 2010. Comparison of tree size and growth for partially harvested and even-aged hemlock-spruce stands in southeast Alaska. Journal of Forest Research. 15: 31–37.

Deal, R.L.; Tappeiner, J.C. 2002. The effects of partial cutting on stand structure and growth of western hemlock—Sitka spruce stands in southeast Alaska. Forest Ecology and Management. 159: 173–186.

Debano, L.F.; Savage, S.M.; Hamilton, D.A. 1976. The transfer of heat and hydrophobic substances during burning. Soil Science Society of America Journal. 40: 779–782.

DeMars, D.J. 1996a. Board-foot and cubic-foot volume tables for Alaska-cedar in southeast Alaska. Res. Note PNW-RN-516. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 14 p.

DeMars, D.J. 1996b. Board-foot and cubic-foot volume tables for western redcedar in southeast Alaska. Res. Note PNW-RN-517. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p.

DeMeo, T.; Bouchers, S.; Martin, J.; Pawuk, B. 1990. Plant indicator cards. Unpublished picture identification guide. On file with: Beth Schulz, Forestry Sciences Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99503. 40 p.

DeMeo, T.; Martin, J.; West, R.A. 1992. Forest plant association management guide, Ketchikan Area, Tongass National Forest. R10-MB-210. Juneau, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 405 p.

DeVelice, R.L.; Hubbard, C.J.; Boggs, K.; Boudreau, S.; Potkin, M.; Boucher, T.; Wertheim, C. 1999. Plant community types of the Chugach National Forest: southcentral Alaska. Tech. Publ. R10-TP 76. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Chugach National Forest, Alaska Region. 375 p.

De Volder, A. 1999. Fire and climate history of lowland black spruce forests, Kenai National Wildlife Refuge, Alaska. Flagstaff, AZ: Northern Arizona University. 128 p. M.S. thesis.

Dial, R.J.; Berg, E.E.; Timm, K.; McMahon, A.; Geck, J. 2007. Changes in the alpine forest-tundra ecotone commensurate with recent warming in southcentral Alaska: evidence from orthophotos and field plots. Journal of Geophysical Research-Biogeosciences. 112: G4.

Embry, R.S.; Haack, P.M. 1965. Volume tables and equations for young-growth western hemlock and Sitka spruce in southeast Alaska. Res. Note NOR-12. Juneau, AK: U.S. Department of Agriculture, Forest Service, Northern Forest Experiment Station. 21 p.

Eyre, F.H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Fahey, T.; Siccama, T.; Driscoll, C.; Likens, G.; Campbell, J.; Johnson, C.; Battles, J.; Aber, J.; Cole, J.; Fisk, M.; Groffman, P.; Hamburg, S.; Holmes, R.; Schwarz, P.; Yanai, R. 2005. The biogeochemistry of carbon at Hubbard Brook. Biogeochemistry. 75: 109–176.

Farr, W.A. 1967. Growth and yield of well-stocked white spruce stands in Alaska. Res. Pap. PNW-53. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 30 p.

Fenn, M.E.; Jovan, S.; Yuan, F.; Geiser, L.; Meixner, T.; Gimeno, B.S. 2008. Empirical and simulated critical loads for nitrogen deposition in California mixed conifer forests. Environmental Pollution. 155: 492–511.

Flint, C.G. 2004. Community response to forest disturbance on Alaska's Kenai Peninsula. University Park, PA: The Pennsylvania State University. 297 p. Ph.D. dissertation.

Flint, C.G. 2006. Community perspectives on spruce beetle impacts on the Kenai Peninsula, Alaska. Forest Ecology and Management. 227(3): 207–218.

Franklin, J.F.; Hall, F.; Laudenslayer, W. 1986. Interim definitions for old-growth Douglas-fir and mixed-conifer forests in the Pacific Northwest and California. Res. Note PNW-RN-447. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p.

Franklin, J.F.; Spies, T.A. 1991. Composition, function, and structure of old-growth Douglas-fir forests. In: Ruggiero, L.F.; Aubry, K.B.; Carey, A.B.; Huff, M.H., eds. Wildlife and vegetation of unmanaged Douglas-fir forests. Gen. Tech. Rep. PNW-GTR-285. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 71–80.

Geiser, L.H.; Dillman, K.L.; Derr, C.C.; Stensvold, M.C. 1998. Lichens and allied fungi of Southeast Alaska. In: Glenn, M.G.; Harris, R.C.; Dirig, R.; Cole, M.S., eds. *Lichenographia thomsoniana*: North American lichenology in honor of John W. Thomson. Ithaca, NY: Mycotaxon Ltd. 42 p.

Geiser, L.H.; Neitlich, P.N. 2007. Air pollution and climate gradients in western Oregon and Washington indicated by epiphytic macrolichens. Environmental Pollution. 145: 203–218.

Gray, A.N.; Azuma, D.L. 2005. Repeatability and implementation of a forest vegetation indicator. Ecological Indicators. 5: 57–71.

Halbrook, J.M.; Morgan, T.A.; Brandt, J.P.; Keegan, C.E.; Dillon, T.; Barrett, T. 2009. Alaska's timber harvest and forest products industry, 2005. Gen. Tech. Rep. PNW-GTR-787. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 30 p.

Harris, A.S.; Farr, W.A. 1974. The forest ecosystem of southeast Alaska: 7. Forest ecology and timber management. Gen. Tech. Rep. PNW-GTR-025. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 116 p.

Harvey, A.E.; Meurisse, R.T.; Geist, J.M.; Jurgensen, M.F.; McDonald, G.I.; Graham, R.T.; Stark, N. 1989. Managing productivity processes in the inland Northwest: mixed conifers and pines. In: Perry, D.A.; Meurisse, R.; Thomas, B.; Miller, R.; Boyle, J.; Means, J.; Perry, C.R.; Powers, R.F., eds. Maintaining long-term forest productivity of Pacific Northwest forest ecosystems. Portland, OR: Timber Press: 164–184.

Hegyi, F.; Jelinek, J.J.; Viszlai, J.; Carpenter, D.B. 1979. Site index equations and curves for major tree species in British Columbia. Forest Inventory Report No. 1, Rev. 1981. Victoria, BC: Ministry of Forests. 59 p.

Helms, J.A., ed. 1998. The dictionary of forestry. Bethesda, MD: The Society of American Foresters. 210 p.

Hennon, P.E.; D'Amore, D.; Wittwer, D.; Caouette, J. 2008. Yellow-cedar decline: conserving a climate-sensitive tree species as Alaska warms. In: Deal, R., ed. Integrated restoration of forested ecosystems to achieve multiresource benefits: Proceedings of the 2007 national silviculture workshop. Gen. Tech. Rep. PNW-GTR-733. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 233–245.

Hennon, P.E.; McClellan, M.H. 2003. Tree mortality and forest structure in the temperate rain forests of southeast Alaska. Canadian Journal of Forest Research. 33(9): 1621–1634.

Hennon, P.E.; Shaw, C.G., III. 1994. Did climatic warming trigger the onset and development of yellow-cedar decline in southeast Alaska? European Journal of Forest Pathology. 24: 399–418.

Hennon, P.; Shaw, C.G., III. 1997. The enigma of yellow-cedar decline: What is killing these defensive, long-lived trees in Alaska? Journal of Forestry. 95(12): 4–10.

Hennon, P.E.; Trummer, L.M. 2001. Yellow-cedar (*Chamaecyparis nootkatensis*) at the northwest limits of its range in Prince William Sound, Alaska. Northwest Science. 75: 61–72.

Heusser, C.J. 1960. Late Pleistocene environments of North Pacific North America. American Geographical Society. Special Publ. 35.

Homer, C. 2007. Completion of the 2001 National Land Cover Database for the Conterminous United States. Photogrammetric Engineering and Remote Sensing. 73: 4: 337–341.

Hungerford, R.D.; Harrington, M.G.; Frandsen, W.H.; Ryan, K.C.; Niehoff, G.J. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A.E.; Neuenschwander, L.F., comps. Proceedings—Management and productivity of western-montane forest soils. Gen. Tech. Rep. INT-280. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 32–50.

Hutchison, O.K. 1968. Alaska's forest resource. Resour. Bull. PNW-RB-019. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 74 p.

Hutchison, O.K.; LaBau, V.J. 1975. The forest ecosystem of southeast Alaska: 9. Timber inventory, harvesting, marketing, and trends. Gen. Tech. Rep. PNW-GTR-034. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 63 p.

Intergovernmental Panel on Climate Change [IPCC]. 2007. Climate change 2007: the physical science basis. In: Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K.B.; Tignor, M.; Miller, H.L., eds. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Jovan, S. 2008. Lichen bioindication of biodiversity, air quality, and climate: baseline results from monitoring in Washington, Oregon, and California. Gen. Tech. Rep. PNW-GTR-737. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 115 p.

Kasischke, E.S.; Stocks, B.J., eds. 2000. Fire, climate change, and carbon cycling in the North American boreal forest. New York: Springer-Verlag. 461 p.

Knops, J.M.H.; Nash, T.H., III; Schlesinger, W.H. 1996. The influence of epiphytic lichens on the nutrient cycling of an oak woodland. Ecological Monographs. 66: 159–179.

Kramer, M.G.; Hansen, A.J.; Taper, M.L.; Kissinger, E.J. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in southeast Alaska. Ecology. 82(10): 2749–2768.

Krumlik, G.J.; Kimmins, J.P. 1973. Studies of biomass distribution and tree form in old virgin forests in the mountains of south coastal British Columbia, Canada. In: Young, H.E., ed. International Union of Forest Research Organizations Biomass Studies. Orono, ME: University of Maine Press: 363–374.

Lamb, M.; Winton, L., comps. 2010. Forest health conditions in Alaska—2009. Protection Report R10-PR21. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region, Forest Health Protection. 73 p.

Langdon, S.J. 2008. The native people of Alaska. 4th ed. Anchorage, AK: Greatland Graphics. 128 p.

Larsen, C.F.; Motyka, R.J.; Arendt, A.A.; Echelmeyer, K.A.; Geissler, P.E. 2007. Glacier changes in southeast Alaska and northwest British Columbia and contribution to sea level rise. Journal of Geophysical Research. 112: F01007, doi:10.1029/2006JF000586.

Larson, F.R.; Winterberger, K.C. 1988. Tables and equations for estimating volumes of trees in the Susitna River Basin, Alaska. Res. Note PNW-RN-478. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Larson, F.R.; Winterberger, K.C. 1990. International board-foot volume tables for trees in the Susitna River Basin, Alaska. Res. Note PNW-RN-495. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p.

Lee, M. 2002. The cooler ring: urban Alaska Native women and the subsistence debate. Arctic Anthropology. 39(1/2): 3–9.

Leighty, W.; Hamburg, S.; Caouette, J. 2006. Effects of management on carbon sequestration in forest biomass in southeast Alaska. Ecosystems. 9: 1051–1065.

Levitt, J. 1980. Responses to plants to environmental stress. Vol.1: Chilling, freezing, and high temperature stresses. 2nd ed. New York: Academic Press. 497 p.

Lewis, S.A.; Wu, J.Q.; Robichaud, P.R. 2006. Assessing burn severity and comparing soil water repellency, Hayman Fire, Colorado. Hydrological Processes. 20: 1–16.

Manning, G.H.; Massie, M.R.C.; Rudd, J. 1984. Metric single-tree weight tables for the Yukon Territory. BC-X-250. Victoria, BC: Environment Canada, Canadian Forestry Service, Pacific Forest Research Centre. 60 p.

Martin, J.R.; Trull, S.J.; Brady, W.W.; West, R.A.; Downs, J.M. 1995. Forest plant association management guide, Chatham Area, Tongass National Forest. R10-TP-57. Juneau, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. [Irregular pagination].

Mater, C. 2000. Alaskan special forest products markets report. In: Laufenberg, T.L.; Brady, B.K., eds. Proceedings: Linking healthy forests and communities through Alaska value-added forest products. Gen. Tech. Rep. PNW-GTR-500. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 127–202.

McCune, B.; Geiser, L.H. 2009. Macrolichens of the Pacific Northwest. 2nd ed. Corvallis, OR: Oregon State University Press. 504 p. ISBN 978-0-87071-565-5.

Molina, R. 2008. Protecting rare, little known, old-growth forest-associated fungi in the Pacific Northwest USA: a case study in fungal conservation. Mycological Research. 112(6): 613–638.

Moore, D.S.; McCabe, G.P. 1989. Introduction to the practice of statistics. New York: W.H. Freeman and Co. 790 p.

Muir, J. A.; Hennon, P.E. 2007. A synthesis of the literature on the biology, ecology and management of western hemlock dwarf mistletoe. Gen. Tech. Rep. PNW-GTR-718. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 141 p.

Newton, R.G.; Moss, M.L. 2005. *Haa atxaayi haa kusteeyix sittee*, our food is our Tlingit way of life: excerpts from oral interviews. R10-MR-30. Juneau, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 55 p.

Nicholls, D. 2007. Recent biomass developments in Alaska. In: Alaska Wood Tides: a newsletter of the Alaska Wood Utilization Research and Development Center. Sitka, AK: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. No. 6.

Nicholls, D.; Miles, T. 2009. Cordwood energy systems for community heating in Alaska—an overview. Gen. Tech. Rep. PNW-GTR-783. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

Nowacki, G.J.; Kramer, M.G. 1998. The effects of wind disturbance on temperate rainforest structure and dynamics of southeast Alaska. Gen. Tech. Rep. PNW-GTR-421. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 25 p.

Nowacki, G.; Spencer, P.; Fleming, M.; Brock, T.; Jorgenson, T. 2002. Unified ecoregions of Alaska: 2001. U.S. Geological Survey Open-File Report 02-297 (map). http://agdc.usgs.gov/data/usgs/erosafo/ecoreg/index.html. (March 8, 2010).

Parrent, D. 2007. Wood energy opportunities for Alaska. Presentation at Alaska wood energy conference. Fairbanks, AK. http://www.tananachiefs.org/natural/forestry/AWEC/Day2/New%20project%20opportunities/Dan_Parrent.pdf. (April 14, 2010).

Pawuk, W.H.; Kissinger, E. 1989. Preliminary forest plant associations: Stikine Area, Tongass National Forest. [Not paged]. Unpublished report. On file with: Beth Schulz, Forestry Sciences Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99503.

Payandeh, B. 1974. Nonlinear site index equations for several major Canadian timber species. The Forestry Chronicle. 50(5): 194–196.

Pearce, D.W. 2001. The economic value of forest ecosystems. Ecosystem Health. 7(4): 284–296.

Peterson, K.; Bruns, J. 2006. Alternative energy for southeast Alaska: biomass fuels: wood-burning boilers save money for homes, schools, and community buildings. Alaska Business Monthly. October.

Pilz, D.; Alexander, A.; Smith, J.; Schroeder, R.; Freed, J. 2006. Nontimber forest product opportunities in Alaska. Gen. Tech. Rep. PNW-GTR-671. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 79 p.

PRISM Climate Group. 2002. Precipitation and temperature models for Alaska, 1961–1990. Corvallis, OR: Oregon State University. http://www.prismclimate.org. (March 13, 2010).

Reynolds, K.M.; Holsten, E.H. 1994. Estimating priorities of risk factors for spruce beetle outbreaks. Canadian Journal of Forest Research. 24: 3027–3033.

Reynolds, K.M.; Holsten, E.H. 1996. Classification of spruce beetle hazard in Lutz and Sitka spruce stands on the Kenai Peninsula, Alaska. Forest Ecology and Management. 84: 251–262.

Reynolds, K.M.; Holsten, E.H. 1997. Sbexpert user guide (Version 2.0): a knowledge-based decision-support system for spruce beetle management. Gen. Tech. Rep. PNW-GTR-401. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 62 p.

Schaberg, P.G.; Hennon, P.E.; D'Amore, D.V.; Hawley, G.J. 2008. Influence of simulated snow cover on the cold tolerance and freezing injury of yellow-cedar seedlings. Global Change Biology. 14: 1282–1293.

Sharnoff, S.; Rosentreter, R. 1998. Lichen use by wildlife in North America. http://www.lichen.com/fauna.html. (July 12, 2010).

Schroeder, R. 2002. Contemporary subsistence use of nontimber forest products in Alaska. In: Jones, E.T.; McLain, R.J.; Weigand, J., eds. Nontimber forest products in the United States. Lawrence, KS: University of Kansas Press: 300–326.

Schulz, B. 2003. Changes in downed and dead woody material following a spruce beetle outbreak on the Kenai Peninsula, Alaska. Res. Pap. PNW-RP-559. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 9 p.

Schulz, B. [In press]. Vegetation diversity. In: Conkling, B. Forest Health Monitoring 2007 National Technical Report. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Schulz, B.K.; Bechtold, W.A.; Zarnoch, S.J. 2009. Sampling and estimation procedures for the vegetation diversity and structure indicator. Gen. Tech. Rep. PNW-GTR-781. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 53 p.

Shaw, D.L., Jr. 1979. Biomass equations for Douglas-fir, western hemlock, and redcedar in Washington and Oregon. In: Forest resource inventories workshop proceedings. Fort Collins, CO: Colorado State University: 763–781. Vol. 11.

Shephard, M.E. 1995. Plant community ecology and classification of the Yukatat Foreland, Alaska. R10-TP-56. Juneau, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 214 p.

