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Forests of the Susitna-Copper Unit, Alaska, 2020: Forest Inventory and Analysis Report

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Cover photo: Alaska paper birch trees frame the view of a distant glacier in a grassy opening of an upland forest in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Photo by Geneva Preston, State of Alaska.

Abstract

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This report provides detailed estimates and highlights key findings from U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) data collected across its Alaska Susitna-Copper FIA unit in 2019 and 2020. The Susitna-Copper FIA unit encompasses much of the Susitna River and upper Copper River watersheds and is one of six FIA inventory units designed to measure the expansive boreal forests of Alaska. Estimates of forest area, volume, aboveground biomass, and ecosystem carbon are provided across land ownerships, forest types, and forest demographics throughout the unit. The Susitna-Copper FIA unit covers about 31.6 million acres, of which 9.1 million acres (29 percent) were considered forest land. As is typical in boreal forests, tree species diversity and average tree volume are extraordinarily low in the unit. The black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.) forest type composed the most forest area, with white spruce (*Picea glauca* (Moench) Voss) and Alaska paper birch (*Betula neoalaskana* Sarg.) also covering a significant amount of area. Most of the forest land is managed by the State of Alaska, including most of the tree volume on 1.3 million acres of timberland in the unit. Unique to the FIA program measurement of boreal forests in its interior Alaska inventory, is the assessment of the nonvascular ground layer, collection of tree cores, and analysis of soil cores from each plot. Across the Susitna-Copper FIA unit, belowground carbon represented 70 percent of ecosystem carbon, compared to 17 percent for aboveground carbon in live trees. Vascular vegetation cover in forest understories was dominated by shrubs, though overall cover was relatively low at a mean of 20.67 percent. A significant spruce beetle (*Dendroctonus rufipennis* (Kirby)) outbreak in the Matanuska watershed coincided with FIA plot measurement in the Susitna-Copper FIA unit and is reflected in the number and volume of standing dead white and black spruce recorded, particularly in trees greater than 5 inches diameter at breast height. This report summarizes the status of forests in a region that has previously lacked a comprehensive inventory at such a scale.

KEYWORDS

Boreal forest
Carbon
Interior Alaska
Southcentral Alaska
FIA
Soil carbon

Preface

This is the second general technical report in a series of U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) reports covering the forests of the interior Alaska FIA unit as six subunits (hereafter referred to as FIA units). This work builds on *Forest Resources of the Tanana Unit, Alaska: 2018* (Cahoon and Baer 2022), which reports on the Tanana FIA unit, by describing the forests of the adjacent Susitna-Copper FIA unit. *Forest Resources of the Tanana Unit, Alaska: 2018* is an important reference to this report that contains background information on the FIA program in interior Alaska, including a history of FIA sampling in interior Alaska, more extensive descriptions of methodology, and a more indepth ecological context for FIA measurements.

The Tanana and Susitna-Copper FIA units are the first two of six areas planned for measurement across the entirety of the interior Alaska group of FIA units. Together with the Coastal Alaska FIA unit, this work will eventually cover the entire state of Alaska. The series of FIA reports to date covering the forests of Alaska are as follows:

Key Forest Inventory and Analysis Statistics, Susitna-Copper FIA unit, Alaska

- Number of forested plots measured: 297
- Inventory unit area: 31.6 million acres
- Estimated forest area: 9.1 million acres
- Most common forest type: black spruce, 3.2 million acres
- Estimated number of live trees: 5.1 billion
- Number of tree species: 6
- Estimated total sound live-tree volume: 4.7 billion cubic feet
- Estimated total aboveground net live-tree biomass: 134.5 million megagrams (148.3 million tons)
- Estimated total aboveground net live-tree carbon: 66.0 million megagrams (72.7 million tons)
- Estimated total soil carbon: 280.0 million megagrams (308.6 million tons)

Alaska Forest Inventory and Analysis unit	Report title	Publication year
Interior: Tanana	Forest Resources of the Tanana Unit, Alaska: 2018	2022
Interior: Tanana	Updates to Forest Resources of the Tanana Unit, Alaska: 2018	2025
Interior: Susitna-Copper	Forests of the Susitna-Copper Unit, Alaska, 2020: Forest Inventory and Analysis Report (this report)	2026
Coastal	Forests of Southeast and South-Central Alaska, 2004–2008: Five-Year Forest Inventory and Analysis Report	2011
Coastal	Coastal Alaska's Forest Resources, 2004–2013: Ten-Year Forest Inventory and Analysis Report	2020
Coastal	Forests of the Coastal Alaska Unit, 2019: Forest Inventory and Analysis Report	In progress

Contents

Introduction

Program Background

The Forest Inventory and Analysis (FIA) program of the U.S. Department of Agriculture, Forest Service provides comprehensive, standardized information on the nation's forest[1] resources across public and private land ownerships. The program began in 1928 and now operates in all 50 states and the U.S.-Affiliated Pacific and Caribbean Islands. The core design of the FIA program includes regular revisits to permanent field plots installed on a randomized, systematic grid, utilizing a nationally standardized set of core measurements and regionally specific auxiliary measurements. Comparison of data between field visits produces estimates of the current status and trends of our nation's forests. With a spatially unbiased sample and routine remeasurements of forest resources, FIA data are widely used by policymakers, natural resource managers, private industry, and academic researchers to inform decision making and deepen understanding of forest ecology.

Although FIA was first established in 1928 by the McSweeney-McNary Forest Research Act, because of the operational challenges and expense of operating in Alaska, the first comprehensive forest inventory of the state did not begin until 1995 and was limited to relatively accessible southeast and southcentral coastal Alaska. The Agricultural Research, Extension, and Education Reform Act (1998), commonly known as the Farm Bill, mandated a nationally consistent methodology in which a portion of all plots across the entire state are measured each year. This inventory design is known as an "annual" inventory and is a substantially different design than the originally implemented "periodic" inventory in which all plots are measured in an area before moving to the next area. The first annualized measurement of coastal Alaska began in 2004 and ended in 2013 (Barrett and Christensen 2011, Cahoon et al. 2020), and remeasurement is ongoing (table 1).

[1] For data summarized in this report, the FIA program defines a forest as currently or formerly (within 30 years) having at least 10-percent canopy cover of live trees of any size and not subject to nonforest use(s) that prevent normal tree regeneration and succession. Forests must be at least 1 acre in size with a minimum width of 120 feet. This is the FIA domestic reporting definition, which is different from the definition used in international reporting (that includes a minimum tree canopy height criteria).

Table 1—Forest Inventory and Analysis units in Alaska

Forest Inventory and Analysis unit	Geographic description	Plot intensity	Approximate unit area[a]	Approximate total plots	Approximate forested plots	Sample design
			Acres	Number		
Coastal Alaska						
Coastal	Alexander archipelago, Gulf of Alaska coastline, Prince William Sound, Kenai Peninsula and Kodiak Island	Full	57,905,526	7,871	2,246	Annual: about 10 percent of plots sampled each year; estimates updated annually
Interior Alaska						
Tanana Valley	Tanana River basin	$1/5$th	33,444,309	1,128	727	Periodic: all plots sampled, and estimates generated unit by unit
Susitna-Copper	Susitna River watershed and upper Copper River watershed[b]	$1/5$th	31,646,281	1,055	334	
Southwest	Kuskokwim River basin	$1/5$th	91,733,072	2,909	839	
Lower Yukon	Lower Yukon River basin	$1/5$th	106,253,498	3,574	1,671	
Upper Yukon	Upper Yukon River basin	$1/5$th	38,740,164	1,299	988	
North Slope	Largely unforested region north of the Brooks Range	$1/5$th	53,138,474	1,795	5	

[a] Approximate unit area may differ from other published values as this approximation is based on U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) unit boundaries, including census water and a 3-mile buffer around coastlines, rather than being extrapolated from a number of sampled plots.

[b] Although Susitna River watershed and upper Copper River watershed are more commonly defined as part of Alaska's southcentral region, FIA measures it as part of the interior FIA unit because the ecology and logistics between them and other areas measured as part of the interior FIA unit are similar.

Because of their remote and roadless nature, the vast boreal forests of interior Alaska are the last in the nation to be fully inventoried using standardized FIA methodology, although prior, disparate studies estimated forest resources in some parts of the state. Recognizing the important need to fill this knowledge gap about the nation's forests, in 2014, Congress provided guidance and funding for the Forest Service, Pacific Northwest Research Station to begin a systematic inventory of interior Alaska. The inventory began that same year (Pattison et al. 2018). However, it would be prohibitively expensive and time intensive to install field plots on an annualized design, and at the standard FIA grid intensity of one ground plot per 6,000 acres throughout the estimated 110 million acres of interior Alaska forests—one-fifth of all U.S. forest land (Andersen et al. 2019). Therefore, the FIA program implemented a periodic design throughout interior Alaska in which field crews collect data across the entirety of one interior Alaska FIA unit before moving on to the next (fig. 1). Additionally, the program reduced the plot grid intensity to one plot per 30,000 acres. To reduce the higher sampling error associated with the coarser resolution of field plots and improve estimate precision, the FIA program partnered with scientists from the National Aeronautics and Space Administration (NASA) to acquire remotely sensed estimates of forest resources. The program used this methodology to complete the Tanana FIA unit inventory in 2018 (Cahoon and Baer 2022). Because the project has never been fully funded, the program estimates that the full inventory of interior Alaska will be completed in 2042. The program is engaged in an intensive internal study to propose changes to the interior Alaska inventory methods that, if adopted, would allow the area to be measured on a shorter timeframe, perhaps as short as 15 years for all boreal forests of the entire interior Alaska group of FIA units.

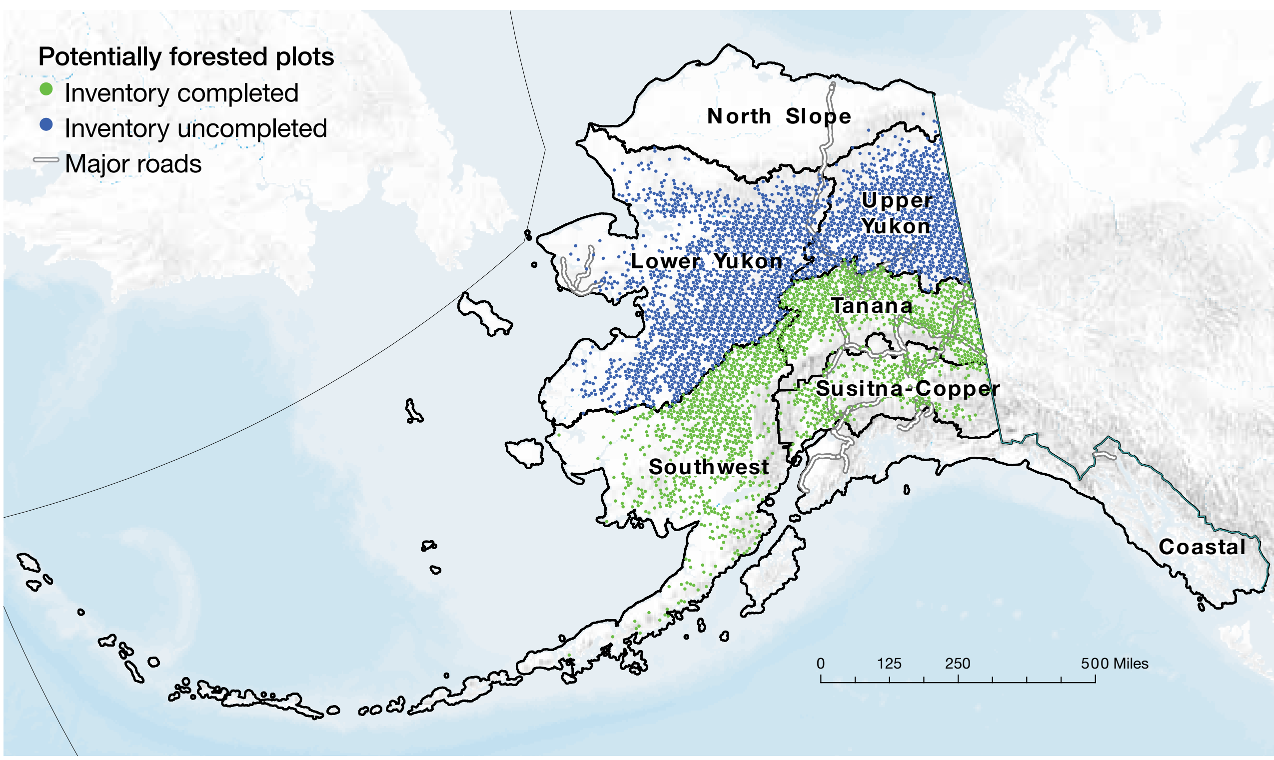

Figure 1—The seven Forest Service, Forest Inventory and Analysis (FIA) units in the state of Alaska. The six interior Alaska FIA units, inventoried using a periodic design, are shown with potentially forested FIA locations as green dots for completed plots and blue for uncompleted plots. Although the Susitna-Copper FIA unit is more commonly defined as part of Alaska's southcentral region, the FIA program measures it as part of the interior Alaska inventory because it shares logistical and ecological similarities with the remainder of the boreal forests of Alaska. The Coastal unit is inventoried separately with an annual design. Plot locations are approximate to meet confidentiality requirements. Map base layer source: ESRI (2015, 2017).