Singh, T. 1984. Biomass equations for six major tree species of the Northwest Territories. Inf. Rep. NOR-X-257. Edmonton, AB: Canadian Forestry Service, Northern Forest Research Centre. 21 p.

Smith, W.B.; Miles, P.D.; Perry, C.H.; Pugh, S.A., tech. coords. 2009. Forest resources of the United States, 2007. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 p.

Standish, J.T. 1983. Development of a system to estimate quantity of biomass following logging in British Columbia forest to specified recovery criteria. Project No. 7952, D.S.S. Contract No. OSB80-0001. Vancouver, BC: Talisman Land Resource Consultants. 68 p. + appendices.

Tart, D.; Williams, C.; DiBendedetto, J.; Crow E.; Girard, M.; Gordon, H.; Sleavin, K.; Manning, M.; Haglund, J.; Short, B.; Wheeler, D. 2005. Section 2: existing vegetation classification protocol. In: Brohman, R.; Bryant, L., eds. Existing vegetation classification and mapping guide. Gen. Tech. Rep. WO-67. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff: 2-1–2-34.

Taylor, R.F. 1934. Yield of second-growth western hemlock-Sitka spruce stands in southeast Alaska. Tech. Bull. 412. Washington, DC: U.S. Department of Agriculture. 29 p.

Turner, M.G.; Romme, W.H.; Gardner, R.H. 1999. Prefire heterogeneity, fire severity, and early postfire plant reestablishment in subalpine forests of Yellowstone National Park, Wyoming. International Journal of Wildland Fire. 9(1): 21–36.

U.S. Census Bureau. 2009. Population estimates. http://www.census.gov/popest/estimates.html (August 3, 2010).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2000. Alaska Region interim special forest products resource management policy. Juneau, AK: Alaska Region. 7 p.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2006. Forest Inventory and Analysis glossary. On file with: Pacific Northwest Forest Inventory and Analysis program, 620 SW Main Street, Suite 400, Portland, OR 97205.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2007. Sale and disposal of National Forest System timber; special forest products and forest botanical products, 0596-AB81; Proposed rule; request for comment. 72 Federal Register 203: 59496–59506.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2008a. Forest Inventory and Analysis national core field guide: field methods for phase 3 measurements. Version 4.0. Vegetation diversity and structure. On file with: USDA Forest Service, Forestry Sciences Laboratory, 3041 Cornwallis Rd., Research Triangle Park, NC 27709. http://www.fia.fs.fed.us/library/field-guides-methods-proc/. (April 19, 2010).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2008b. Tongass land and resource management plan, final environmental impact statement, plan amendment, Volume 1. R10-MB-603c. Juneau, AK: Region 10 [Alaska Region]. 882 p. (+ volume II—appendices).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2000. The PLANTS Database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. http://plants.usda.gov. (April 12, 2010).

U.S. Department of Commerce, Bureau of Economic Analysis [USDC BEA]. 2007. Regional accounts data. www.bea.gov/bea/regional/quick.cfm. (November 14, 2008).

U.S. Department of the Interior, U.S. Geological Survey [USGS]. 1999. National elevation data set. Sioux Falls, SD: U.S. Geological Survey, EROS Data Center. eros.usgs.gov. (July 23, 2010).

van Hees, W.W.S. 1987. Effects of recent national legislation on ownership of timberland resources in southeast Alaska. Res. Note PNW-RN-469. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 12 p.

van Hees, W.W.S. 1988. Timber productivity of seven forest ecosystems in southeastern Alaska. Res. Pap. PNW-RP-391. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 10 p.

van Hees, W.W.S. 2003. Forest resources of southeast Alaska, 2000: results of a single-phase systematic sample. Res. Pap. PNW-RP-557. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 96 p.

van Hees, W.W.S. 2005a. Spruce reproduction dynamics on Alaska's Kenai Peninsula. 1987–2000. Res. Pap. PNW-RP-563 Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

van Hees, W.W.S. 2005b. Timber resource statistics of south-central Alaska, 2003. Resour. Bull. PNW-RB-248. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

van Hees, W.S.; Larson, R.F. 1991. Timberland resources of the Kenai Peninsula, Alaska, 1987. Tech. Rep. R10-TP-123. Portland, OR: U.S. Department of Agriculture, Forest Service, Alaska Region. 56 p.

Viereck, L.A.; Dyrness, C.T.; Batten, A.R.; Wenzlick, K.J. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 278 p.

Viereck, L.A.; Little, E.L., Jr. 2007. Alaska trees and shrubs. 2nd ed. Fairbanks, AK: University of Alaska Press. 359 p.

Werner, R.A. 1994. Forest insect research in boreal forests of Alaska: trends in agricultural sciences-entomology. Council of Scientific Research Integration. Entomology. 2: 35–46.

Werner, R.A. 1996. Forest health in boreal ecosystems of Alaska. The Forestry Chronicle. 72(1): 43–46.

Werner, R.A.; Holsten, E.H. 1985. Factors influencing generation times of spruce beetles in Alaska. Canadian Journal of Forest Research. 15: 438–443.

Wiles, G.C.; D'Arrigo, R.D.; Jacoby, G.C. 2004. Gulf of Alaska atmosphere-ocean variability over recent centuries inferred from coastal tree ring records. Climatic Change. 38(3): 289–306.

Wolfe, R. 2008. Global warming and carbon sequestration—a future for Sealaska? Presentation at 8th annual conference on carbon capture and sequestration. Anchorage, AK. http://westcarb.org/Anchorage_pdfs/Wolfe_SE-AK-Forest%20Carbon.pdf. (April 14, 2010).

Woolwine, P.A. 2003. Summary information on access to nontimber forest products on federal lands in Alaska. In: Alaska Boreal Forest Council, comps. Proceedings: hidden forest values. The first Alaska-wide nontimber forest products conference and tour. Gen. Tech. Rep. PNW-GTR-579. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 38–40.

Youngblood, A.; Cole, E.C. 2003. White spruce and moose enhancement project [Brochure]. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Appendix 1: Inventory Methods and Design

Field Design and Sampling Method

Data used in this report came from two inventories conducted by the Forest Inventory and Analysis (FIA) program of the Pacific Northwest Research Station (PNW).[1] The first inventory (the "periodic inventory") includes data from southeast Alaska collected between 1995 and 2001 and data from south-central Alaska collected between 1999 and 2003. The second inventory (the "annual inventory") includes data from 2004 through 2008 for both the southeast and south-central areas, which were combined into a single coastal Alaska inventory unit. Most, but not all, of the plots in the second inventory were remeasurements of plots established during the first inventory. However, there were some differences in sampling design and inventory methods that are discussed in the following sections. All estimates of current (2004–08) conditions in this report are produced with the annual inventory, with the exception of mistletoe (*Arceuthobium tsugense*), which used the 1995 through 2003 inventory. All estimates of change were produced with the remeasured plots in both inventories.

The Annual Inventory

In the 2004 through 2008 annual inventory system in coastal Alaska, a random subsample of 10 percent of the plots in the inventory unit is measured each year. This annual subsample is referred to as a panel. Because there are very few roads in the coastal Alaska region, most plots must be accessed by a helicopter/boat combination. Owing to limitations on the use of helicopters, Glacier Bay National Park and wilderness areas in the Chugach and Tongass National Forests are currently excluded from the inventory (see fig. 2). With those exceptions, the plots measured in a single panel span all forest land in the inventory unit, including all public and privately owned forests. One panel of data was collected from wilderness areas in the national forests in 2005 and was used in this report.

Estimates of forest attributes made from a single panel are 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 from 2004 to 2008 were combined to produce most of the statistics in this report. One extra panel of plots was collected and used for this report on the Kenai National Wildlife refuge. When all panels have been measured once (2013), panels will be remeasured, creating a 10-year remeasurement interval.

The PNW-FIA program collects information in three phases. In phase 1, the area in the inventory unit is interpreted from remotely sensed imagery, classifying land into broad relatively homogenous groups. 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, one of every 16 phase 2 field plots is visited and a variety of forest health measurements are taken.

Phase 1

The goal of phase 1 is to reduce the variance associated with estimates of various forest attributes. For the phase 1 interpretation of the coastal Alaska unit, we used the National Land Cover Dataset 2001 (Homer et al. 2007) to stratify the land by forest, water, and nonforest and by canopy density class within forest land. We also incorporated an elevation grouping from Digital Elevation Models (USGS 1999), broad ownership information from a variety of sources, and climate data representing a spatial model of 1961 through 1990 average annual temperature and precipitation (PRISM Climate Group 2002). The resulting strata are evaluated for each estimation unit, 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. Because of the statistical methods used, misclassification errors in the phase 1 data may cause imprecision but do not create bias in the estimators used. More information on sample design and estimators is available in Bechtold and Patterson (2005).

[1] The Forest Inventory and Analysis unit is now part of the Resource Monitoring and Assessment Program at the Pacific Northwest Research Station.

Phase 2

Phase 2 plots are a systematic sample with a random component selected from the entire area within the inventory unit, including both land and water. Plots are visited in the field if an air photo indicates that they might contain forest. The plot installed at each forested phase 2 location is a cluster of four subplots spaced 120 feet apart (fig. 64). Subplot 1 is in the center, with 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.).

Field crews delineate areas that are relatively homogenous by using (1) reserved status, (2) owner group, (3) forest type, (4) stand size class, (5) regeneration status, and (6) 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, and vertical crown dimensions. They also collect general descriptive information such as proximity to roads, and the geographic position of the plot in the larger landscape.

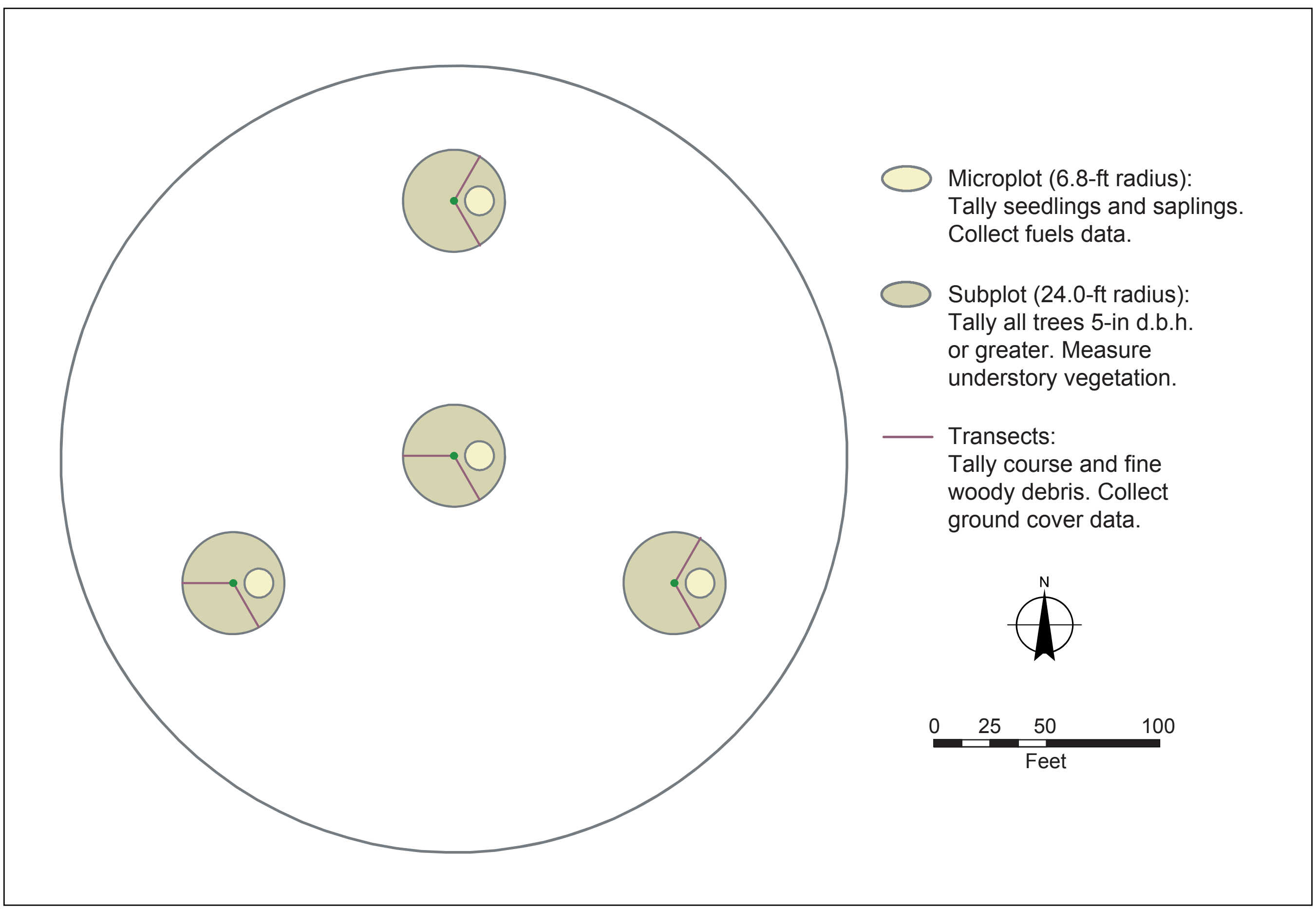


Figure 64—The Forest Inventory and Analysis plot design used in the Alaska annual inventory, 2004–2008; d.b.h. = diameter at breast height.

The PNW-FIA program measured 1,193 forested phase 2 plots in Alaska between 2004 and 2008. Estimates of tree biomass 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 Alaska. Estimates of growth, removals, and mortality were determined from measurements taken at a subset of 975 forested plots that were also measured during the 1994 through 2003 periodic inventory.

Phase 3

Some additional forest health measurements are collected on a subset (1/16) of phase 2 sample locations. At the phase 3 plots, measurements are taken on tree crowns, lichens, downed woody material, and understory vegetation, in addition to the phase 2 variables. Although one half of the phase 3 plots were not scheduled to be visited until 2009 through 2013, we accelerated the measurement schedule for phase 3 plots and visited the full 1/16 subsample between 2003 and 2008. This provided 135 forested phase 3 plots in the coastal Alaska inventory unit. One forest health measurement, ozone injury, was monitored in 2004 and 2005 with four specially selected plots near Anchorage and Juneau; no ozone injury was detected. 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

Almost all of the FIA variables collected in Alaska are identical to those collected by FIA elsewhere in the United States—these are national "core" or "core optional" variables. Core optional, as the name suggests, are variables that are optional for any state but, if collected, must be collected using the standard national method. A small number of other variables are unique to PNW-FIA. These are "regional" variables and include such items as the species and cover of any invasive plants found on the plot and some variables used to help link measurements between the periodic and annual inventories. The database and documentation of variables used in this report are available from the Web site http://fiatools.fs.fed.us/fiadb-downloads/datamart.html. Field manuals can also be useful for understanding how variables were collected and are available in electronic form from http://www.fs.fed.us/pnw/fia/publications/fieldmanuals.shtml.

Data Processing

The annual data used for this report are stored in the FIA National Information Management System (NIMS). It provides a means to input, edit, process, manage, and distribute FIA data. The NIMS 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 compute calculated attributes, a table report generator, and routines to populate the presentation database. The NIMS applies numerous algorithms and equations to calculate, for example, stocking, forest type, stand size, volume, and biomass. The NIMS generates estimates and associated statistics based on the combined phase 1 and phase 2 information. Additional FIA statistical design and estimation techniques are further reviewed in Bechtold and Patterson (2005).

Periodic Inventory

The periodic inventory (1995–2003) of southeast and south-central Alaska used the same plot layout as the annual inventory with the exception of the microplot used to measure trees less than 5 inches d.b.h. This microplot was located at subplot center in the periodic inventory and was offset in the annual inventory, resulting in no remeasurement information for trees less than 5 inches d.b.h.

The periodic inventory differed from the annual inventory in not being a paneled inventory. Instead, data collection began in 1995 in southeast Alaska, and gradually moved up the coast finishing in south-central Alaska in 2003. Although most estimates of change were converted to annual values before being used to calculate change, in general the time period between measurements was greater in southeast Alaska than in south-central Alaska.

There were also some differences in the sampling methods. Although both inventories used a spatially balanced design to locate samples, plots are located by using hexagons in the current inventory but were located within a gridded area in the periodic inventory. This resulted in some of the periodic plots being dropped in the annual inventory and reduced the number of remeasured plots available for analysis. In addition, Kodiak Island was sampled at 50 percent intensity in the periodic inventory, resulting in less information about change for that area.

The forest-land definition changed between the periodic and annual inventories, as did a number of items affecting the definition of a tree. These changes in definition had a profound effect on being able to detect change. Forestation (when nonforest land becomes forested) and deforestation (when forested land is converted to nonforest) are indistinguishable from procedural differences. This also means that real differences in carbon, biomass, numbers of trees, and other estimates produced from plots that were in both inventories are masked by procedural differences in the definition of forest land.

We have attempted to compensate for these problems by limiting analysis to plots and portions of plots that were classified as forest in both inventories. Thus reported change applies to land that was considered forest by using one definition in 1995 through 2003 and by using a different definition of forest land in 2004 through 2008. To develop an approximate estimate of land area reverting to or diverting from forest, an experienced field crew person did review each change between forest and nonforest that occurred at the center of each remeasured subplot to categorize whether the change had been caused by real or procedural differences. Although this allowed an approximation for forest area change, no attempt to quantify volume, biomass, forest type, or carbon change associated with reversions and diversions was possible.