Forest Inventory and Analysis in the Susitna-Copper FIA Unit

The Susitna-Copper FIA unit samples the majority of two watersheds in southcentral Alaska: the Copper River[2] and the Susitna River watersheds. At nearly 50,000 square miles (31.6 million acres), the sampled area summarized in this report exceeds that of the states of New Hampshire and New Jersey combined, with a forested area nearly equal to the entire state of Connecticut. With such a large area and with very few roads (half the road density of Wyoming, the state in the contiguous United States with the lowest road density), 75 percent of ground-visited plots were more than 3 miles from the nearest road (fig. 2). Although two of Alaska's largest cities are within this region, comprising the highest population density in the state, a helicopter is required to sample this extremely remote area safely and efficiently (fig. 3).

Because of the substantial logistical and financial hurdles, past FIA work in the area consisted of sampling productive forest land along river valleys and targeted portions of the region (Carroll et al. 1985; Hegg 1970, 1975; Mead et al. 1985; Setzer et al. 1984a, 1984b). The first FIA inventory of the entire Susitna-Copper FIA unit using a systematic grid with standardized national protocols started in 2019 immediately after the successful completion of the inventory of the Tanana FIA unit. Crews completed the first inventory of the unit in 2020. The Susitna-Copper FIA unit inventory applied the same methodology that was successful in the Tanana FIA unit inventory (Cahoon and Baer 2022, Pattison et al. 2018), including both nationally standardized methods of measuring site, tree, and understory vegetation, as well as regionally specific methods for measuring the nonvascular ground layer and deep soils that are critical to the ecological understanding of boreal forests.

[2] The southern portion of the Copper River watershed is sampled annually in the Coastal Alaska FIA unit (Barrett and Christensen 2011, Cahoon et al. 2020).

Figure 2—Field crew members hike through dense cottongrass tussocks toward a black spruce forest. Because of the low road density and dense vegetation in the Susitna-Copper Forest Inventory and Analysis (FIA) unit, field crews often hiked great distances from a road or helicopter landing zone to access FIA plots. Photo courtesy of Sarah Lilly, State of Alaska.

Figure 3—Susitna-Copper Forest Inventory and Analysis unit, interior Alaska. Helicopters were used to transport field crews to nearly all ground-sampled plots; however, crews still often hiked long distances to plot locations because of dense vegetation. Photo courtesy of the State of Alaska.

Partnerships Key to Operational Success in Interior Alaska

Ecological fieldwork in interior Alaska is defined by the extreme logistical challenges of its expansive and remote environment, challenging weather patterns, and low population densities. The U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Inventory and Analysis program (PNW-FIA) staff in interior Alaska works closely with local, regional, and national partners to safely and effectively implement its inventory of forest resources. Partnerships began in 2011 with a collaboration between PNW-FIA and University of Alaska Fairbanks, Bonanza Creek Long Term Ecological Research site staff, enabling the program to assess regional data collection protocols in the boreal forest before full implementation of the inventory.

In 2014, the Farm Bill (Agricultural Research, Extension, and Education Reform Act 1998) directed the national FIA program to implement the inventory across interior Alaska, and a pilot study was initiated (Pattison et al. 2018). That year, the PNW-FIA and the State of Alaska Department of Natural Resources, Division of Forestry and Fire Protection (Alaska DOF) began a collaboration that has since become foundational to the operational success of the project. Toward a shared vision for a comprehensive survey of Alaska's forest resources, the Alaska DOF and the PNW-FIA collaborate to implement annual FIA field data collection operations. The Alaska DOF draws on its experience working across interior Alaska to lead planning and to provide data collection field crews, aviation logistics, and infrastructure for the inventory. The PNW-FIA and Alaska DOF have also partnered with the Tanana Chiefs Conference, a tribal consortium of the interior's 42 Alaska Native villages, to provide annual hands-on forest mensuration trainings in support of their adjacent forest inventories using FIA field procedures.

The Alaska DOF crew continuously adapts to changing logistical constraints as the inventory moves across increasingly remote regions and continues to conduct most of the operational planning and field implementation (fig. 4). In support of remote aviation operations, the PNW-FIA partners with the U.S. Department of the Interior (DOI) to facilitate safe fueling and transport across interior Alaska. An agreement with the department's Bureau of Land Management, Alaska Fire Service supports the delivery and installation of interagency-approved jet fuel sites for helicopter operations from airstrips that lack access to local fuel sources. Alaska Fire Service brings vast experience facilitating aerial operations across interior Alaska to support fire suppression and monitoring around the state. In addition, an interagency agreement enables the PNW-FIA field staff to use DOI-contracted aircraft for visiting remote villages and project hubs beyond the road system where there are no regularly scheduled flights.

Field crews can live and work in remote Alaskan communities for weeks at a time. Connections with communities and landowners offer insights into local forest conditions and concerns, including forest disturbance and treatment history and traditional uses of forest resources. Before each inventory, the PNW-FIA and Alaska DOF engage with community leaders and visit local schools to discuss local values and understand local concerns, as well as discuss the importance of forest monitoring. This nexus with local needs allows the FIA program to better understand how FIA data may best serve the communities in which it is collected.

Beyond partnerships supporting field data collection, several additional collaborations support interior Alaska's enhanced forest inventory. Since 2014, the PNW-FIA has partnered with the National Aeronautics and Space Administration (NASA) to collect high-resolution, remote-sensing data from an aerial platform using NASA's Goddard LiDAR, hyperspectral and thermal imager (G-LiHT) (see "Interagency Partnership to Support the Inventory in the Susitna-Copper FIA Unit With Airborne Remote Sensing" on p. 33). The rich remote-sensing dataset on field-measured FIA plots helps improve the precision of forest attribute estimates using model-assisted estimation techniques to characterize Alaska's forests. In addition, field-collected tree-core and soil samples are processed and analyzed in partnership with Alaska's universities to provide a detailed look at tree age and growth as well as soil composition across the boreal forests. Soil samples collected in the Susitna-Copper FIA unit were analyzed by the Forest Soils Lab at the University of Alaska Fairbanks (see "Soil Carbon" section in this report on page 28). Tree cores were processed and analyzed through a partnership with the University of Alaska Anchorage, Environment and Natural Resources Institute (see "Forest Inventory and Analysis [FIA] Tree-Ring Analyses Indicate Importance of Winter Temperature and Precipitation for White Spruce Growth in Alaska Boreal Forests" on p. 18).

The modern inventory of interior Alaska stands out for the robust collaborations across and beyond the state that facilitate an enhanced approach to accomplishing this logistically challenging project.

Figure 4—State of Alaska Department of Natural Resources, Division of Forestry employees conducted most of the fieldwork for the Forest Service, Forest Inventory and Analysis (FIA) inventory on the Susitna-Copper FIA unit. Photo courtesy of Sarah Lilly, State of Alaska.

What Is in This Report

This report summarizes the forests of the Susitna-Copper FIA unit, highlighting key forest characteristics. Our estimates focus on forest area, composition, ownership, volume, and carbon content of various components of the forest ecosystem, including soil carbon. We also present estimates of understory vegetation, down woody debris, and ground cover. Forest pathogens are summarized, with a focus on a significant spruce beetle (*Dendroctonus rufipennis* (Kirby)) outbreak that coincided with our ground measurement. Except where noted, all estimates in this report are based on FIA data collected from field-sampled forested plots from 2019 through 2020. FIA plots in the Susitna-Copper FIA unit were sampled as follows:

Plots	Number
Field sampled:	
Forest land	297
Nonforest land	31
Total	328
Inaccessible forested:	
Denied access	20
Hazardous	7
Skipped	10
Total	37
Photo-interpreted:	
Nonforest land	690
Total plots in unit	1,055

Skipped = plots not completed in time for processing; hazardous = plots not accessed because of danger; denied access = plots to which owners denied complete access.

Additionally, a set of 57 supplemental online tables are available to accompany this report, which provide more detailed estimates of the high-level summaries presented here. These tables can be downloaded from https://doi.org/10.2737/pnw-gtr-1037. The tables summarize Susitna-Copper FIA unit data regarding forest area, number of trees, volume, biomass, carbon, forest disturbances, ground layer composition, soil composition, down woody material, and understory vegetation. A complete list of these supplemental tables is provided at the end of this report.

National-Scale Volume and Biomass Framework

The FIA program published a new modeling system in September 2023 for predicting tree[3] cubic-foot volume, biomass, and carbon attributes, completing a 2015 FIA Strategic Plan goal. This system, called the National-Scale Volume and Biomass (NSVB) framework, provides a more consistent and accurate accounting of structural components of trees across the United States for individual tree cubic-foot volume, biomass, and carbon (Westfall et al. 2024).

These new methods replace the former Component Ratio Method (CRM) and Regional cubic-foot volume and biomass equations (Woodall et al. 2011). An update was necessary as the old models varied in approach across the country, contingent upon the tree species and geographic location. The new equations provide comparable predictions of tree volume, biomass, and carbon content across the entire United States. National-scale comparisons between older methods and the NSVB framework show that overall, the NSVB framework causes only a small increase in volume, but substantial increases in biomass and carbon because of relatively large increases in predicted tree top/limbs biomass and carbon. Changes in tree carbon were also affected by the use of newly developed species carbon fractions instead of the conversion factor of 0.5. For the detailed methodology, see Westfall et al. (2024).

For volume estimates across the Susitna-Copper FIA unit (trees ≥5 inches diameter at breast height [DBH]), the NSVB changes resulted in a 9-percent increase for live- and 11-percent increase for standing dead-tree volume estimates overall, compared to the prior Regional equations (table A1.1). Changes for estimates by individual tree species varied from a 7- to a 46-percent increase, with similar changes to live- and standing dead-tree volume within a given species. The estimate of aboveground biomass for live trees increased by 6 percent overall, though notably, white spruce (*Picea glauca* (Moench)

[3] The U.S. Department of Agriculture, Forest Service defines a tree as a woody perennial plant, usually with a single well-defined stem carrying a crown, with a minimum height of 15 feet at maturity. Tally trees measured as part of the FIA inventory are all live and standing dead trees (snags) in accessible forest land or measurable nonforest land condition classes.

Voss) live biomass estimates increased by 23 percent, while black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.) decreased by 10 percent (table A1.2). Estimates of aboveground biomass for standing dead trees varied more substantially, with an overall increase of 42 percent. Much of this increase in estimated biomass is driven by a 50-percent increase in the standing dead white spruce estimate across the Susitna-Copper FIA unit. Estimates for aboveground live- and standing dead-tree carbon followed a similar pattern for aboveground biomass (table A1.3). Ellison and Kuegler (2025) provides a similar summary of the effects of NSVB on estimates in the Tanana FIA unit, as well as summary tables of forested areas of the Tanana FIA unit updated to reflect the new NSVB equations.

Where to Find Additional Information

Field Instructions for the Annual Inventory of Alaska in 2020 (USDA FS 2020) describes the field methods used to collect data for this report. Cahoon and Baer (2022) provide detailed information on the methodology for regionally specific protocols unique to the interior Alaska FIA program, including remote-sensing and model-assisted estimates, ground layer assessment, and soil core collection and processing. The data used in this report are accessible through the Forest Inventory and Analysis Database (FIADB) (USDA FS NRS 2024), which contains both national core data and regional variables collected by individual FIA program units.

The FIA webpage (USDA FS 2025a) provides many resources, including data, a glossary of terms, and the tools described here. FIA DataMart (USDA FS 2024) provides access to the FIADB and the data used in this report, downloadable in several formats. EVALIDator (USDA FS 2025b) is the primary estimation tool that allows users to generate custom summaries from the most recent data in the FIADB. A description of the database structure, and definitions of tables and fields are available in the FIADB user guide (Burrill et al. 2024). Pugh et al. (2018) provides a detailed guide to producing population-level estimates using the publicly available data from the FIADB. For detailed documentation of the FIA program's sampling and estimation procedures, see Bechtold and Patterson (2005) and Westfall et al. (2022). See appendix 4 for specific instructions on database access.

Forests of the Susitna-Copper FIA Unit, Alaska

Regional Description

The Susitna-Copper FIA unit covers most of the Susitna River and Copper River watersheds in south-central Alaska. The unit overlaps eight ecoregions with the forested areas primarily found in the Copper River Basin and Cook Inlet Basin ecoregions, and scattered forests occurring throughout the Alaska Range and Chugach-St. Elias Mountains ecoregions (Nowacki et al. 2003). The Cook Inlet Basin ecoregion covers the lower portion of the Susitna River watershed, which drains the Talkeetna Mountains and portions of the Alaska Range into the Cook Inlet. A small portion of the upper Susitna River watershed, including the headwaters of the Yentna and Tokositna Rivers, is included in the Tanana FIA unit because it is in Denali National Park and Preserve. A portion of the lower Copper River watershed, including the Copper River Delta, is measured in the Coastal Alaska FIA unit (fig. 5).

Adjacent to the population centers of Anchorage and Wasilla, and relatively accessible by road, the Susitna River watershed contains some of the most often visited lands in Alaska. Primarily originating from glacier-fed tributaries of the Alaska Range and Talkeetna Mountains, the Susitna River supports all five species of Pacific salmon, including significant runs of king (*Oncorhynchus tshawytscha*) and sockeye salmon (*O. nerka*). The Cook Inlet Basin ecoregion, which comprises the lower portion of the Susitna River watershed, is characterized by low-elevation gentle slopes underlain by fine-textured lacustrine deposits and coarse-textured glacial tills and outwash remaining from deep ice and flooding during the Pleistocene. These geological features, coupled with a warmer maritime climate and significant precipitation, create wet, deep organic soils as well as many small lakes, ponds, and wetlands, resulting in a mosaic of wildlife habitats (Nowacki et al. 2003).