Estimates produced from the periodic inventory data used in this report will differ slightly from those reported in van Hees (2003, 2005) for additional reasons. Errors in species identification or d.b.h. made at the first visit to the plot were often correctable at the second measurement. Additional errors found, such as missing data and misidentification of ownership or reserve status for a few plots and imprecise metric-to-English conversions for small trees were also corrected before using the periodic data. A substantial change to the definition of forest type, and slight alterations to site index, volume, and biomass equations, were also made to match methods in the annual inventory. New information on boundaries and ownership was incorporated into the annual inventory.

Change calculation used the Beers and Miller (1964) method, which is the method currently used by the national FIA program.[2] It fixes the inclusion probability of trees at time 1, or as they were measured in the periodic inventory. Change by ownership category, forest type, or site class are also reported by the category assigned in the periodic inventory. Because plots that were inaccessible during either the periodic or the annual inventory are not included in change calculations, the potential for bias from missing data is higher than for current (2004–08) estimates.

Site Index, Volume, and Biomass Estimates

Site index is used to measure potential productivity of forest land and to distinguish timberland from forest land. For Pacific silver fir, subalpine fir, Sitka spruce, western hemlock, and mountain hemlock (See “Common and Scientific Names”) more than 200 years of age, site index curves from Hegyi et al. (1979) were used. For trees of these species less than 200 years old, a site index equation was fitted to data from Taylor (1934) by using data from Payandeh (1974). For yellow-cedar, lodgepole pine, western redcedar, paper birch, aspen, and red alder, Hegyi et al. (1979) was used. For white spruce and black spruce, Farr (1967) was used.

Volume equations used include Bracket (1973), DeMars (1996a and 1996b), Embry and Haack (1965), Larson and Winterberger (1988, 1990), and Bruce (1984). Application to individual trees differed depending on the height class and diameter class of the tree and what type of volume (cubic foot, Scribner board foot, international board foot) was being estimated. For application to specific cases, contact the FIA office.

[2] PNW-FIA is one of four regional programs within the national FIA program.

Biomass calculations come from direct biomass equations, as shown in the following tablulation.

Tree type	Biomass citation
Seedlings	Alemdag (1984)
Balsam popular	Singh (1984)
Birch	Alemdag (1984)
Black spruce	Manning et al. (1984)
Cottonwood	Singh (1984)
Lodgepole pine	Manning et al. (1984)
Mountain hemlock	Shaw (1979)
Pacific silver fir	Krumlik and Kimmins (1973)
Red alder	Standish (1983)
Sitka spruce	Standish (1983)
Tamarack	Singh (1984)
Western hemlock	Shaw (1979)
Western redcedar	Shaw (1979)
White spruce	Manning et al. (1984)
Yellow-cedar	Standish (1983)

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 SE 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 2, we estimated the total forest area in the coastal Alaska inventory unit to be 15.301 million acres, with a SE of 0.268 million acres. A 95-percent confidence interval for the total forest area ranges from 14.765 to 15.837 million 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 are assumed to be nearly uncorrelated, the standard error 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, table 44 in appendix 2 contains estimates of tree volume by diameter class. If one wants to compare the volume of trees in the diameter class 9.0 to 10.9 d.b.h. with that of trees in the diameter class 21.0 to 22.9 d.b.h., the covariance between the estimates is not zero, and this equation should not be used. For more complex and indepth analysis, the reader may contact the PNW-FIA.

All estimates—means, totals and their associated SE—are based on the poststratification methods described in detail 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"). In coastal Alaska, it is common to have plots that are temporarily inaccessible owing to snow presence at the time that the boat is in that section of the coast.

Many of the plots that were inaccessible owing to snow in 2003 through 2008 were measured in 2009, owing to an unusually mild winter and warm summer, but were not able to be included in this report. Coastal Alaska also has many areas with extreme topography that can be very hazardous or impossible to reach, and plots in those areas will never be field measured.

This kind of missing data can introduce bias into the estimates if the nonsampled plots tend to be different from the entire population. The field crew rarely visit plots that are nonforested, and, therefore, the proportion of denied-access, hazardous, or inaccessible plots is significantly smaller for them 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 nonsampled proportion within each stratum. To reduce the possible bias introduced by nonsampled plots, the phase 1 data are used to group plots in similar climate, vegetation, and ownership strata. Table 29 in appendix 2 shows the estimated land area in the categories of denied-access, temporarily inaccessible, and hazardous/inaccessible plots that were scheduled to be measured in 2004 through 2008.

By inventory subunit, 80 percent of plots (four panels) in the Chugach and Tongass National Forest Wilderness and Wilderness study areas were nonsampled, 100 percent of plots in Glacier Bay National Park and Preserve were nonsampled, and 1.3 percent of plots in the remaining coastal inventory area were nonsampled (table 29). Because no information was available for Glacier Bay National Park and Preserve, that area of land was excluded from all estimates throughout this report.

For the Tongass and Chugach National Forest wilderness and wilderness study areas, the 2005 panel of plots was used in some summary estimates. The process of stratification redistributed the 6.188 million unsampled acres to the sampled area, resulting in an estimate of 4.057 million forested acres and 5.806 million nonforested acres in the national forest wilderness areas. Because the ratio of plots to land area is very low (one plot per 58,000 acres), all estimates produced for the national forest wilderness are very imprecise.

Appendix 2: Summary Data Tables

The following tables contain basic information about the forest resources of southeast and south-central Alaska. The tables aggregate data to a variety of levels (owner, forest type), along the Pacific Northwest Research Station Forest Inventory and Analysis (FIA) inventory results to be applied at various scales and used for various anises. Many other tables could be generated from the FIA data but are not included here because of limited space. Data are also available in nonsummarized form at http://www.fia.fs.fed.us.

The national FIA Web site (http://www.fia.fs.fed.us/tools-data) contains some tools for querying the coastal Alaska annual data and generating custom tables or maps. Some of the tables in this appendix contain summaries of regional variables; data for regional variables are not currently included in the national FIA database (FIADB) but can be requested from the regional FIA office http://www.fs.fed.us/pnw/fia/.

Please note that information in tables presented here and those generated from the 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., 2004–2009, 2004–2010, etc.), whereas tables in this publication contain only data from 2004 through 2008. The user can take a snapsot of data from FIADB by selecting the desired years and generating tables that are similar, but probably not identical, to those presented here.

List of Tables in Appendix

Table 29—Number of Forest Inventory and Analysis plots by inventory subunit and measurement status, coastal Alaska, 2004–2008[a]

Inventory subunit and measurement status	Plots	Area
	Number	*Acres*
Coastal inventory area:		
Accessible		
Forest	1,050	13,723,099
Nonforest	3,128	36,413,062
Total accessible	4,178	50,136,161
Inaccessible		
Denied access	3	34,793
Hazardous	22	241,947
Delayed access (weather)	30	348,956
Total inaccessible	55	625,696
Total coastal inventory area	4,233	50,761,857
Tongass and Chugach Wilderness and Wilderness Study Areas:		
Accessible, 2004 panel		
Forest	53	752,509
Nonforest	87	1,191,530
Total accessible	140	1,944,039
Inaccessible, 2004 panel	4	42,088
Unknown, 2005–2008 plots dropped from the inventory	554	6,146,356
Total—Tongass and Chugach Wilderness	698	8,132,484
Glacier Bay National Park and Preserve:		
Unknown, 2004–2008 plots dropped from the inventory	282	2,694,819
Total for all categories	5,213	61,589,160

[a] Totals in this table will not match other tables that follow. During the process of stratification, acres associated with inaccessible plots and dropped plots (excluding Glacier Bay, which is not included in this report) are redistributed across measured plots.

Table 30—Estimated area by land class, owner group, and reserved component, coastal Alaska, 2004–2008[a]

	Timberland[b]		Other forest land[c]		Total forest land		Nonforest land		Noncensus water		Census water		All land	
Owner group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
							Thousand acres							
National forest:														
All	3,747	155	7,034	268	10,781	253	—	—	—	—	—	—	10,781	253
Reserved	—	—	4,123	232	4,123	232	—	—	—	—	—	—	4,123	232
Other federal:														
All	68	27	1,240	61	1,308	65	—	—	—	—	—	—	1,308	65
Reserved	—	—	1,168	55	1,168	55	—	—	—	—	—	—	1,168	55
State and local	879	84	453	67	1,331	90	—	—	—	—	—	—	1,331	90
Private	1,481	102	399	63	1,880	106	—	—	—	—	—	—	1,880	106
All owners	6,174	185	9,126	287	15,301	268	22,483	267	90	24	16,539	152	37,783	183

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

[a] Area includes wilderness in the Tongass and Chugach National Forests and excludes Glacier Bay National Park.

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

[c] 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.

Table 31—Estimated area of forest land by owner group, reserved status, and forest type, coastal Alaska, 2004–2008[a]

	U.S. Forest Service						Other federal											
	Reserved		Nonreserved		Total		Reserved		Nonreserved		Total		State and local		Private		All land	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
									Thousand acres									
Softwoods:																		
Alaska yellow-cedar	995	208	1,239	111	2,233	235	—	—	—	—	—	—	54	24	68	26	2,355	237
Black spruce	—	—	1	1	1	1	407	49	15	13	422	51	24	17	52	25	499	59
Lodgepole pine	20	16	356	59	377	60	—	—	—	—	—	—	37	19	31	18	445	66
Mountain hemlock	1,333	231	1,410	110	2,743	255	75	27	35	20	110	33	143	40	166	42	3,162	263
Sitka spruce	319	115	615	80	933	139	23	16	3	3	25	16	450	58	549	66	1,957	164
Western hemlock	988	197	2,352	136	3,340	236	—	—	16	14	16	14	219	47	396	62	3,971	245
Western redcedar	382	131	550	70	932	148	—	—	—	—	—	—	43	21	65	28	1,040	152
White spruce	—	—	24	15	24	15	223	39	9	11	232	40	62	26	129	38	447	63
Total	4,036	236	6,556	145	10,592	256	728	57	77	29	805	63	1,031	85	1,457	100	13,885	273
Hardwoods:																		
Aspen	—	—	—	—	—	—	123	32	—	—	123	32	3	3	37	21	163	38
Cottonwood	86	63	61	26	147	68	110	33	31	17	140	37	126	38	118	36	532	93
Paper birch	—	—	12	12	12	12	203	36	33	20	235	41	112	36	242	50	601	74
Total	86	63	103	33	189	71	435	55	63	26	498	61	241	51	397	62	1,325	121
Nonstocked	—	—	—	—	—	—	5	6	—	—	5	6	60	26	26	17	90	31
Total	4,123	232	6,658	146	10,781	253	1,168	55	140	39	1,308	65	1,331	90	1,880	106	15,301	268

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

[a] Area includes wilderness in the Tongass and Chugach National Forests and excludes Glacier Bay National Park.

Table 32—Estimated area of timberland by owner group and forest type, coastal Alaska, 2004–2008

Forest type	U.S. Forest Service Total	U.S. Forest Service SE	Other federal Total	Other federal SE	State and local Total	State and local SE	Private Total	Private SE	All owners Total	All owners SE
	Thousand acres									
Softwoods:										
Alaska yellow-cedar	323	61	—	—	12	11	14	11	350	62
Black spruce	—	—	—	—	24	17	19	15	43	23
Lodgepole pine	45	19	—	—	30	18	—	—	75	27
Mountain hemlock	298	56	—	—	56	25	29	17	383	63
Sitka spruce	553	76	3	3	305	54	541	65	1,402	113
Western hemlock	2,061	130	16	14	196	45	366	61	2,639	147
Western redcedar	379	62	—	—	11	12	17	15	407	64
White spruce	17	14	9	11	41	21	109	35	176	44
Total	3,677	154	28	18	676	77	1,096	90	5,477	181
Hardwoods:										
Aspen	—	—	—	—	—	—	37	21	37	21
Cottonwood	39	21	31	17	96	33	118	36	284	55
Paper birch	—	—	10	11	58	26	204	46	272	53
Total	69	26	41	20	154	42	359	59	624	77
Nonstocked	—	—	—	—	48	23	26	17	74	29
Total	3,747	155	68	27	879	84	1,481	102	6,174	185

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

Table 33—Estimated area of forest land, by forest type and stand size class, coastal Alaska, 2004–2008

Forest type	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:								
Alaska yellow-cedar	1,816	217	116	55	423	100	2,355	237
Black spruce	23	14	63	26	413	54	499	59
Lodgepole pine	146	41	53	20	247	48	445	66
Mountain hemlock	2,269	224	155	49	738	144	3,162	263
Sitka spruce	1,401	150	171	43	382	63	1,957	164
Western hemlock	3,523	235	50	25	399	84	3,971	245
Western redcedar	979	150	—	—	61	25	1,040	152
White spruce	71	27	141	35	235	49	447	63
Total	10,227	256	752	100	2,902	214	13,885	273
Hardwoods:								
Aspen	37	18	39	19	87	29	163	38
Cottonwood	300	55	142	68	90	30	532	93
Paper birch	232	48	220	47	149	41	601	74
Total	569	74	431	86	326	57	1,325	121
Nonstocked	—	—	—	—	—	—	90	31
Total	10,796	262	1,183	130	3,227	219	15,301	268

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

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

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

[c] Stands in which the majority of trees are less than 5.0 inches d.b.h.

Table 34—Estimated area of forest land, by forest type and stand age class, coastal Alaska, 2004–2008

	Stand age class (years)[a]											
	1–20		21–40		41–60		61–80		81–100		101–120	
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres											
Softwoods:												
Alaska yellow-cedar	—	—	23.9	14.9	—	—	12.5	11.5	10.4	11.4	11.7	11.2
Black spruce	—	—	76.5	25.4	109.0	31.1	87.2	28.7	75.5	25.5	99.8	30.9
Lodgepole pine	10.9	9.6	7.8	10.0	5.8	7.5	42.2	19.0	18.8	14.6	7.0	9.4
Mountain hemlock	95.7	70.2	48.0	46.8	89.1	57.2	110.6	67.2	167.4	43.1	173.0	70.1
Sitka spruce	182.4	41.9	201.8	48.0	168.2	43.4	161.4	41.5	206.6	46.4	148.7	61.0
Western hemlock	177.6	44.2	201.4	47.1	43.6	23.7	31.5	19.4	44.4	20.4	171.1	43.7
Western redcedar	17.4	14.5	5.9	8.9	—	—	—	—	13.1	12.5	20.7	14.4
White spruce	9.1	10.8	49.0	22.8	151.9	38.0	99.6	31.8	40.3	20.0	51.9	22.8
Total	493.1	92.9	619.7	90.8	567.6	89.7	545.1	94.2	576.5	76.9	687.6	110.6
Hardwoods:												
Aspen	12.1	12.4	30.3	16.5	32.1	17.3	35.3	18.9	21.1	14.3	25.1	14.5
Cottonwood	10.7	7.6	134.0	66.6	168.6	43.3	86.8	31.3	62.0	25.5	27.5	17.2
Paper birch	—	—	56.0	24.1	58.6	25.3	99.9	33.1	124.4	36.1	131.7	36.8
Total	22.8	14.6	239.7	74.0	262.2	53.1	222.0	49.3	207.6	46.2	184.4	42.9
Nonstocked	—	—	—	—	—	—	—	—	—	—	—	—
Total	515.8	94.0	859.4	116.4	829.8	103.7	767.1	105.7	784.1	89.0	872.0	118.2

	Stand age class (years)[a]										All accessible forest land	
	121–140		141–160		161–180		181–200		201+			
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres											
Softwoods:												
Alaska yellow-cedar	82.1	29.7	162.3	71.0	298.9	101.5	75.2	28.6	1,677.8	210.8	2,354.7	237.2
Black spruce	41.9	20.9	9.3	9.0	—	—	—	—	—	—	499.2	59.3
Lodgepole pine	27.5	17.1	32.0	19.1	43.6	20.7	28.6	16.6	221.0	48.6	445.2	65.5
Mountain hemlock	336.1	117.6	258.6	77.0	215.5	74.1	289.4	78.8	1,378.2	170.9	3,161.7	263.3
Sitka spruce	124.5	37.7	168.9	43.2	90.6	31.7	60.3	26.9	443.7	111.5	1,957.1	163.9
Western hemlock	135.9	40.1	135.1	39.7	323.3	98.3	320.8	81.9	2,386.3	213.7	3,970.9	244.7
Western redcedar	15.2	12.3	64.8	47.3	74.2	29.1	144.6	40.7	684.1	137.9	1,040.1	151.8
White spruce	12.8	11.1	15.4	12.1	17.0	13.7	—	—	—	—	447.0	62.8
Total	775.9	136.3	846.4	130.7	1,063.2	164.7	918.8	125.7	6,791.2	285.7	13,885.0	272.8
Hardwoods:												
Aspen	6.6	8.1	—	—	—	—	—	—	—	—	162.7	38.4
Cottonwood	10.7	11.6	15.7	14.1	—	—	—	—	15.9	12.5	532.0	92.9
Paper birch	69.9	26.8	40.5	22.3	13.0	9.8	—	—	6.6	8.1	600.6	74.0
Total	87.3	30.2	63.8	27.3	13.0	9.8	—	—	22.5	14.9	1,325.3	120.7
Nonstocked	—	—	—	—	—	—	—	—	—	—	90.3	31.4
Total	863.2	139.3	910.2	133.4	1,076.2	165.0	918.8	125.7	6,813.7	285.9	15,300.6	267.6

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

[a] The age of the stand is unknown on some plots because no trees were available for boring.

Table 35—Estimated area of timberland by owner group and stand size class, coastal Alaska, 2004–2008

Stand size class	U.S. Forest Service Total	U.S. Forest Service SE	Other federal Total	Other federal SE	State and local Total	State and local SE	Private Total	Private SE	All owners Total	All owners SE
					Thousand acres					
Seedling and sapling	251	50	18	13	145	40	579	73	993	97
Poletimber	150	40	—	—	83	30	149	40	382	64
Sawtimber	3,330	145	50	24	571	72	662	76	4,613	170
Nonstocked	16	10	—	—	79	29	91	32	186	44
All classes	3,747	155	68	27	879	84	1,481	102	6,174	185

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

Table 36—Estimated area of forest land, by forest type and productivity class, coastal Alaska, 2004–2008

	Site productivity class (cubic feet per acre per year)[a]														All productivity classes	
	0–19		20–49		50–84		85–119		120–164		165–224		225+			
Forest type	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
								Thousand acres								
Softwoods:																
Alaska yellow-cedar	1,631	198	553	114	170	89	—	—	—	—	—	—	—	—	2,355	237
Black spruce	272	47	211	43	16	11	—	—	—	—	—	—	—	—	499	59
Lodgepole pine	370	61	67	26	8	5	—	—	—	—	—	—	—	—	445	66
Mountain hemlock	2,549	250	560	120	53	23	—	—	—	—	—	—	—	—	3,162	263
Sitka spruce	102	33	468	82	805	119	292	57	228	68	33	20	29	18	1,957	164
Western hemlock	577	125	1,416	161	1,576	174	286	57	107	35	—	—	9	9	3,971	245
Western redcedar	393	101	429	102	218	73	—	—	—	—	—	—	—	—	1,040	152
White spruce	105	32	234	46	100	31	9	9	—	—	—	—	—	—	447	63
Total	6,009	320	3,937	254	2,946	219	587	82	335	77	33	20	37	21	13,885	273
Hardwoods:																
Aspen	15	11	102	32	45	21	—	—	—	—	—	—	—	—	163	38
Cottonwood	22	16	121	35	209	47	150	69	20	15	9	11	—	—	532	93
Paper birch	174	43	284	53	110	31	21	16	—	—	—	—	12	13	601	74
Total	211	48	523	69	379	61	171	71	20	15	9	11	12	13	1,325	121
Nonstocked	11	12	26	16	42	23	—	—	11	12	—	—	—	—	90	31
Total	6,232	323	4,486	261	3,367	227	758	107	366	79	42	23	50	25	15,301	268

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

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

Table 37—Estimated area of timberland by owner group and cubic foot site class, coastal Alaska, 2004–2008

Site class[a]	U.S. Forest Service Total	U.S. Forest Service SE	Other federal Total	Other federal SE	State and local Total	State and local SE	Private Total	Private SE	All owners Total	All owners SE
$ft^3 \cdot ac^{-1} \cdot yr^{-1}$					*Thousand acres*					
20–49	1,910	133	21	14	445	67	579	74	2,955	161
50–84	1,240	111	35	19	323	57	666	76	2,263	144
85–119	365	65	—	—	62	27	173	44	600	82
120–164	162	43	12	12	27	18	63	28	264	55
All classes	3,747	155	68	27	879	84	1,481	102	6,174	185

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

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

Table 38—Estimated area of timberland by forest type and stand size class, coastal Alaska, 2004–2008

Forest type	Seedling and sapling		Poletimber		Sawtimber		Nonstocked		All stand size classes	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand acres									
Softwoods:										
Alaska yellow-cedar	6	6	—	—	344	62	—	—	350	62
Black spruce	28	18	15	14	—	—	—	—	43	23
Lodgepole pine	67	26	2	2	4	3	3	3	75	27
Mountain hemlock	23	16	10	11	343	60	8	7	383	63
Sitka spruce	269	54	133	38	942	95	58	24	1,402	113
Western hemlock	300	57	47	24	2,271	137	21	15	2,639	147
Western redcedar	22	15	—	—	385	62	—	—	407	64
White spruce	105	35	37	19	25	17	10	11	176	44
Total	820	88	243	52	4,313	164	100	31	5,477	181
Hardwoods:										
Aspen	37	21	—	—	—	—	—	—	37	21
Cottonwood	43	20	56	26	174	43	12	12	284	55
Paper birch	93	33	53	24	126	38	—	—	272	53
Total	173	44	139	39	300	56	12	12	624	77
Nonstocked	—	—	—	—	—	—	74	29	74	29
Total	993	97	382	64	4,613	170	186	44	6,174	185

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

Table 39—Estimated number of live trees on forest land, by species and diameter class, coastal Alaska, 2004–2008

	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	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand trees															
Softwoods:																
Alaska yellow-cedar	782,923	121,669	202,655	31,436	117,281	14,606	76,215	9,509	58,380	7,828	38,639	4,552	29,857	4,414	19,013	2,639
Black spruce	463,328	60,750	119,980	17,977	24,177	4,749	2,882	899	283	163	77	67	—	—	—	—
Lodgepole pine	114,308	25,601	38,760	8,837	22,686	2,842	15,838	1,924	13,231	2,454	9,568	2,059	5,758	1,463	1,820	413
Mountain hemlock	661,742	72,991	355,995	50,101	188,735	18,347	128,244	12,649	93,653	11,218	59,704	6,492	42,801	4,348	31,583	4,152
Sitka spruce	443,293	53,818	151,498	17,243	95,776	8,919	65,033	5,844	48,619	3,991	34,761	3,551	29,226	2,820	22,992	2,135
Western hemlock	1,379,355	101,783	476,716	36,852	280,680	16,073	181,420	10,471	122,191	6,884	81,630	5,236	56,760	3,564	36,346	2,513
Western redcedar	192,755	35,793	55,570	14,251	32,900	4,466	24,757	3,685	18,540	3,116	16,514	2,545	10,986	2,249	8,302	1,655
White spruce	148,497	28,419	71,456	13,158	35,679	4,283	19,156	2,123	7,963	1,215	4,077	672	1,258	335	638	261
Other softwood	508	706	—	—	623	296	294	150	47	61	62	69	155	110	93	85
Total	4,186,709	225,235	1,472,630	74,569	798,538	30,050	513,838	19,974	362,907	15,123	245,032	10,255	176,802	7,947	120,788	5,924
Hardwoods:																
Black cottonwood	58,007	23,397	20,089	6,655	9,270	2,354	12,188	5,240	6,966	1,770	4,233	1,220	4,421	1,251	2,732	657
Paper birch	109,125	27,746	31,665	9,579	17,476	3,621	12,511	2,247	9,232	1,588	5,786	951	2,378	509	1,744	529
Quaking aspen	25,095	13,644	2,869	2,195	3,010	1,331	2,477	1,110	2,621	1,203	2,331	761	1,003	323	357	156
Red alder	10,639	4,336	14,945	6,550	9,093	2,755	5,182	1,106	3,577	1,110	1,067	338	636	328	788	425
Total	202,866	38,295	69,568	13,478	38,850	5,346	32,358	5,914	22,397	2,878	13,417	1,768	8,439	1,433	5,620	956
Total	4,389,575	229,099	1,542,198	75,804	837,388	30,386	546,196	20,166	385,304	15,323	258,449	10,315	185,241	7,985	126,408	5,950

	Diameter class (inches)															
	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	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand trees															
Softwoods:																
Alaska yellow-cedar	16,497	2,615	8,926	1,459	9,484	1,649	4,564	921	2,963	666	1,400	498	998	434	1,369,797	167,526
Black spruce	—	—	—	—	—	—	—	—	—	—	—	—	—	—	610,728	74,077
Lodgepole pine	2,317	726	568	208	748	231	69	71	—	—	—	—	—	—	225,671	33,384
Mountain hemlock	21,672	2,534	12,872	2,194	13,725	2,030	6,987	1,487	3,361	897	1,340	471	1,296	568	1,623,710	143,210
Sitka spruce	17,275	1,702	11,709	1,392	19,000	1,942	12,080	1,492	8,906	2,053	4,813	1,081	7,393	1,089	972,375	73,525
Western hemlock	26,936	2,593	19,165	1,657	29,532	2,685	17,124	1,694	10,453	1,342	5,922	886	3,708	645	2,727,939	142,156
Western redcedar	7,943	1,575	4,363	831	7,871	1,531	5,807	2,099	3,830	1,053	1,084	292	4,562	1,261	395,784	53,819
White spruce	278	177	80	77	—	—	—	—	—	—	—	—	—	—	289,081	40,477
Other softwood	95	84	—	—	—	—	—	—	—	—	—	—	—	—	1,877	985
Total	93,013	5,079	57,684	3,479	80,360	4,322	46,631	3,493	29,514	2,926	14,559	1,520	17,957	1,802	8,216,961	306,544
Hardwoods:																
Black cottonwood	2,060	479	1,170	357	1,888	667	566	257	73	75	65	68	—	—	123,729	31,541
Paper birch	750	290	241	132	250	119	—	—	—	—	—	—	—	—	191,157	36,853
Quaking aspen	164	103	93	73	—	—	46	52	—	—	—	—	—	—	40,067	15,293
Red alder	—	—	71	72	79	75	—	—	—	—	—	—	—	—	46,078	13,115
Total	2,974	573	1,575	394	2,217	688	612	262	73	75	65	68	—	—	401,031	51,847
Total	95,987	5,100	59,259	3,497	82,577	4,398	47,242	3,505	29,587	2,930	14,624	1,522	17,957	1,802	8,617,992	309,675

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

Table 40—Estimated number of growing-stock[a] trees on timberland by species and diameter class, coastal Alaska, 2004–2008

	Diameter class (inches at breast height)									
	All classes		5.0–6.9		7.0–8.9		9.0–10.9		11.0–12.9	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand trees									
Softwoods:										
Alaska yellow-cedar	65,267	8,133	13,984	2,380	10,429	1,633	9,079	1,646	6,478	1,023
Black spruce	3,589	1,756	3,271	1,610	318	187	—	—	—	—
Lodgepole pine	8,022	2,059	2,318	763	1,929	540	1,190	436	906	325
Mountain hemlock	101,814	11,387	29,020	3,662	20,517	2,790	14,840	2,063	10,025	1,402
Sitka spruce	228,558	17,866	57,529	6,940	37,179	4,117	30,025	2,918	22,365	2,717
Western hemlock	457,087	23,522	134,225	8,411	88,361	5,578	65,111	4,528	41,636	2,972
Western redcedar	49,112	7,292	9,199	1,833	7,306	1,439	5,309	1,018	4,786	1,096
White spruce	23,596	4,348	10,161	2,358	6,887	1,304	3,330	861	1,972	512
Other softwood	586	402	218	183	103	89	47	61	62	69
Total	937,632	39,042	259,925	13,648	173,028	8,801	128,929	6,945	88,228	4,910
Hardwoods:										
Black cottonwood	20,882	4,712	4,950	1,525	4,680	1,603	2,925	864	1,562	492
Paper birch	16,296	3,473	4,222	1,125	3,303	961	3,884	1,028	2,783	742
Quaking aspen	1,138	837	748	622	183	218	—	—	—	—
Red alder	16,768	4,028	8,014	2,696	4,778	1,095	1,922	632	1,004	331
Total	55,083	7,210	17,935	3,383	12,944	2,179	8,731	1,491	5,350	958
All species	992,715	40,139	277,859	14,233	185,972	9,234	137,660	7,166	93,578	5,040

	Diameter class (inches at breast height)											
	13.0–14.9		15.0–16.9		17.0–18.9		19.0–20.9		21.0–28.9		29.0+	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Thousand trees											
Softwoods:												
Alaska yellow-cedar	6,742	1,138	4,755	916	3,659	644	2,682	495	5,190	876	2,270	495
Black spruce	—	—	—	—	—	—	—	—	—	—	—	—
Lodgepole pine	773	317	471	210	67	70	159	109	210	125	—	—
Mountain hemlock	7,545	1,180	5,549	1,048	5,246	881	2,394	504	4,775	802	1,904	530
Sitka spruce	16,603	1,880	14,704	1,641	10,937	1,202	8,003	1,020	19,529	1,953	11,685	1,245
Western hemlock	32,308	2,346	21,032	1,649	16,491	1,456	13,380	1,310	30,537	2,531	14,007	1,454
Western redcedar	4,398	798	3,589	780	2,801	602	1,869	476	6,137	1,058	3,720	770
White spruce	633	255	392	193	221	168	—	—	—	—	—	—
Other softwood	62	69	—	—	95	84	—	—	—	—	—	—
Total	69,063	3,933	50,492	2,970	39,515	2,423	28,487	1,977	66,377	3,733	33,586	2,341
Hardwoods:												
Black cottonwood	1,924	652	1,662	521	1,096	342	532	229	1,478	752	73	75
Paper birch	641	273	940	436	326	231	195	121	—	—	—	—
Quaking aspen	133	100	—	—	73	75	—	—	—	—	—	—
Red alder	497	313	403	200	—	—	71	72	79	75	—	—
Total	3,196	772	3,005	711	1,495	430	799	269	1,557	755	73	75
All species	72,259	4,013	53,497	3,039	41,010	2,446	29,286	1,997	67,934	3,855	33,660	2,354

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

[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 41—Estimated net volume of all live trees, by owner class and forest land status, coastal Alaska, 2004–2008

	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
	Million cubic feet													
U.S. Forest Service:														
National forest	22,430	1,176	6,161	480	28,591	1,098	13,256	1,709	5,103	833	18,359	1,498	46,950	1,768
Total	22,430	1,176	6,161	480	28,591	1,098	13,256	1,709	5,103	833	18,359	1,498	46,950	1,768
Other federal government:														
National Park Service	—	—	—	—	—	—	231	98	43	36	275	103	275	103
Bureau of Land Management	390	261	60	30	449	262	—	—	—	—	—	—	449	262
U.S. Fish and Wildlife Service	—	—	—	—	—	—	585	96	173	47	759	99	759	99
Departments of Defense and Energy	20	22	2	2	22	22	—	—	—	—	—	—	22	22
Total	410	262	61	30	471	263	817	137	217	59	1,034	143	1,505	295
State and local government:														
State	2,900	423	350	110	3,250	424	626	215	1	1	627	215	3,877	440
Local	100	55	150	86	250	102	—	—	—	—	—	—	250	102
Total	3,000	425	500	135	3,500	429	626	215	1	1	627	215	4,127	445
Private:	3,287	460	409	93	3,696	461	—	—	—	—	—	—	3,696	461
Total	3,287	460	409	93	3,696	461	—	—	—	—	—	—	3,696	461
All owners	29,127	1,319	7,131	505	36,258	1,237	14,699	1,728	5,321	835	20,020	1,520	56,278	1,858

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

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

[b] 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.

Table 42—Estimated net volume of all live trees on forest land, by forest type and stand size class, coastal Alaska, 2004–2008

	Large-diameter stands[a]		Medium-diameter stands[b]		Small-diameter stands[c]		All size classes	
Forest type	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
				Million cubic feet				
Softwoods:								
Alaska yellow-cedar	6,456	996	173	105	160	78	6,788	993
Black spruce	8	9	44	20	39	10	91	23
Lodgepole pine	204	59	34	15	53	16	291	63
Mountain hemlock	8,355	1,034	183	62	145	30	8,683	1,035
Sitka spruce	10,357	1,417	218	72	83	23	10,658	1,416
Western hemlock	22,215	1,566	73	39	183	92	22,472	1,564
Western redcedar	5,317	1,193	—	—	18	10	5,335	1,193
White spruce	44	21	83	23	57	18	184	35
Total	52,956	1,901	809	150	738	128	54,503	1,854
Hardwoods:								
Aspen	50	27	81	43	12	7	144	50
Cottonwood	830	272	210	108	8	3	1,049	292
Paper birch	350	94	170	44	30	10	551	99
Total	1,230	288	495	125	51	13	1,776	311
All forest types	54,186	1,914	1,303	193	789	129	56,278	1,858

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

[a] Stands with a majority of trees at least 11.0 inches diameter at breast height (d.b.h.) for hardwoods and 9.0 inches d.b.h. for softwoods.

[b] Stands with a majority of trees at least 5.0 inches d.b.h. but not as large as large-diameter trees.

[c] Stands with a majority of trees less than 5.0 inches d.b.h.