Flowing from the glaciers of Wrangell-St. Elias National Park and Preserve, the Copper River drains the Wrangell and Chugach mountain ranges, terminating in the Gulf of Alaska just east of Prince William Sound. Highly valued for its rich salmon runs, the Copper River forms a delta nearly 50 miles wide, which provides habitat and a migratory stopover for millions of birds. The

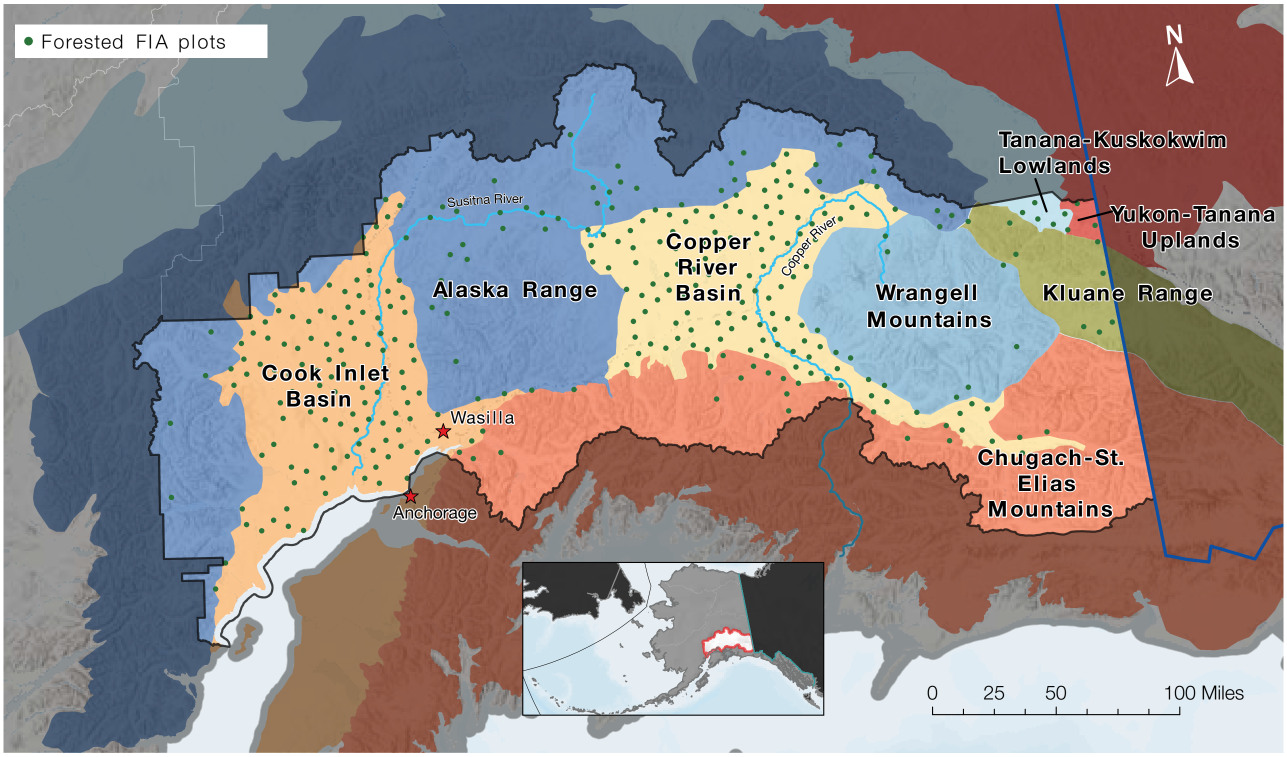

Figure 5—The Susitna-Copper Forest Inventory and Analysis (FIA) unit encompasses eight ecoregions in interior Alaska. The majority of forested plots (green dots) are in the Cook Inlet Basin and the Copper River Basin ecoregions, which coincide with the Susitna River and upper Copper River watersheds, respectively. Ecoregions follow Nowacki et al. (2003). Plot locations are approximate to meet confidentiality requirements. Map base layer source: ESRI (2015, 2017).

Copper River Basin ecoregion, as part of the former bed of Glacial Lake Ahtna, is a large wetland complex also underlain by fine-textured lacustrine deposits and coarse-textured glacial tills. In addition to deep, wet organic soils, large glacial rivers with wide, braided, gravel floodplains run throughout the basin supporting deciduous shrubs and trees (Nowacki et al. 2003).

Both watersheds support vast areas of boreal forests, open tundra, and rugged mountain ranges that are home to many of the tallest mountains in North America. Like the rest of the boreal region, these watersheds are relatively low in biodiversity, although moose (*Alces alces*), caribou (*Rangifer tarandus*), black bears (*Ursus americanus*), grizzly bears (*U. arctos*), and gray wolves (*Canis lupus*) are abundant. Smaller animals include voles, foxes, snowshoe hares (*Lepus americanus*), Canada lynx (*Lynx canadensis*), and mustelids (members of the weasel family, including wolverines [*Gulo gulo*]). The vast complex of wetlands and boreal forests, pockmarked by thaw ponds and larger lakes, provide important habitat for migrating and resident birds, such as hawks, waterfowl, finches, warblers, and others (fig. 6).

Today, many residents of both the Susitna and Copper River regions live rural lifestyles that are intimately intertwined with the land and seasons, often relying on subsistence hunting and fishing. The Susitna River watershed is part of the historic home of the Dena'ina Athabascan people. The upper Copper River watershed is part of the ancestral home of the Ahtna Athabascan people. The northeastern corner of the unit includes a small portion of the ancestral home of the Tanana Athabascans where it overlaps the Tanana-Kuskokwim Lowlands and Yukon-Tanana Uplands ecoregions. Locally harvested timber forest products in the region include house logs and firewood. Nontimber forest products are culturally important and include several berry-producing subshrubs and forbs, as well as other plants harvested for commercial, subsistence, or medicinal uses.

Climatically, the unit varies from a warm, wet coastal marine environment adjacent to the Chugach Mountains, to the dry and cold interior that represents a much larger portion of the unit (fig. 7). Both watersheds show similar precipitation patterns, with drier intermountain areas and higher precipitation in the steep Alaska Range, Chugach

Figure 6—The Susitna-Copper Forest Inventory and Analysis unit, as is typical of boreal forests, is characterized in places by a vast mosaic of wetlands and forests. This mosaic is particularly prevalent on the cold, poorly drained soils commonly found in the upper Copper River watershed. USDA Forest Service photo by Mike Ausman.