Table 43—Estimated net volume of all live trees on forest land, by species and owner group, coastal Alaska, 2004–2008

	Owner group									
	U.S. Forest Service		Other federal		State and local government		Private		All owners	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet									
Softwoods:										
Alaska yellow-cedar	5,727	593	—	—	95	45	78	23	5,899	594
Black spruce	—	—	49	11	4	3	11	8	64	14
Lodgepole pine	587	98	2	2	26	11	49	21	665	100
Mountain hemlock	7,512	784	148	53	445	121	299	92	8,405	800
Sitka spruce	11,475	1,211	410	179	2,274	318	1,765	327	15,923	1,301
Western hemlock	17,387	1,001	116	89	958	209	1,103	264	19,564	1,042
Western redcedar	3,855	678	—	—	90	36	45	19	3,990	679
White spruce	46	19	188	25	42	16	84	21	360	41
Other softwood	13	7	—	—	4	4	—	—	17	8
Total	46,601	1,768	913	228	3,937	440	3,434	458	54,885	1,850
Hardwoods:										
Black cottonwood	194	103	260	92	147	56	97	33	697	152
Paper birch	5	4	205	38	34	12	144	39	388	55
Quaking aspen	—	—	128	38	2	2	6	5	136	38
Red alder	150	37	—	—	7	5	15	12	172	39
Total	349	109	592	108	190	60	262	52	1,393	172
All species	46,950	1,768	1,505	295	4,127	445	3,696	461	56,278	1,858

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

Table 44—Estimated net volume of all live trees on forest land, by species and diameter class, coastal Alaska, 2004–2008

	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	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
Softwoods:														
Alaska yellow-cedar	220	27	379	47	502	65	534	66	632	101	587	93	661	115
Black spruce	49	10	12	4	2	1	1	1	—	—	—	—	—	—
Lodgepole pine	32	4	68	9	104	20	135	31	113	29	51	12	84	27
Mountain hemlock	312	34	532	51	783	100	847	93	886	95	932	138	835	99
Sitka spruce	224	23	379	36	532	46	654	71	828	84	871	84	927	95
Western hemlock	648	39	1,025	61	1,379	88	1,449	95	1,523	97	1,350	95	1,367	131
Western redcedar	58	8	114	17	151	27	207	33	218	42	214	42	276	66
White spruce	75	9	96	11	72	12	59	10	24	6	21	9	11	7
Other softwood	1	1	2	1	1	1	1	1	4	3	3	3	5	4
Total	1,620	63	2,606	98	3,526	145	3,887	163	4,228	191	4,030	209	4,166	239
Hardwoods:														
Black cottonwood	12	4	57	27	62	17	65	23	104	39	76	20	69	16
Paper birch	35	8	57	10	83	15	79	14	44	10	42	15	25	10
Quaking aspen	8	4	15	7	29	14	36	12	22	8	11	5	8	5
Red alder	21	6	33	8	36	11	22	7	16	9	28	13	—	—
Total	76	12	162	30	210	28	203	30	187	42	157	29	101	20
All species	1,697	64	2,769	100	3,736	147	4,089	165	4,415	192	4,187	210	4,267	239

	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	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet													
Softwoods:														
Alaska yellow-cedar	413	72	645	116	467	103	463	124	239	84	155	57	5,899	594
Black spruce	—	—	—	—	—	—	—	—	—	—	—	—	64	14
Lodgepole pine	28	11	44	14	6	6	—	—	—	—	—	—	665	100
Mountain hemlock	621	106	930	139	698	156	434	114	249	84	345	155	8,405	800
Sitka spruce	831	105	1,857	193	1,762	227	1,793	432	1,272	285	3,993	635	15,923	1,301
Western hemlock	1,329	118	2,670	248	2,287	248	1,879	261	1,490	247	1,168	193	19,564	1,042
Western redcedar	172	36	475	105	461	165	404	113	137	39	1,104	362	3,990	679
White spruce	3	3	—	—	—	—	—	—	—	—	—	—	360	41
Other softwood	—	—	—	—	—	—	—	—	—	—	—	—	17	8
Total	3,397	207	6,620	370	5,681	422	4,973	563	3,386	384	6,765	748	54,885	1,850
Hardwoods:														
Black cottonwood	51	16	125	51	51	24	15	15	9	10	—	—	697	152
Paper birch	9	5	12	6	—	—	—	—	—	—	—	—	388	55
Quaking aspen	4	3	—	—	3	4	—	—	—	—	—	—	136	38
Red alder	5	5	12	11	—	—	—	—	—	—	—	—	172	39
Total	69	17	149	52	55	24	15	15	9	10	—	—	1,393	172
All species	3,466	208	6,769	378	5,736	423	4,988	564	3,395	384	6,765	748	56,278	1,858

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

Table 45—Estimated net volume of growing-stock and sawtimber on timberland by class of timber, owner group, and species group, coastal Alaska, 2004–2008

	Volume per acre		Total net volume					
			Species group					
	All species		Softwoods		Hardwoods		All species	
Forest type	**Mean**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Units per acre		*Million units*					
Growing-stock[a] (cubic feet)								
National forest	5,961	217	22,277	1,173	55	35	22,332	1,174
Other federal	6,006	2,732	328	205	82	73	410	262
State and local	3,407	369	2,868	420	125	56	2,993	424
Private	2,213	278	3,178	459	100	32	3,278	460
Total	4,699	166	28,652	1,306	362	102	29,014	1,317
Sawtimber[b] (board feet)[c]								
National forest	32,796	1,395	122,593	6,959	278	190	122,871	6,961
Other federal	30,654	15,792	1,663	1,089	430	398	2,093	1,436
State and local	17,245	2,134	14,492	2,311	658	319	15,150	2,337
Private	11,274	1,659	16,335	2,670	363	125	16,698	2,670
Total	25,397	1,035	155,082	7,704	1,729	554	156,811	7,767

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

[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).

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

[c] International 1/4-inch rule.

Table 46—Estimated net volume of growing-stock[a] trees on timberland by species and diameter class, coastal Alaska, 2004–2008

	Diameter class (inches at breast height)											
	All classes		5.0–6.9		7.0–8.9		9.0–10.9		11.0–12.9		13.0–14.9	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet											
Softwoods:												
Alaska yellow-cedar	1,813	218	29	5	56	9	90	17	102	16	158	27
Black spruce	7	4	6	3	1	1	—	—	—	—	—	—
Lodgepole pine	108	29	4	1	11	3	12	4	17	6	19	8
Mountain hemlock	1,946	243	54	7	98	14	135	20	156	22	178	28
Sitka spruce	10,048	771	140	18	224	25	341	35	445	59	486	58
Western hemlock	12,709	777	332	23	540	37	770	60	813	63	934	71
Western redcedar	1,555	231	18	4	36	7	46	9	69	16	93	17
White spruce	148	30	20	5	34	7	31	8	29	8	12	5
Other softwood	10	6	1	0	1	1	1	1	1	1	2	2
Total	28,343	1,301	605	35	1,001	54	1,425	84	1,632	98	1,882	113
Hardwoods:												
Black cottonwood	354	102	5	2	19	7	24	7	22	7	38	13
Paper birch	166	43	9	3	17	5	39	10	43	12	13	6
Quaking aspen	8	5	2	2	1	1	—	—	—	—	3	2
Red alder	142	35	19	6	30	8	24	8	21	7	14	9
Total	670	116	36	7	67	11	87	15	85	16	68	17
All species	29,014	1,317	641	36	1,068	56	1,511	86	1,717	101	1,950	114

	Diameter class (inches at breast height)									
	15.0–16.9		17.0–18.9		19.0–20.9		21.0–28.9		29+	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet									
Softwoods:										
Alaska yellow-cedar	161	31	167	31	149	29	474	81	426	99
Black spruce	—	—	—	—	—	—	—	—	—	—
Lodgepole pine	17	8	2	3	8	5	16	10	—	—
Mountain hemlock	178	34	224	38	127	27	411	70	385	113
Sitka spruce	589	69	599	68	587	81	2,322	239	4,316	521
Western hemlock	829	67	884	83	967	97	3,439	303	3,202	344
Western redcedar	105	24	103	23	80	21	417	74	588	128
White spruce	13	6	9	7	—	—	—	—	—	—
Other softwood	—	—	5	4	—	—	—	—	—	—
Total	1,892	114	1,993	130	1,918	141	7,078	427	8,917	701
Hardwoods:										
Black cottonwood	48	17	35	11	27	12	121	63	15	15
Paper birch	27	14	11	8	7	4	—	—	—	—
Quaking aspen	—	—	3	3	—	—	—	—	—	—
Red alder	17	9	—	—	5	5	12	11	—	—
Total	92	23	49	14	39	14	133	64	15	15
All species	1,984	117	2,042	130	1,957	142	7,211	438	8,932	703

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

[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 47—Estimated net volume of sawtimber[a] on timberland by species and diameter class, coastal Alaska, 2004–2008

	Diameter class (inches at breast height)																	
	All classes		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+	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (International 1/4-inch rule)																	
Softwoods:																		
Alaska yellow-cedar	9,562	1,211	341	64	448	72	760	130	823	161	890	166	824	162	2,796	479	2,681	629
Lodgepole pine	470	134	47	17	85	31	100	41	93	44	13	13	41	28	91	56	—	—
Mountain hemlock	9,587	1,306	522	78	676	99	849	135	884	170	1,176	206	688	149	2,359	403	2,432	709
Sitka spruce	57,262	4,703	1,411	148	2,109	292	2,472	305	3,120	375	3,314	386	3,361	475	13,910	1,456	27,565	3,383
Western hemlock	68,908	4,555	3,294	266	3,895	312	4,790	374	4,465	370	4,966	473	5,624	571	21,268	1,887	20,605	2,230
Western redcedar	7,904	1,225	159	33	279	68	403	78	495	117	482	110	412	112	2,202	397	3,471	775
White spruce	424	107	120	31	128	34	57	22	69	35	50	38	—	—	—	—	—	—
Other softwood	44	28	3	4	6	6	7	8	—	—	27	24	—	—	—	—	—	—
Total	154,160	7,684	5,898	362	7,626	477	9,438	579	9,949	614	10,918	729	10,950	823	42,626	2,623	56,755	4,534
Hardwoods:																		
Black cottonwood	1,697	554	—	—	111	35	203	69	258	91	193	61	158	68	689	360	86	88
Paper birch	558	181	—	—	201	56	74	33	162	81	72	53	48	30	—	—	—	—
Quaking aspen	33	26	—	—	—	—	15	12	—	—	18	18	—	—	—	—	—	—
Red alder	364	143	—	—	92	32	74	48	98	50	—	—	26	26	74	71	—	—
Total	2,651	603	—	—	404	74	366	91	518	133	283	86	232	79	763	367	86	88
All species	156,811	7,767	5,898	362	8,030	488	9,804	587	10,467	627	11,201	732	11,182	828	43,389	2,684	56,841	4,547

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

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

Table 48—Estimated net volume of growing-stock[a] on timberland by species and owner group, coastal Alaska, 2004–2008

	U.S. Forest Service		Other federal		State and local		Private		All owners	
Owner group	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million cubic feet									
Softwoods:										
Alaska yellow-cedar	1,752	215	—	—	36	34	25	16	1,813	218
Black spruce	—	—	—	—	4	3	3	2	7	4
Lodgepole pine	96	29	2	2	5	4	5	4	108	29
Mountain hemlock	1,592	217	—	—	221	88	134	68	1,946	243
Sitka spruce	6,496	621	204	155	1,597	292	1,751	327	10,048	771
Western hemlock	10,681	715	102	88	876	207	1,050	264	12,709	777
Western redcedar	1,502	229	—	—	54	33	—	—	1,555	231
White spruce	29	14	1	1	38	16	79	21	148	30
Other softwood	6	5	—	—	4	4	—	—	10	6
Total	22,153	1,168	309	204	2,834	418	3,047	456	28,343	1,301
Hardwoods:										
Black cottonwood	55	35	82	73	124	56	94	32	354	102
Paper birch	3	4	19	21	28	12	116	36	166	43
Quaking aspen	—	—	—	—	2	2	6	5	8	5
Red alder	120	33	—	—	7	5	15	12	142	35
Total	179	48	101	76	160	60	231	49	670	116
All species	22,332	1,174	410	262	2,993	424	3,278	460	29,014	1,317

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

[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 49—Estimated net volume of sawtimber trees[a] on timberland, by species and owner group, coastal Alaska, 2004–2008

	Owner group									
	U.S. Forest Service		Other federal		State and local government		Private		All owners	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million cubic feet									
Softwoods:										
Alaska yellow-cedar	1,633	205	—	—	33	33	20	13	1,687	208
Lodgepole pine	80	25	1	1	3	4	4	3	88	25
Mountain hemlock	1,438	208	—	—	179	73	121	62	1,739	228
Sitka spruce	6,271	613	197	152	1,456	277	1,601	314	9,524	753
Western hemlock	9,772	684	71	61	769	190	944	251	11,556	740
Western redcedar	1,421	220	—	—	46	32	—	—	1,467	222
White spruce	22	11	—	—	23	12	48	15	94	22
Other softwood	6	4	—	—	3	3	—	—	8	5
Total	20,643	1,124	269	182	2,513	390	2,738	436	26,163	1,250
Hardwoods:										
Black cottonwood	51	34	78	72	115	54	62	23	306	98
Paper birch	1	3	13	14	12	8	75	27	101	31
Quaking aspen	—	—	—	—	2	2	4	4	5	4
Red alder	49	21	—	—	3	2	9	9	60	23
Total	101	40	91	73	130	57	150	36	472	106
All species	20,744	1,128	359	244	2,643	396	2,888	438	26,635	1,265

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

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

Table 50—Estimated net volume of sawtimber[a] on timberland by species and owner group, coastal Alaska, 2004–2008

	Owner group									
	U.S. Forest Service		Other federal		State and local government		Private		All owners	
Species	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	Million board feet (International 1/4-inch rule)									
Softwoods:										
Alaska yellow-cedar	9,274	1,194	—	—	193	197	95	62	9,562	1,211
Lodgepole pine	429	132	5	5	17	20	19	16	470	134
Mountain hemlock	7,990	1,200	—	—	971	404	626	327	9,587	1,306
Sitka spruce	38,606	3,916	1,187	933	8,257	1,609	9,212	1,882	57,262	4,703
Western hemlock	58,292	4,210	387	334	4,514	1,128	5,715	1,571	68,908	4,555
Western redcedar	7,563	1,205	—	—	340	247	—	—	7,904	1,225
White spruce	104	55	—	—	106	60	214	70	424	107
Other softwood	30	24	—	—	13	15	—	—	44	28
Total	122,288	6,940	1,579	1,085	14,411	2,303	15,882	2,656	154,160	7,684
Hardwoods:										
Black cottonwood	278	190	430	398	649	319	339	124	1,697	554
Paper birch	6	11	83	90	67	52	401	148	558	181
Quaking aspen	—	—	—	—	9	10	24	24	33	26
Red alder	298	132	—	—	14	11	52	54	364	143
Total	583	232	513	408	739	334	816	196	2,651	603
All species	122,871	6,961	2,093	1,436	15,150	2,337	16,698	2,670	156,811	7,767

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

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

Table 51—Estimated net volume of growing-stock[a] on timberland by forest type and stand size class, coastal Alaska, 2004–2008

Forest type	Seedling and sapling		Poletimber		Sawtimber		Nonstocked		All stand size classes	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
					Million cubic feet					
Softwoods:										
Alaska yellow-cedar	2	2	—	—	1,564	315	—	—	1,565	315
Black spruce	3	3	7	6	—	—	—	—	9	7
Lodgepole pine	13	8	0	0	15	13	0	0	28	15
Mountain hemlock	14	10	13	16	1,628	327	—	—	1,656	327
Sitka spruce	62	21	153	54	6,626	833	5	3	6,845	833
Western hemlock	82	25	72	39	15,763	1,087	2	2	15,919	1,087
Western redcedar	1	1	—	—	1,967	353	—	—	1,969	353
White spruce	32	14	22	12	25	18	—	—	79	26
Total	209	38	267	69	27,587	1,303	8	4	28,070	1,300
Hardwoods:										
Aspen	3	2	—	—	—	—	—	—	3	2
Cottonwood	3	2	71	38	563	258	1	1	638	260
Paper birch	21	9	33	17	215	82	—	—	269	84
Total	27	9	137	45	778	270	1	1	943	272
Nonstocked	—	—	—	—	—	—	0	0	0	0
All species	235	39	404	82	28,365	1,322	9	4	29,014	1,317

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

[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 52—Estimated net volume of sawtimber[a] on timberland by forest type and stand size class, coastal Alaska, 2004–2008

	Seedling and sapling		Poletimber		Sawtimber		All stand size classes	
Forest type	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million board feet (International 1/4-inch rule)							
Softwoods:								
Alaska yellow-cedar	3	3	—	—	7,658	1,627	7,661	1,627
Black spruce	—	—	9	8	—	—	9	8
Lodgepole pine	37	31	1	2	76	68	115	75
Mountain hemlock	69	49	23	27	8,272	1,749	8,364	1,750
Sitka spruce	185	75	313	126	37,272	4,985	37,770	4,983
Western hemlock	222	115	138	77	88,576	6,367	88,936	6,366
Western redcedar	—	—	—	—	9,506	1,809	9,506	1,809
White spruce	81	40	40	25	88	64	208	79
Total	598	153	524	154	151,448	7,669	152,569	7,660
Hardwoods:								
Aspen	10	11	—	—	—	—	10	11
Cottonwood	7	7	124	70	3,007	1,496	3,138	1,497
Paper birch	61	34	48	29	943	419	1,052	419
Total	78	36	214	81	3,950	1,552	4,242	1,552
All species	675	157	738	173	155,398	7,779	156,811	7,767

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

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

Table 53—Estimated net volume of growing-stock[a] on timberland by forest type and owner group, coastal Alaska, 2004–2008