Mountains, and Wrangell Mountains. Because of the warming influence of the marine environment of Cook Inlet, the Susitna River watershed has warmer annual temperatures than the Copper River watershed, while the extreme topography of the Wrangell Mountains—with elevations more than 16,000 feet and some of the largest glaciers in the world—acts as a sink for cold, dense air, resulting in extremely cold wintertime temperatures relative to the Susitna River watershed (fig. 8). Consequently, modeling suggests that the forested areas of the Susitna River watershed are unlikely to contain near-surface permafrost, while those of the upper Copper River watershed are more likely to contain the discontinuous permafrost more typical of boreal forests (Pastick et al. 2015). Sites underlain by permafrost tend to be poorly drained, which restricts forest productivity, while areas with deeper active layers or no permafrost and those on well-drained upland sites exhibit higher tree-growth rates and more tree volume. Throughout this report, forested plots, mainly in the Susitna River basin, which fall in the warmer western portion of the Susitna-Copper FIA unit, are referred to as in the Susitna River watershed, while forested plots in the colder eastern portion of the unit, mainly in the Copper River watershed, are referred to as in the upper Copper River watershed.

Area and Composition

Land Cover

The Susitna-Copper FIA unit has an estimated 9.1 million forested acres that cover nearly one-third of the unit's total land area (31.6 million acres) (fig. 9). Timberland[4] area (the unreserved, productive component of forest land) is estimated at 1,324,300 acres (4 percent of the total unit area), while low productivity forests comprise 84 percent of forest land (24 percent of total unit area [7,593,900 acres]). Although the unit has more than 10 million acres of reserved land, primarily located in Wrangell-St. Elias National Park and Preserve, much of this land is vegetated nonforest or barren rock and snow. Reserved forest land[5] is only 6 percent of the unit's land area at 1,902,200 acres (fig. 9), with 93 percent of these forests being low productivity.

[4] Timberland is forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from management for production of wood products by statute or administrative mandate (unreserved). Areas qualifying as timberland are capable of producing more than 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.

[5] Reserved forest land is forest land permanently prohibited from being managed for the production of wood products through statute or agency mandate; the prohibition cannot be changed through a decision by the land manager. Examples include state and national parks and congressionally designated wilderness areas.

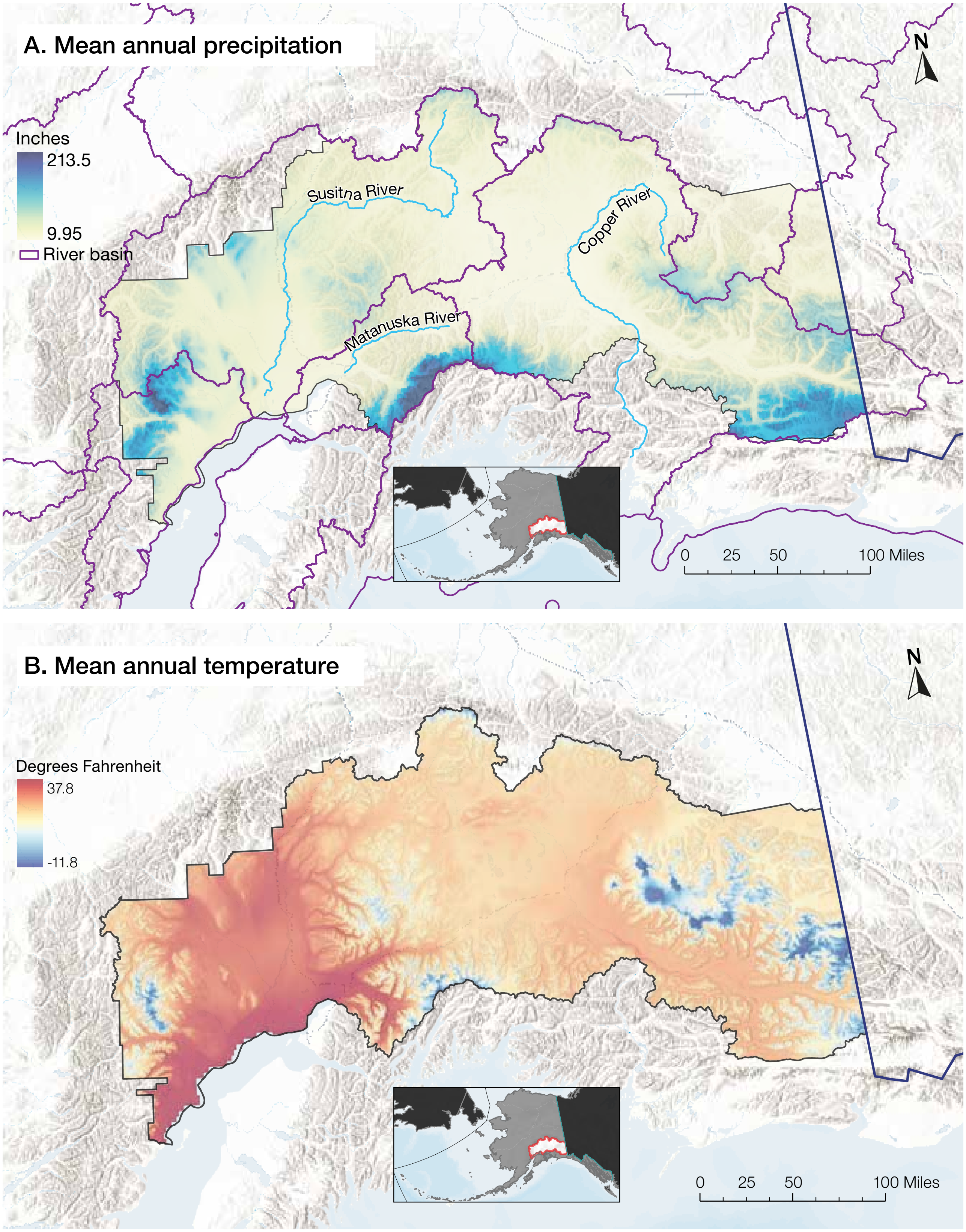

Figure 7—Regional climate of the Susitna-Copper Forest Inventory and Analysis unit: (A) 30-year normal mean annual precipitation, and (B) mean annual temperature, 1981–2010. Data were generated using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) at 800-meter resolution (Daly et al. 2018). The solid black lines represent FIA unit boundaries. Purple-lined river basin boundaries in map A also approximately indicate the Susitna River and upper Copper River watersheds discussed in this report. Map base layer source: ESRI (2015, 2017).

Figure 8—The Susitna-Copper Forest Inventory and Analysis unit is characterized by extreme topography. Photo courtesy of Joe Vorderbruggen, State of Alaska.