	U.S. Forest Service		Other federal		State and local		Private		All owners	
Forest type	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million cubic feet									
Softwoods:										
Alaska yellow-cedar	1,472	308	—	—	56	59	37	28	1,565	315
Black spruce	—	—	—	—	7	6	2	3	9	7
Lodgepole pine	22	14	—	—	6	7	—	—	28	15
Mountain hemlock	1,300	300	—	—	243	110	112	71	1,656	327
Sitka spruce	3,811	680	5	6	1,241	290	1,788	387	6,845	833
Western hemlock	13,636	1,023	156	138	1,120	277	1,007	268	15,919	1,087
Western redcedar	1,905	348	—	—	63	66	1	1	1,969	353
White spruce	13	11	0	0	19	11	47	21	79	26
Total	22,159	1,174	161	138	2,757	419	2,993	459	28,070	1,300
Hardwoods:										
Aspen	—	—	—	—	—	—	3	2	3	2
Cottonwood	140	110	229	222	135	65	134	48	638	260
Paper birch	0	1	20	22	102	67	147	46	269	84
Total	173	112	249	223	236	93	285	65	943	272
Nonstocked	—	—	—	—	—	—	0	0	0	0
All species	22,332	1,174	410	262	2,993	424	3,278	460	29,014	1,317

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

[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 54—Estimated net volume of sawtimber[a] on timberland by forest type and owner group, coastal Alaska, 2004–2008

	U.S. Forest Service		Other federal		State and local		Private		All owners	
Forest type	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million board feet (International 1/4-inch rule)									
Softwoods:										
Alaska yellow-cedar	7,216	1,591	—	—	291	323	154	116	7,661	1,627
Black spruce	—	—	—	—	9	8	—	—	9	8
Lodgepole pine	91	69	—	—	24	28	—	—	115	75
Mountain hemlock	6,749	1,643	—	—	1,107	513	508	335	8,364	1,750
Sitka spruce	21,899	4,154	19	21	6,308	1,575	9,545	2,269	37,770	4,983
Western hemlock	76,978	6,031	669	594	5,869	1,519	5,419	1,559	88,936	6,366
Western redcedar	9,095	1,764	—	—	411	431	—	—	9,506	1,809
White spruce	26	23	—	—	46	33	136	68	208	79
Total	122,054	6,965	688	594	14,065	2,298	15,762	2,668	152,569	7,660
Hardwoods:										
Aspen	—	—	—	—	—	—	10	11	10	11
Cottonwood	775	642	1,321	1,305	608	324	433	162	3,138	1,497
Paper birch	—	—	83	90	477	372	492	177	1,052	419
Total	817	643	1,405	1,308	1,085	493	935	233	4,242	1,552
All species	122,871	6,961	2,093	1,436	15,150	2,337	16,698	2,670	156,811	7,767

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

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

Table 55—Estimated average biomass, volume, and density of snags on forest land, by forest type and diameter class, coastal Alaska, 2004–2008

Forest type	Biomass: Diameter class (d.b.h. inches) 5 to 19 Mean	SE	20 to 39 Mean	SE	≥40 Mean	SE	Total Mean	SE	Volume: Diameter class (d.b.h. inches) 5 to 19 Mean	SE	20 to 39 Mean	SE	≥40 Mean	SE	Total Mean	SE	Density: Diameter class (d.b.h. inches) 5 to 19 Mean	SE	20 to 39 Mean	SE	≥40 Mean	SE	Total Mean	SE
	Bone-dry tons per acre								*Cubic feet per acre*								*Snags per acre*							
Softwoods:																								
Alaska yellow-cedar	12.3	1.2	8.4	3.3	0.3	0.3	21.1	3.5	372.6	34.4	156.0	47.5	5.1	6.9	533.8	59.2	58.3	4.4	3.7	1.1	—	—	62.0	4.4
Black spruce	1.6	0.7	—	—	—	—	1.6	0.7	51.5	23.5	—	—	—	—	51.5	23.5	14.8	4.3	—	—	—	—	14.8	4.3
Lodgepole pine	4.6	0.8	0.2	0.2	—	—	4.7	0.9	152.8	29.0	1.6	1.8	—	—	154.5	29.1	36.2	5.9	0.1	0.2	—	—	36.3	5.9
Mountain hemlock	3.9	0.5	5.1	1.0	0.5	0.4	9.6	1.2	95.2	13.9	75.9	19.0	8.9	8.1	180.0	27.1	16.5	1.8	2.3	0.5	—	—	18.9	1.9
Sitka spruce	8.4	1.5	9.0	1.9	2.6	1.4	20.0	3.4	212.2	44.2	105.3	31.6	5.6	4.7	323.0	71.0	30.6	4.1	3.3	0.7	0.3	0.1	34.1	4.5
Western hemlock	10.8	0.8	19.6	1.8	7.8	2.0	38.2	2.7	229.8	20.3	189.2	21.5	52.6	23.6	471.6	41.3	32.1	2.4	6.0	0.5	0.5	0.1	38.6	2.4
Western redcedar	16.5	1.3	11.2	2.2	4.7	3.7	32.5	4.2	522.5	46.6	207.8	46.5	19.7	19.6	750.1	77.2	77.2	5.1	5.0	1.0	0.5	0.4	82.7	5.1
White spruce	10.8	1.7	0.8	0.5	—	—	11.7	1.9	373.7	63.3	36.8	20.7	—	—	410.5	72.8	56.8	8.2	0.5	0.3	—	—	57.3	8.3
Total	9.0	0.4	10.3	0.8	3.1	0.7	22.5	1.2	238.4	12.1	129.5	12.0	20.2	7.3	388.1	20.3	36.4	1.5	3.7	0.3	0.2	0.1	40.4	1.6
Hardwoods:																								
Aspen	7.7	2.0	—	—	—	—	7.7	2.0	297.7	80.4	—	—	—	—	297.7	80.4	49.9	12.4	—	—	—	—	49.9	12.4
Cottonwood	2.8	1.0	0.6	0.3	—	—	3.3	1.3	99.3	39.4	19.4	11.9	—	—	118.7	50.4	12.9	4.1	0.4	0.2	—	—	13.3	4.2
Paper birch	8.0	1.3	0.4	0.3	—	—	8.4	1.4	251.3	49.0	11.9	11.4	—	—	263.1	49.9	36.4	5.3	0.2	0.2	—	—	36.6	5.3
Total	5.9	0.8	0.4	0.2	—	—	6.3	0.9	193.7	31.0	13.2	7.1	—	—	206.9	33.8	28.3	3.7	0.3	0.1	—	—	28.6	3.7
Nonstocked	11.6	3.7	6.5	3.0	—	—	18.1	3.1	358.5	129.7	86.6	44.5	—	—	445.1	129.7	63.1	19.0	3.8	1.5	—	—	66.9	18.0
All species	8.8	0.4	9.5	0.8	2.8	0.6	21.1	1.1	235.2	11.3	119.1	10.9	18.4	6.6	372.7	18.7	35.9	1.4	3.4	0.2	0.2	0.0	39.5	1.5

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, or 0.05 snags per acre was estimated; includes snags ≥5 inches in diameter at breast height (d.b.h.).

Table 56—Estimated biomass and carbon mass of snags on forest land, by forest type and owner, coastal Alaska, 2004–2008

	U.S. Forest Service				Other federal				State and local government				Private				All owners			
	Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon		Biomass		Carbon	
Forest type	**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:																				
Alaska yellow-cedar	48.3	10.1	24.1	5.0	—	—	—	—	0.8	0.4	0.4	0.2	0.5	0.3	0.3	0.1	49.6	10.1	24.8	5.0
Black spruce	—	—	—	—	0.7	0.3	0.4	0.2	—	—	—	—	0.1	0.0	—	—	0.8	0.3	0.4	0.2
Lodgepole pine	1.8	0.5	0.9	0.2	—	—	—	—	—	—	—	—	0.2	0.2	0.1	0.1	2.1	0.5	1.1	0.3
Mountain hemlock	26.7	4.2	13.3	2.1	0.6	0.3	0.3	0.2	1.9	0.8	0.9	0.4	1.0	0.5	0.5	0.2	30.2	4.3	15.1	2.1
Sitka spruce	27.1	7.9	13.6	4.0	0.9	1.0	0.5	0.5	5.6	1.5	2.8	0.7	5.4	1.4	2.7	0.7	39.1	8.2	19.5	4.1
Western hemlock	140.4	13.8	70.2	6.9	0.4	0.3	0.2	0.2	4.3	1.6	2.2	0.8	6.5	2.0	3.3	1.0	151.6	14.0	75.8	7.0
Western redcedar	32.6	6.3	16.3	3.1	—	—	—	—	0.7	0.6	0.4	0.3	0.4	0.2	0.2	0.1	33.8	6.3	16.9	3.1
White spruce	0.1	0.1	—	—	2.4	0.6	1.2	0.3	1.4	0.7	0.7	0.4	1.4	0.7	0.7	0.3	5.2	1.1	2.6	0.6
Total	277.0	15.7	138.5	7.8	5.0	1.3	2.5	0.6	14.7	2.4	7.4	1.2	15.6	2.4	7.8	1.2	312.3	15.9	156.2	8.0
Hardwoods:																				
Aspen	—	—	—	—	1.2	0.4	0.6	0.2	—	—	—	—	—	—	—	—	1.3	0.4	0.6	0.2
Cottonwood	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.9	0.6	0.4	0.3	0.4	0.4	0.2	0.2	1.8	0.7	0.9	0.4
Paper birch	—	—	—	—	1.8	0.5	0.9	0.3	1.6	0.7	0.8	0.4	1.7	0.6	0.9	0.3	5.1	1.1	2.5	0.5
Total	0.5	0.2	0.2	0.1	3.2	0.7	1.6	0.3	2.5	0.9	1.2	0.5	2.1	0.7	1.1	0.3	8.3	1.3	4.2	0.7
Nonstocked	—	—	—	—	—	—	—	—	1.2	0.6	0.6	0.3	0.4	0.3	0.2	0.2	1.6	0.6	0.8	0.3
All species	277.5	15.6	138.7	7.8	8.2	1.3	4.1	0.7	18.4	2.4	9.2	1.2	18.1	2.5	9.1	1.2	322.3	16.0	161.1	8.0

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

Table 57—Lichen species found across all coastal Alaska plots, 2004–2008

Species	Common name	Frequency	Functional group[a]
Alectoria imshaugii	Spiny witch's hair	0.76	
Alectoria nigricans	Grey witch's hair	1.52	F
Alectoria sarmentosa	Common witch's hair	68.94	F
Anaptychia setifera	Hanging fringe lichen	0.76	
Bryocaulon pseudosatoanum	Foxhair lichen	6.06	
Bryoria bicolor	Electric horsehair lichen	18.18	F
Bryoria capillaris	Grey horsehair lichen	7.58	F
Bryoria cervinula	Spiny horsehair	6.06	F
Bryoria fuscescens	Pale-footed horsehair	15.15	F
Bryoria glabra	Shiny horsehair	29.55	F
Bryoria pseudofuscescens	Mountain horsehair	6.06	F
Bryoria tenuis	Pied horsehair	18.94	F
Bryoria trichodes	Elegant horsehair	54.55	F
Bunodophoron melanocarpum	Northern fancoral	2.27	
Cavernularia hultenii	Powdered saguaro	39.39	
Cavernularia lophyrea	Eyed saguaro	9.85	
Cetraria chlorophylla	Shadow ruffle	33.33	
Cetraria orbata	Variable ruffle	1.52	
Cetraria pinastri	Powdered sunshine lichen	3.79	
Cetraria sepincola	Eyed ruffle	1.52	
Cetraria subalpina	Iceland moss	3.03	
Cetrelia cetrarioides	Speckled rag	2.27	
Cladonia albonigra	Sordid pixie cup	11.36	
Cladonia amaurocraea	Quill clad	0.76	
Cladonia bellidiflora	British soldiers	42.42	
Cladonia carneola	Crowned pixie cup	18.18	
Cladonia cenotea	Miner's funnel	6.06	
Cladonia chlorophaea	Mealy pixie cup	14.39	
Cladonia coniocraea	Lesser powderhorn	15.91	
Cladonia cornuta	Common bighorn	41.67	
Cladonia crispata	Lesser organpipe	2.27	
Cladonia deformis	Lesser sulfur cup	5.3	
Cladonia digitata	Fingered pixie cup	0.76	
Cladonia ecmocyna	Greater frost soldiers	2.27	
Cladonia fimbriata	Powdered trumpet	13.64	
Cladonia furcata	Many-forked clad	1.52	
Cladonia gracilis	Black-footed soldiers	5.3	
Cladonia gracilis ssp. *turbina*	Bronzed pixie cup	0.76	
Cladonia macilenta	Lipstick powderhorn	1.52	
Cladonia metacorallifera	Dragon pixie cup	2.27	
Cladonia multiformis	Slotted clad	1.52	
Cladonia ochrochlora	Greater powderhorn	38.64	
Cladonia pleurota	Mind-altering pixie cup	9.85	
Cladonia portentosa	Reindeer lichen	1.52	
Cladonia pyxidata	Pebbled pixie cup	5.3	
Cladonia rangiferina	Reindeer lichen	1.52	
Cladonia scabriuscula	Many-winged clad	1.52	
Cladonia squamosa	Dragon funnel	54.55	
Cladonia squamosa var. *subsquamo*	Dragon funnel	9.85	

Species	Common name	Frequency	Functional group[a]
Cladonia stygia	Black-footed reindeer lichen	0.76	
Cladonia sulphurina	Greater sulfur cup	6.82	
Cladonia transcendens	Magic pebblehorn	24.24	
Cladonia umbricola	Shaded cladonia	15.91	
Cladonia verruculosa	Greater pebblehorn	5.3	
Collema furfuraceum	Blister tarpaper lichen	2.27	C
Erioderma sorediatum	Treepelt	0.76	C
Fuscopannaria sp.	Mouse lichen	1.52	C
Fuscopannaria laceratula	Cushion mouse	3.03	C
Fuscopannaria leucostictoides	Petalled mouse	1.52	C
Fuscopannaria pacifica		1.52	C
Hypogymnia apinnata	Beaded bone	45.45	
Hypogymnia austerodes	Powdered bone	3.79	
Hypogymnia bitteri	Powdered bone	6.06	
Hypogymnia duplicata	Tickertape bone	50	
Hypogymnia enteromorpha	Beaded bone	44.7	
Hypogymnia inactiva	Forking bone	0.76	
Hypogymnia metaphysodes	Deflated bone	3.03	
Hypogymnia occidentalis	Lattice bone	15.91	
Hypogymnia oceanica	Lattice bone	7.58	
Hypogymnia physodes	Monk's hood	21.97	
Hypogymnia pulverata	Tube lichen	0.76	
Hypogymnia rugosa	Puckered bone	0.76	
Hypogymnia tubulosa	Dog bone	1.52	
Hypogymnia vittata	Monk's hood	11.36	
Hypotrachyna sinuosa	Green loop	1.52	
Imshaugia aleurites	Salted starburst	1.52	
Leptogium brebissonii	Jellied vinyl	0.76	C
Leptogium burnetiae	Peppered vinyl	2.27	C
Leptogium saturninum	Peppered vinyl	6.06	C
Lobaria hallii	Iron lung	2.27	C
Lobaria linita	Cabbage lung	50	C
Lobaria oregana	Lettuce lung	41.67	C
Lobaria pulmonaria	Lungwort	10.61	C
Lobaria scrobiculata	Textured lung	15.15	C
Melanohalea exasperatula	Lustrous brown lichen	2.27	
Melanohalea multispora	Eyed brown lichen	6.06	
Melanohalea septentrionalis	Northern brown lichen	0.76	
Melanohalea subolivacea	Eyed brown lichen	1.52	
Nephroma arcticum	Green paw lichen	5.3	C
Nephroma bellum	Cat paw lichen	30.3	C
Nephroma helveticum	Dog paw lichen	18.18	C
Nephroma isidiosum	Pepper paw lichen	3.79	C
Nephroma laevigatum	Seaside paw lichen	1.52	C
Nephroma parile	Powder paw lichen	10.61	C
Nephroma resupinatum	Blister paw lichen	6.06	C
Nodobryoria oregana	Pendent foxtail	0.76	F
Parmelia hygrophila	Salted shield	29.55	
Parmelia pseudosulcata	Salted shield	25	
Parmelia saxatilis	Salted shield	3.03	

Species	Common name	Frequency	Functional group[a]
Parmelia squarrosa	Salted shield	0.76	
Parmelia sulcata	Powdered shield	34.09	
Parmeliopsis ambigua	Green starburst lichen	5.3	
Parmeliopsis hyperopta	Grey starburst lichen	48.48	
Peltigera aphthosa	Freckle pelt	1.52	C
Peltigera britannica	Freckle pelt	34.85	C
Peltigera canina	Dog pelt	0.76	C
Peltigera collina	Tree pelt	15.15	C
Peltigera elisabethae	Concentric pelt	0.76	C
Peltigera leucophlebia	Freckle pelt	0.76	C
Peltigera membranacea	Dog pelt	12.12	C
Peltigera neopolydactyla	Frog pelt	40.15	C
Peltigera pacifica	Frog pelt	0.76	C
Peltigera scabrosa	Toad pelt	7.58	C
Physcia aipolia	Grey-eyed rosette	3.03	E
Physcia caesia	Powdered rosette	1.52	E
Physcia tenella	Fringed rosette	0.76	E
Physconia americana	Fancy frost lichen	0.76	E
Physconia perisidiosa	Bordered frost lichen	0.76	E
Platismatia glauca	Ragbag lichen	81.06	
Platismatia herrei	Tattered rag lichen	37.12	
Platismatia lacunosa	Crinkled rag lichen	34.09	
Platismatia norvegica	Laundered rag lichen	58.33	
Polychidium contortum	Maritime woollybear	10.61	C
Pseudocyphellaria anomala	Netted specklebelly	5.3	C
Pseudocyphellaria crocata	Yellow specklebelly	3.79	C
Pseudocyphellaria perpetua	Yellow specklebelly	3.79	C
Ramalina dilacerata	Punctured bush lichen	7.58	
Ramalina farinacea	Powdery ramalina	11.36	
Ramalina obtusata	Hooded bush lichen	0.76	
Ramalina roesleri	Frayed bush lichen	12.12	
Ramalina thrausta	Angelhair	3.03	F
Sphaerophorus globosus	Clustered coral lichen	73.48	
Stereocaulon sp.	Foam lichen	1.52	C
Sticta fuliginosa	Peppered moon lichen	7.58	C
Usnea chaetophora	Articulated beard lichen	0.76	F
Usnea cornuta	Crab's beard	3.03	F
Usnea filipendula	Fishbone beard	7.58	F
Usnea lapponica	Powdered beard	6.82	F
Usnea longissima	Methuselah's beard	3.03	F
Usnea scabrata	Straw beard	0.76	F
Xanthoria candelaria	Shrubby orange lichen	3.03	E

[a] Functional groups are F = forage lichen, C = cyanolichen, and E = eutroph.

Table 58—Most common species by forest type, coastal Alaska, 2004–2008

Scientific name	Common name	Indicator codes	Constancy	Average cover	SE
			- - - - - - - *Percent*	- - - - - - -	
Western hemlock forest type (n = 28):					
Tsuga heterophylla (Raf.) Sarg.	Western hemlock	wds, wrm	100	51.29	4.05
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd. hlght	100	7.83	1.20
Menziesia ferruginea Sm.	Rusty menziesia	hlght, rdr	100	7.52	1.34
Vaccinium ovalifolium Sm.	Early blueberry	dwe	96.4	25.30	3.15
Cornus canadensis L.	Bunchberry	df	89.3	6.52	1.49
Blechnum spicant (L.) Sm.	Deer fern		89.3	1.94	0.35
Gymnocarpium dryopteris (L.) Newman	Western oakfern		85.7	4.56	.89
Athyrium filix-femina (L.) Roth	Common ladyfern	wms, nr	82.1	4.64	1.59
Rubus pedatus Sm.	Five-leaf bramble	df	82.1	4.54	1.01
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		82.1	0.75	.15
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		82.1	.53	.13
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wms, nr	78.6	2.64	1.07
Lysichiton americanus Hultén & H. St. John	American skunk cabbage	pdr, np, bf, df	75	5.55	1.22
Coptis aspleniifolia Salisb.	Fernleaf goldthread	df	71.4	5.73	1.34
Tiarella trifoliata L.	Threeleaf foamflower	df	67.9	1.93	.41
Vaccinium parvifolium Sm.	Red huckleberry		64.3	3.56	.78
Oplopanax horridus Miq.	Devil's club	wms, nr	60.7	4.87	1.43
Moneses uniflora (L.) Gray	Single delight		60.7	.39	.11
Rubus spectabilis Pursh	Salmonberry	sd, fld	57.1	5.61	1.74
Mountain hemlock forest type (n = 19):					
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock	cld, pdr	100	28.22	4.02
Rubus pedatus Sm.	Five-leaf bramble	df	100	5.50	1.27
Vaccinium ovalifolium Sm.	Early blueberry	dwe	94.7	26.12	4.67
Menziesia ferruginea Sm.	Rusty menziesia	hlght, rdr	94.7	7.4	1.33
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		84.2	1.23	0.3
Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg	Deercabbage	very pdr, np, cld, df	78.9	9.12	1.53
Cornus canadensis L.	Bunchberry	df	78.9	5.04	1.01
Veratrum viride Aiton	Green false hellebore		78.9	2.26	0.43
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		78.9	1.29	0.24
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	73.7	6.43	2.06
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd, hlght	73.7	5.73	1.11
Gymnocarpium dryopteris (L.) Newman	Western oakfern		73.7	4.57	1.22
Elliottia pyroliflorus (Bong.) S.W. Brim & P.F. Stevens	Copperbush	cld, pdr, snpk	68.4	10	3.82
Oplopanax horridus (Sm.) Miq.	Devil's club	wms, nr	68.4	3.88	2.04
Blechnum spicant (L.) Sm.	Deer fern		68.4	2.74	0.65
Tiarella trifoliata L.	Threeleaf foamflower	df	68.4	2.26	0.74
Rubus spectabilis Pursh	Salmonberry	sd, fld	63.2	6.26	2.5

Table 58—Most common species by forest type, coastal Alaska, 2004–2008 (continued)

Scientific name	Common name	Indicator codes	Constancy	Average cover	SE
			- - - - - - - Percent	- - - - - - -	
Dryopteris expansa (K. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wms, nr	63.2	1.66	0.27
Sorbus sitchensis M. Roemer	Western mountain ash		63.2	1.5	0.41
Harrimanella stelleriana (Pall.) Coville	Alaska bellheather	cld, helev	57.9	7.65	2.32
Coptis aspleniifolia Salisb.	Fernleaf goldthread	df	57.9	6.03	1.21
Streptopus lanceolatus (Aiton) Reveal var. *roseus* (Michx.) Reveal	Twistedstalk		57.9	2.92	0.69
Lysichiton americanus Hultén & H. St. John	American skunk cabbage	pdr, np, bf, df	52.6	2.85	0.65
Yellow-cedar forest type (n = 15):					
Chamaecyparis nootkatensis (D. Don)	Yellow-cedar	pdr, helev	100	27.00	3.90
Tsuga heterophylla (Raf.) Sarg.	Western hemlock	wds, wrm	100	21.23	3.34
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock	cld, pdr	100	12.41	2.14
Cornus canadensis L.	Bunchberry dogwood	df	100	5.22	1.06
Rubus pedatus Sm.	Five-leaf bramble	df	100	2.47	0.46
Blechnum spicant (L.) Sm.	Deer fern		100	1.87	0.21
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		100	0.96	0.22
Vaccinium ovalifolium Sm.	Early blueberry	dwe	93.3	20.57	4.06
Menziesia ferruginea Sm.	Rusty menziesia	hlght, rdr	93.3	8.80	1.22
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd, hlght	93.3	4.82	0.91
Coptis aspleniifolia Salisb.	Fernleaf goldthread	df	93.3	3.69	0.75
Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg	Deercabbage	very pdr, np, cld df	86.7	11.48	2.30
Lysichiton americanus Hultén & H. St. John	American skunk cabbage	pdr, np bf, df	86.7	7.85	1.58
Lycopodium annotinum L.	Stiff clubmoss		86.7	1.40	0.43
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		86.7	0.94	0.14
Tiarella trifoliata L.	Threeleaf foamflower	df	80	1.68	0.43
Platanthera stricta Lindl.	Slender bog orchid		80	0.58	0.21
Coptis trifolia (L.) Salisb.	Threeleaf goldthread	muskeg, very pdr	73.3	1.84	0.72
Veratrum viride Aiton	Green false hellebore		73.3	1.76	0.31
Trichophorum caespitosum (L.) Hartm.	Tufted bulrush		60	7.94	1.72
Pinus contorta Dougl. ex Loud.	Lodgepole pine	pdr, ptl	60	7.52	1.16
Gymnocarpium dryopteris (L.) Newman	Western oakfern		60	5.35	0.94
Vaccinium parvifolium Sm.	Red huckleberry		60	2.54	0.80
Streptopus lanceolatus (Aiton) Reveal var. *roseus* (Michx.) Reveal	Twistedstalk		60	2.04	0.38
Drosera rotundifolia L.	Roundleaf sundew		60	0.88	0.41
Trientalis europaea L.	Arctic starflower		53.3	1.73	0.61
Vaccinium vitis-idaea L.	Lingonberry		53.3	1.68	0.36
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	53.3	1.57	0.35
Maianthemum dilatatum (Alph.Wood) A. Nels. & J.F. Macbr.	False lily of the valley	df	53.3	1.43	0.20

Table 58—Most common species by forest type, coastal Alaska, 2004–2008 (continued)

Scientific name	Common name	Indicator codes	Constancy	Average cover	SE
			- - - - - - - *Percent* - - - - - - -		
Erigeron peregrinus (Banks ex Pursh) Greene	Subalpine fleabane		53.3	1.24	0.34
Oplopanax horridus (Sm.) Miq.	Devil's club	wms, nr	53.3	1.00	0.16
Western redcedar forest type (n = 6):					
Tsuga heterophylla (Raf.) Sarg.	Western hemlock	wdr, wrm	100	24.27	9.21
Thuja plicata Donn ex D. Don	Western redcedar		100	21.25	5.03
Vaccinium ovalifolium Sm.	Early blueberry	dwe	100	15.19	8.91
Menziesia ferruginea Sm.	Rusty menziesia	hlght, rdr	100	6.75	2.77
Cornus canadensis L.	Bunchberry	df	100	6.13	2.10
Lysichiton americanus Hultén & H. St. John	American skunk cabbage	pdr, np, bf, df	100	3.89	0.67
Blechnum spicant (L.) Sm.	Deer fern		100	2.32	0.83
Vaccinium parvifolium Sm.	Red huckleberry		100	1.81	0.25
Gaultheria shallon Pursh	Salal	pdr, np, hlght	83	17.06	4.83
Coptis aspleniifolia Salisb.	Fernleaf goldthread	df	83	4.05	1.55
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd, hlght	83	3.89	1.37
Rubus pedatus Sm.	Five-leaf bramble	df	83	3.69	1.81
Maianthemum dilatatum (Alph.Wood) A. Nels. & J.F. Macbr.	False lily of the valley	df	83	2.35	0.49
Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg	Deer cabbage	very pdr, np, cld df	83	2.07	0.56
Linnaea borealis L.	Twinflower		83	1.37	0.40
Veratrum viride Aiton	Green false hellebore		83	1.09	0.14
Chamaecyparis nootkatensis (D. Don) Spach	Yellow-cedar	pdr, helev	67	10.00	3.35
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	67	5.00	2.36
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock	cld, pdr	67	3.50	0.99
Vaccinium vitis-idaea L.	Lingonberry		67	2.85	1.24
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		67	1.33	0.26
Listera caurina Piper	Northwestern twayblade		67	0.78	0.18
Platanthera stricta Lindl.	Slender bog orchid		67	0.78	0.20
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		67	0.75	0.19
Polypodium glycyrrhiza D.C. Eaton	Licorice fern		67	0.50	0.25
Trichophorum caespitosum (L.) Hart.	Tufted bulrush		50	20.25	5.92
Carex anthoxanthea J.& C. Presl	Grassyslope arctic sedge		50	11.38	3.06
Carex pluriflora Hultén	Manyflower sedge		50	9.00	4.48
Pinus contorta Dougl. ex Loud.	Lodgepole pine	pdr, ptl	50	6.64	1.32
Ledum groenlandicum Oeder	Bog Labrador tea	muskeg, very pdr	50	6.10	1.06
Phegopteris connectilis (Michx.) Watt	Long beechfern		50	4.00	1.48
Streptopus lanceolatus (Aiton) Reveal var. *roseus* (Michx.) Reveal	Twistedstalk		50	2.57	0.84
Rubus spectabilis Pursh	Salmonberry	sd, fld	50	2.40	0.51
Gentiana douglasiana Bong.	Swamp gentian		50	1.63	0.40
Coptis trifolia (L.) Salisb.	Threeleaf goldthread	muskeg, very pdr	50	1.14	0.26
Tiarella trifoliata L.	Threeleaf foamflower	df	50	0.86	0.10

Table 58—Most common species by forest type, coastal Alaska, 2004–2008 (continued)

Scientific name	Common name	Indicator codes	Constancy	Average cover	SE
			- - - - - - - *Percent*	- - - - - - -	
Trientalis europaea L.	Arctic starflower		50	0.70	0.34
Streptopus streptopoides (Ledeb.) Frye & Rigg	Small twistedstalk		50	0.67	0.28
Tofieldia glutinosa (Michx.) Pers.	Sticky tofieldia		50	0.50	0.30
Sitka spruce forest type (n = 8):					
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd, hlght	100	34.92	6.89
Vaccinium ovalifolium Sm.	Early blueberry	dwe	80	18.44	4.69
Oplopanax horridus Miq.	Devil's club	wms, nr	80	15.00	7.38
Rubus spectabilis Pursh	Salmonberry	sd, fld	80	10.21	2.98
Gymnocarpium dryopteris (L.) Newman	Western oakfern		80	10.00	1.85
Rubus pedatus Sm.	Five-leaf bramble	df	80	8.45	2.42
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wms, nr	80	6.23	1.52
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		80	1.48	0.34
Cornus canadensis L.	Bunchberry	df	60	6.48	1.49
Menziesia ferruginea Sm.	Rusty menziesia	hlght, rdr	60	6.24	2.16
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	60	5.43	1.35
Phegopteris connectilis (Michx.) Watt	Long beechfern		60	3.77	1.76
Tiarella trifoliata L.	Threeleaf foamflower	df	60	3.42	0.43
Listera cordata (L.) R. Br. ex Ait. f.	Heartleaf twayblade		60	1.30	0.71
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint		60	0.75	0.27
Equisetum arvense L.	Field horsetail		50	23.09	16.36
Alnus viridis (Chaix) DC. ssp. *sinuata* (Regel) A. Löve & D. Löve	Sitka alder	sd, fld, all elevations	50	15.10	2.23
Lycopodium annotinum L.	Stiff clubmoss		50	2.18	1.09
Moneses uniflora (L.) Gray	Single delight		50	1.07	0.63
Cottonwood forest type (n = 7):					
Populus balsamifera ssp. *trichocarpa* L.	Black cottonwood		100.0	24.04	5.79
Alnus viridis (Chaix) DC. ssp. *sinuata* (Regel) A. Löve & D. Löve	Sitka alder	sd, fld	85.7	50.21	5.73
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	85.7	3.39	1.20
Pyrola asarifolia Michx.	Liverleaf wintergreen		85.7	1.38	0.43
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		85.7	0.60	0.09
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wms, nr	71.4	1.60	0.52
Orthilia secunda (L.) House	Sidebells wintergreen		71.4	1.34	0.52
Picea sitchensis (Bong.) Carr.	Sitka spruce	sspr, fld, sd, hlght	57.1	19.00	7.90
Salix barclayi Andersson	Barclay's willow		57.1	14.22	2.84
Rubus spectabilis Pursh	Salmonberry	sd, fld	57.1	9.25	6.74
Equisetum arvense L.	Field horsetail		57.1	8.43	5.60
Oplopanax horridus (Sm.) Miq.	Devil's club	wms, nr	57.1	2.72	0.95
Heracleum maximum Bartram	Common cowparsnip		57.1	2.34	1.43
Gymnocarpium dryopteris (L.) Newman	Western oakfern		57.1	1.70	0.99

Table 58—Most common species by forest type, coastal Alaska, 2004–2008 (continued)

Scientific name	Common name	Indicator codes	Constancy	Average cover	SE
			- - - - - - - *Percent*	- - - - - - -	
Carex L.	Sedge		57.1	0.34	0.33
Geum macrophyllum Willd.	Largeleaf avens		57.1	0.29	0.17
Boschniakia rossica (Cham. & Schlecht.) Fedtsch.	Northern groundcone		57.1	0.17	0.16
Birch forest type (n = 5):					
Betula neoalaskana Sarg.	Alaska paper birch		100	30.25	13.12
Chamerion angustifolium (L.) Holub ssp. *angustifolium*	Fireweed		100	20.2	7.37
Gymnocarpium dryopteris (L.) Newman	Western oakfern		100	14.63	1.64
Cornus canadensis L.	Bunchberry	df	100	7.7	2.36
Trientalis europaea L.	Arctic starflower		100	2.26	0.55
Linnaea borealis L.	Twinflower		100	1.67	0.73
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint		80	40.38	15.15
Equisetum sylvaticum L.	Woodland horsetail		80	14.0	6.86
Equisetum arvense L.	Field horsetail		80	8.36	6.08
Dryopteris expansa (C. Presl) Fraser-Jenkins & Jermy	Spreading woodfern	wms, nr	80	7.54	2.46
Rubus pedatus Sm.	Five-leaf bramble	df	80	5.38	2.58
Spiraea stevenii (C.K. Schneid.) Rydb.	Beauverd spirea		80	2.83	0.98
Orthilia secunda (L.) House	Sidebells wintergreen		80	1.01	0.43
Picea glauca (Moench) Voss	White spruce		60	11.3	3.30
Rubus idaeus L.	American red raspberry		60	8.27	1.19
Viburnum edule (Michx.) Raf.	Highbush cranberry		60	3.2	0.83
Sambucus racemosa L.	Red elderberry		60	2.88	0.48
Vaccinium vitis-idaea L.	Lingonberry		60	2.78	1.22
Streptopus amplexifolius (L.) DC.	Claspleaf twistedstalk		60	2.4	0.94
Ribes triste Pall.	Red currant		60	2.37	0.79
Lycopodium annotinum L.	Stiff clubmoss		60	2.25	1.3
Athyrium filix-femina (L.) Roth	Common ladyfern	nr, wms	60	2	0.21
Pyrola asarifolia Michx.	Liverleaf wintergreen		60	1.38	0.39
Galium triflorum Michx.	Fragrant bedstraw		40	0.83	0.08
Stellaria L.	Starwort		400	0.80	0.23
Aconitum delphiniifolium DC.	Larkspurleaf monkshood		40	0.50	0.36

[a] Indicator values: bf = bear forb; cld = cold soils; df = deer forage; dsr = deer summer range; dwe = deer winter energy; fld = flooding; helev = high elevation; hlght = high light; muskeg = muskeg species; np = nutrient poor; nr = nutrient rich; pdr = poorly drained; ptl = peatland; sd = site disturbance; snpk = snow pack areas; sspr = salt spray; wdr = well-drained soils; wms = water moving through soils; wrm = warm site.