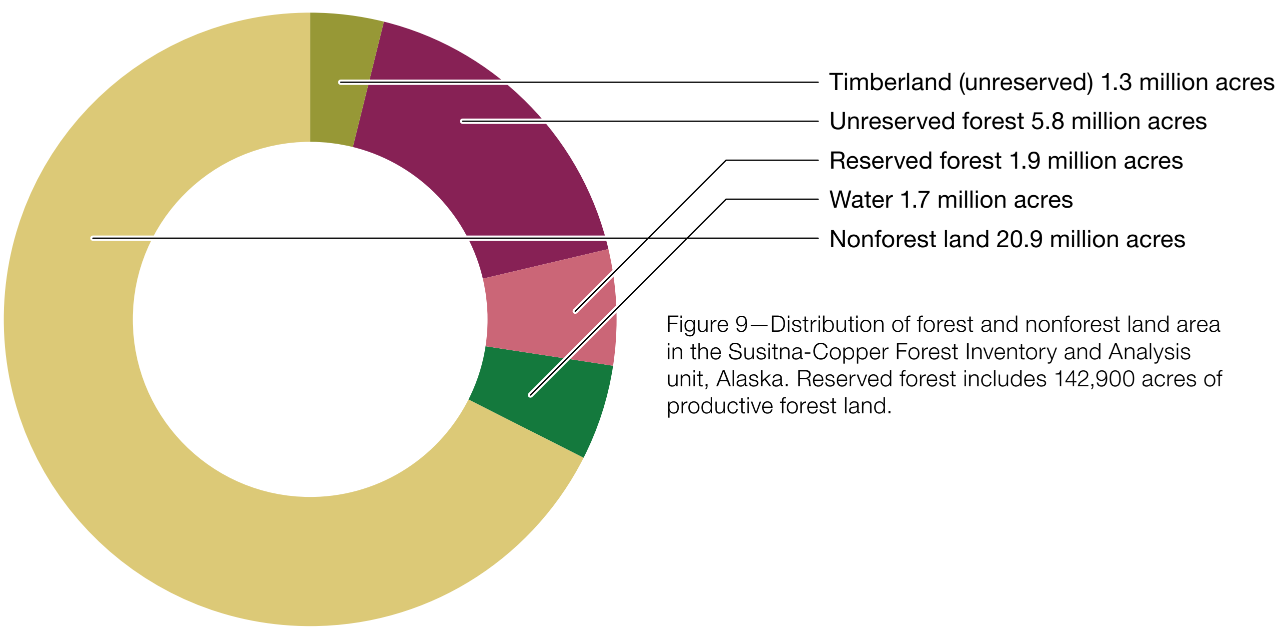

Figure 9—Distribution of forest and nonforest land area in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Reserved forest includes 142,900 acres of productive forest land.

The majority (67 percent) of forests in the Susitna-Copper FIA unit are coniferous, with hardwood forests covering an additional 32 percent. Nonstocked forests—forested areas that currently lack 10-percent tree stocking (typically because of recent disturbance)—make up less than 1 percent of forest area in the Susitna-Copper FIA unit.

Species Composition

Like the rest of interior Alaska, forests of the Susitna-Copper FIA unit show low species diversity, with only six tree species recorded. Although many forest stands in interior Alaska contain a mixture of tree species, the FIA program designates forest type[6] by the species with the plurality of live-tree stocking of non-overtopped trees in the plot area. Black spruce forest type occupies the most area at 3.2 million acres (35 percent of the forested area), followed by white spruce at 2.9 million acres (32 percent of forested area). The most common hardwood forest type, Alaska paper birch (*Betula neoalaskana*), covered 2.3 million acres (25 percent). Other hardwood forest types had significantly smaller percentages of cover—quaking aspen (*Populus tremuloides*) had 0.3 million acres (3 percent of forested area), balsam poplar (*Populus balsamifera* L.) had 0.2 million acres (2 percent of forested area), and black cottonwood (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw) had 0.15 million acres (1.7 percent of forested area) (fig. 10).

Hardwood forest types dominate the warmer western portion of the Susitna-Copper FIA unit (mainly in the Susitna River watershed), while the colder eastern portion of the unit, mainly in the upper Copper River watershed, contains primarily coniferous (softwood) forest types (fig. 11). The warmer air temperatures and lack of permafrost in the Susitna River watershed promote more mature, well-drained soils there, contributing to the prevalence of hardwood species. Additionally, significant mortality due to spruce beetles in large white and black spruce in the Susitna River watershed likely reduced the number of recorded coniferous forest types there. In the upper Copper River watershed, the frequency of black spruce indicates that the watershed maintains colder, wetter soils because of colder air temperatures and more widespread permafrost (Mann et al. 1995).

Ownership

Forest land in the Susitna-Copper FIA unit is under a variety of public and private ownerships (table 2, fig. 12). Most of the forest land (82 percent) is managed publicly, with the State of Alaska and local governments managing 5.4 million acres (60 percent), and the federal government (including the National Park Service and the Bureau of Land Management) managing 2 million acres (22 percent). The remaining 1.6 million acres is held privately, with corporations (including Alaska Native corporations) owning most. Unlike in states with more intensively managed forests, there is not a substantial difference in forest land metrics (e.g., tree volume) in the Susitna-Copper FIA unit between reserved and unreserved areas, as the timber industry in interior Alaska remains very

[6] Most forests contain multiple tree species but are grouped into a single forest type. Forest type usually describes the species with the plurality of non-overtopped live trees (e.g., black spruce [*Picea mariana* (Mill.) Britton, Sterns & Poggenb.] or quaking aspen [*Populus tremuloides* Michx.] forest types).

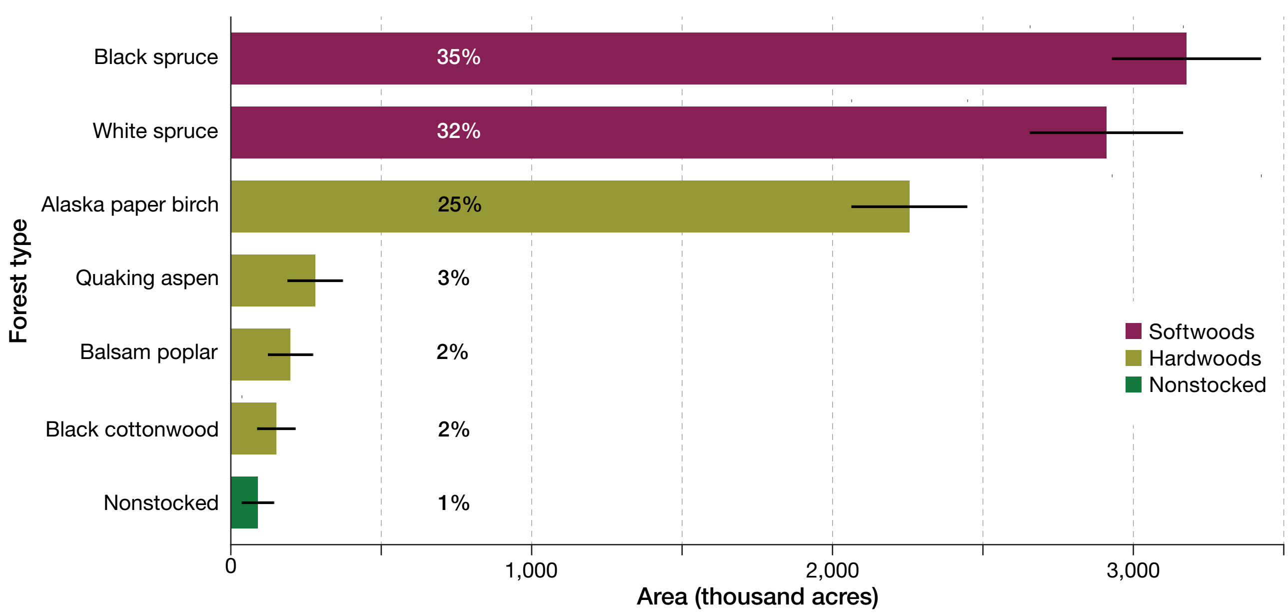

Figure 10—Distribution of forest area by forest type in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Of the six forest types recorded, black spruce and white spruce forest types make up 67 percent of the total forested area of 9.1 million acres. Hardwoods comprise a much smaller portion, with Alaska paper birch by far the most well-represented hardwood. Solid bars represent the total; error bars are ± 1 standard error; nonstocked has <10 percent live-tree stocking.