Table 59—Introduced species that are searched for on standard phase 2 plots, coastal Alaska, 2004–2008

CODE	Scientific name	Common name
ALPE4	*Alliaria petiolata* (M. Bieb.) Cavara & Grande	Garlic mustard
BRIN2	*Bromus inermis* Leyss.	Smooth brome
BRTE	*Bromus tectorum* L.	Cheatgrass
CABU2	*Capsella bursa-pastoris* (L.) Medik.	Shepherd's purse
CAAR18	*Caragana arborescens* Lam.	Siberian peashrub
CEBI2	*Centaurea biebersteinii* DC.	Spotted knapweed
CIAR4	*Cirsium arvense* (L.) Scop.	Canada thistle
CIVU	*Cirsium vulgare* (Savi) Ten.	Bull thistle
CRTE3	*Crepis tectorum* L.	Narrowleaf hawksbeard
CYSC4	*Cytisus scoparius* (L.) Link	Scotch broom
DAGL	*Dactylis glomerata* L.	Orchardgrass
ELRE4	*Elymus repens* (L.) Gould	Quackgrass
GALEO	*Galeopsis* sp. L.	Hempnettle
HIAU	*Hieracium aurantiacum* L.	Orange hawkweed
HIPI	*Hieracium pilosella* L.	Mouseear hawkweed
HICA10	*Hieracium caespitosum* Dumort.	Meadow hawkweed
HIUM	*Hieracium umbellatum* L.	Narrowleaf hawkeed
HOJU	*Hordeum jubatum* L.	Foxtail barley
HYRA3	*Hypochaeris radicata* L.	Hairy catsear
IMGL	*Impatiens glandulifera* Royle	Ornamental jewelweed
LASQ	*Lappula squarrosa* (Retz.) Dumort.	European stickseed
LEVU	*Leucanthemum vulgare* Lam.	Oxeye daisy
LIVU2	*Linaria vulgaris* P. Mill.	Butter and eggs
LOLIU	*Lolium* sp. L.	Ryegrass
MADI6	*Matricaria discoidea* DC.	Pineapple weed
MEDIC	*Medicago* sp. L.	Alfalfa
MEAL12	*Melilotus alba* Medikus	Sweetclover, white
MEOF	*Melilotus officinalis* (L.) Lam.	Sweetclover, yellow
PHAR3	*Phalaris arundinacea* L.	Reed canarygrass
PHPR3	*Phleum pratense* L.	Timothy
PLMA2	*Plantago major* L.	Plantain
POAV	*Polygonum aviculare* L.	Prostrate knotweed
POCU6	*Polygonum cuspidatum* Sieb. & Zucc.	Japanese knotweed
PRPA5	*Prunus padus* L.	European bird cherry
RARE3	*Ranunculus repens* L.	Creeping buttercup
SEJA	*Senecio jacobaea* L.	Tansy ragwort
SEVU	*Senecio vulgaris* L.	Common groundsel
SOAR2	*Sonchus arvensis* L.	Perennial sowthistle
STME2	*Stellaria media* (L.) Vill.	Common chickweed
TAOF	*Taraxacum officinale* G.H. Weber ex Wiggers	Dandelion
TAVU	*Tanacetum vulgare* L.	Common tansy
TRDU	*Tragopogon dubius* Scop.	Western salsify
TRIFO	*Trifolium* sp.	Clover
VICRC	*Vicia cracca* L. ssp *cracca*	Bird vetch

Table 60—Plants found in the coastal Alaska Forest Inventory and Analysis inventory unit phase 3 plots with documented subsistence use or inquired about for commercial use on the Chugach or Tongass National Forests

Scientific name	Common name	Subsistence use	Intended commercial use/ parts harvested	Constancy [a b] Percent	Constancy [a b] SE
Abies lasiocarpa var. *lasiocarpa*	Subalpine fir		Transplants	0.74	0.74
Aconitum delphiniifolium	Larkspurleaf monkshood		Foliage	9.63	2.55
Achillea millefolium	Common yarrow	Medicinal		3.70	1.63
Actaea rubra	Red baneberry		Foliage	5.93	2.04
Adiantum pedatum	Northern maidenhair		Transplants	1.48	1.04
Alnus rubra	Red alder	Fuel, wood articles, dye, medicinal	Transplants	6.67	2.15
Allium schoenoprasum	Wild chives	Edible leaves		0.74	0.74
Andromeda polifolia	Bog rosemary		Whole plant	7.41	2.26
Aquilegia formosa	Western columbine		Foliage, seeds	3.70	1.63
Arctostaphylos alpina	Alpine bearberry	Edible berry		0.74	0.74
Aruncus dioicus	Bride's feathers		Whole plant	8.15	2.36
Arabis hirsuta	Hairy rockcress	Edible leaves or shoots		0.74	0.74
Arabis lyrata	Lyrate rockcress	Edible leaves or shoots		0.74	0.74
Arctostaphylos rubra	Red fruit bearberry	Edible berry		0.74	0.74
Asplenium trichomanes-ramosum	Brightgreen spleenwort		Whole plant	2.22	1.27
Athyrium filix-femina	Common ladyfern		Transplants	67.41	4.05
Caltha palustris	Yellow marsh marigold	Edible leaves (with caution)		1.48	1.04
Carex	Sedge		Seeds, transplants	25.93	3.79
Chamerion angustifolium	Fireweed	Cord (fishing nets), seed fluff in padding or clothes, edible leaves or shoots		2.22	1.27
Chamerion latifolium	Dwarf fireweed	Seed fluff in padding or clothes, edible leaves or shoots		2.22	1.27
Chamaecyparis nootkatensis	Alaska cedar	Fuel, wood articles, dye, medicinal, clothing, baskets, bows, tea		31.85	4.02
Cornus canadensis	Bunchberry dogwood	Edible berry		79.26	3.50
Cornus suecica	Lapland cornel	Edible berry		17.78	3.30
Dryopteris expansa	Spreading woodfern	Medicinals, bedding and padding; edible fiddleheads and roots (with caution)		62.96	4.17
Empetrum nigrum	Black crowberry	Edible berry		27.41	3.85
Equisetum	Horsetail	Abrasives for polishing; basketry, possible medicinal; edible root (with caution)		0.74	0.74
Eriophorum angustifolium	Tall cottongrass	Edible root		15.56	3.13
Fritillaria camschatcensis	Kamchatka fritillary	Edible bulb		3.70	1.63
Gaultheria shallon	Salal	Edible berries; medicinal leaves	Berries	11.85	2.79
Geum macrophyllum	Largeleaf avens		Whole plant	5.93	2.04

Table 60—Plants found in the coastal Alaska Forest Inventory and Analysis inventory unit phase 3 plots with documented subsistence use or inquired about for commercial use on the Chugach or Tongass National Forests (continued)

Scientific name	Common name	Subsistence use	Intended commercial use/ parts harvested	Constancy[a b]	
				Percent	SE
Gentiana platypetala	Broadpetal gentian		Whole plant	2.22	1.27
Hippuris vulgaris	Common mare's-tail	Edible leaves or stalk		0.74	0.74
Iris setosa	Beachhead iris		Foliage	2.96	1.46
Juniperus communis	Common juniper	Tea, edible berry (with caution)	Transplants, boughs, seeds	2.22	1.27
Juncus	Rush		Seeds, transplants	2.22	1.27
Kalmia polifolia	Bog laurel		Whole plant	8.15	2.36
Ledum groenlandicum	Bog Labrador tea		Foliage	15.56	3.13
Ligusticum scoticum	Scottish licorice-root	Edible leaves or stalk		1.48	1.04
Lupinus nootkatensis	Nootka lupine		Seeds	2.96	1.46
Lycopodium alpinum	Alpine clubmoss		Whole plant	2.22	1.27
Lysichiton americanus	American skunkcabbage	Food preparation, famine food		48.15	4.32
Lycopodium annotinum	Stiff clubmoss		Whole plant	49.63	4.32
Lycopodium clavatum	Running clubmoss		Whole plant	9.63	2.55
Lycopodium dendroideum	Tree groundpine		Whole plant	0.74	0.74
Maianthemum dilatatum	False lily of the valley	Edible leaves, berries, medicinal		25.93	3.79
Oplopanax horridus	Devil's club	Medicinal		58.52	4.26
Oxyria digyna	Alpine mountainsorrel	Edible leaves or shoots (with caution)		0.74	0.74
Pinus contorta	Lodgepole pine		Christmas trees, seeds, transplants	12.59	2.87
Picea sitchensis	Sitka spruce	Fuel, wood articles, food, medicinal, roots for basketry and crafts	Cones	74.81	3.75
Platanthera dilatata	Scentbottle		Whole plant	11.85	2.79
Pteridium aquilinum	Western brackenfern	Edible rhizomes, fiddleheads (carcinogenic)		2.22	1.27
Ribes bracteosum	Stink currant	Edible berry		11.85	2.79
Ribes laxiflorum	Trailing black currant	Edible berry	Berries	7.41	2.26
Ribes triste	Red currant	Edible berry	Berries	10.37	2.63
Rubus arcticus	Nagoonberry	Edible berry		11.11	2.71
Rubus chamaemorus	Cloudberry	Edible berry, shoots, medicinal use of roots		11.11	2.71
Rubus idaeus	American red raspberry	Edible berry	Berries	3.70	1.63
Rubus parviflorus	Thimbleberry	Edible shoots, berry		2.22	1.27
Rubus spectabilis	Salmonberry	Edible berry	Berries	53.33	4.31
Sanguisorba canadensis	Canadian burnet		Whole plant	17.78	3.30
Salix	Willow	Edible leaves, medicinal use, basketry, dye nets, rope	Transplants, cuttings, seeds	8.89	2.46
Sambucus racemosa	Red elderberry	Edible berry		16.30	3.19

Table 60—Plants found in the coastal Alaska Forest Inventory and Analysis inventory unit phase 3 plots with documented subsistence use or inquired about for commercial use on the Chugach or Tongass National Forests (continued)

			Intended commercial use/	Constancy [a b]	
Scientific name	**Common name**	**Subsistence use**	**parts harvested**	**Percent**	**SE**
Shepherdia canadensis	Russet buffaloberry	Edible berry		0.74	0.74
Sorbus sitchensis	Western mountain ash		Seeds, transplants	20.00	3.46
Streptopus amplexifolius	Claspleaf twistedstalk	Edible leaves, berries, medicinal use	Berries	74.81	3.75
Symphoricarpos albus	Common snowberry		Transplants	0.74	0.74
Thuja plicata	Western red cedar	Wood items, fuel, bark and roots in clothing and basketry	Bark	17.78	3.30
Tsuga heterophylla	Western hemlock	Wood items, fuel, tanning agent, dye, bedding, substrate for herring eggs	Boughs	61.48	4.20
Vaccinium caespitosum	Dwarf bilberry	Edible berries, shoots		22.22	3.59
Vaccinium	Blueberry		Transplants, berries	0.74	0.74
Vaccinium ovalifolium	Early blueberry	Edible berry	Berries	75.56	3.71
Vacc*inium oxycoccos*	Small cranberry	Edible berry	Berries	18.52	3.36
Vaccinium parvifolium	Red huckleberry	Edible berry	Berries	35.56	4.14
Vaccinium uliginosum	Bog blueberry	Edible berries, shoots		22.22	3.59
Vaccinium vitis-idaea	Lingonberry	Edible berry	Berries	30.37	3.97
Viburnum edule	Highbush cranberry	Edible berry	Berries	20.74	3.50

Note: SE = standard error.

[a] Constancy is the percentage of the 135 phase 3 FIA plots where the species was found. See Schultz et al. (2009) for details on data collection methods and sampling error calculations.

[b] Accuracy of estimates may be affected by date plots were visited relative to phenology, partially forested plots, and species misidentification. Plots were sampled from a 38-million-acre region and thus do not provide information on local abundance or rarity.

Table 61—Estimated aboveground biomass of all live trees on forest land, by species and diameter class, coastal Alaska, 2004–2008

	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	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million (bone-dry) tons													
Softwoods:														
Alaska yellow-cedar	6.2	0.8	8.2	1.0	10.7	1.4	11.4	1.4	13.6	2.2	12.8	1.9	14.8	2.5
Black spruce	1.6	0.3	0.4	0.1	0.1	0.0	—	—	—	—	—	—	—	—
Lodgepole pine	1.0	0.1	1.6	0.2	2.3	0.4	3.0	0.7	2.6	0.7	1.2	0.3	2.0	0.6
Mountain hemlock	7.5	0.8	11.6	1.1	16.7	2.1	18.3	2.0	19.5	2.1	21.0	3.1	19.2	2.2
Sitka spruce	6.0	0.6	7.9	0.7	10.2	0.9	12.2	1.3	15.4	1.6	16.4	1.6	17.5	1.8
Western hemlock	15.0	0.9	22.2	1.3	29.0	1.8	31.2	2.0	33.4	2.1	30.4	2.1	31.4	3.0
Western redcedar	1.1	0.2	1.9	0.3	2.5	0.4	3.6	0.6	3.9	0.8	4.2	0.8	5.4	1.2
White spruce	1.9	0.2	2.2	0.2	1.6	0.3	1.3	0.2	0.6	0.1	0.5	0.2	0.2	0.2
Other softwood	—	—	—	—	—	—	—	—	0.1	0.1	0.1	0.1	0.1	0.1
Total softwood	40.3	1.6	55.9	2.1	73.2	3.0	81.1	3.4	89.1	4.0	86.5	4.5	90.6	5.1
Hardwoods:														
Aspen	0.2	0.1	0.4	0.2	0.6	0.3	0.8	0.3	0.5	0.2	0.2	0.1	0.2	0.1
Cottonwood	0.5	0.1	1.4	0.7	1.4	0.4	1.4	0.5	2.1	0.8	1.5	0.4	1.4	0.3
Paper birch	1.2	0.3	1.7	0.3	2.3	0.4	2.2	0.4	1.3	0.3	1.3	0.4	0.7	0.3
Red alder	0.6	0.2	0.7	0.2	0.8	0.2	0.5	0.1	0.3	0.2	0.6	0.3	—	—
Total hardwood	2.5	0.4	4.2	0.8	5.1	0.7	4.8	0.7	4.2	0.9	3.7	0.7	2.3	0.4
Total	42.8	1.6	60.1	2.1	78.3	3.1	85.9	3.4	93.3	4.0	90.2	4.5	92.9	5.1

	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	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**	**Total**	**SE**
	Million (bone-dry) tons													
Softwoods:														
Alaska yellow-cedar	9.7	1.6	15.9	2.8	11.6	2.5	11.4	3.0	6.5	2.1	5.9	2.3	152.5	14.2
Black spruce	—	—	—	—	—	—	—	—	—	—	—	—	7.0	1.0
Lodgepole pine	0.7	0.2	1.1	0.4	0.1	0.2	—	—	—	—	—	—	16.5	2.4
Mountain hemlock	14.6	2.4	22.7	3.3	18.5	4.1	12.9	3.6	7.3	2.3	13.9	7.2	209.7	21.0
Sitka spruce	15.8	2.0	36.0	3.7	34.9	4.5	36.1	8.7	26.3	5.9	91.8	14.8	341.0	27.1
Western hemlock	31.2	2.8	66.4	6.2	60.0	6.4	51.6	7.0	40.3	6.5	35.0	5.8	488.3	26.3
Western redcedar	3.7	0.7	10.4	2.4	11.2	4.0	10.8	2.9	3.9	1.1	32.0	9.8	95.7	17.2
White spruce	0.1	0.1	—	—	—	—	—	—	—	—	—	—	10.5	1.1
Other softwood	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.2
Total softwood	75.8	4.5	152.7	8.6	136.3	10.0	122.9	12.7	84.4	9.0	178.6	19.3	1,321.5	42.7
Hardwoods:														
Aspen	0.1	0.1	—	—	0.1	0.1	—	—	—	—	—	—	3.2	0.8
Cottonwood	1.1	0.3	2.6	1.0	1.1	0.5	0.3	0.3	0.2	0.2	—	—	16.1	3.3
Paper birch	0.3	0.1	0.4	0.2	—	—	—	—	—	—	—	—	12.6	1.7
Red alder	0.1	0.1	0.2	0.2	—	—	—	—	—	—	—	—	4.4	1.0
Total hardwood	1.5	0.4	3.3	1.1	1.2	0.5	0.3	0.3	0.2	0.2	—	—	36.4	3.9
Total	77.3	4.6	156.0	8.7	137.5	10.0	123.2	12.7	84.5	9.0	178.6	19.3	1,357.9	42.8

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.

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890