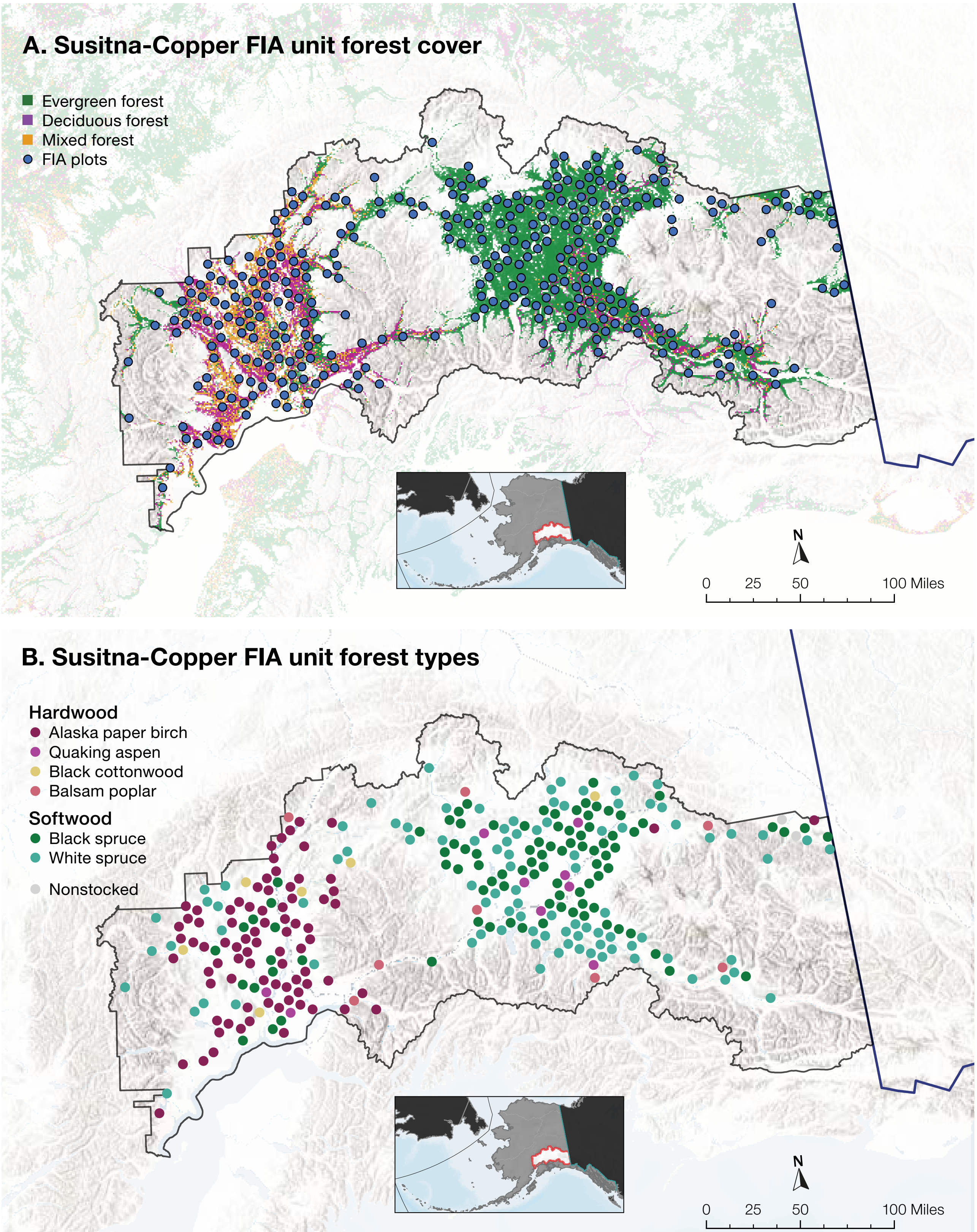

Figure 11—(A) Forest cover in the Forest Service, Forest Inventory and Analysis (FIA) Susitna-Copper unit underlying FIA forested plots (source: USDI GS [2020]) and (B) primary forest types recorded at sampled FIA plot locations. FIA forest type represents either the forest type with the highest proportion of plot area, or the forest type at point center on plots with multiple forest types of equal area. Not all FIA plot locations shown in (A) were sampled. Continuous forest cover layer source: Jin et al. (2017). Plot locations are approximate to meet confidentiality requirements. Map base layer source: ESRI (2015, 2017).

Table 2—Area of forest land by ownership group and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

	Forest land status													
	Unreserved forests						Reserved forests							
	Timberland		Other forest		All		Productive		Other forest		All		All forest land	
Ownership group	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	THOUSAND ACRES													
Federal government														
National Park Service	—	—	—	—	—	—	—	—	1,460.4	111.7	1,460.4	111.7	1,460.4	111.7
Bureau of Land Management	—	—	526.1	85.8	526.1	85.8	—	—	33.5	33.3	33.5	33.3	559.6	83.5
All federal	—	—	526.1	85.8	526.1	85.8	—	—	1,493.9	116.6	1,493.9	116.6	2,020.0	139.5
State and local government														
State	996.9	145.5	3,810.3	230.0	4,807.2	229.2	142.9	67.4	265.5	91.5	408.4	112.8	5,215.6	230.2
Local	152.3	65.7	53.8	41.6	206.2	75.7	—	—	—	—	—	—	206.2	75.7
All state and local	1,149.2	151.2	3,864.2	230.9	5,013.4	225.3	142.9	67.4	265.5	91.5	408.4	112.8	5,421.8	223.7
Private														
Corporate	93.1	49.7	1,405.5	120.6	1,498.6	121.5	—	—	—	—	—	—	1,498.6	121.5
Individual	82.1	49.0	38.7	35.2	120.8	59.1	—	—	—	—	—	—	120.8	59.1
All private	175.1	68.8	1,444.2	117.4	1,619.4	108.5	—	—	—	—	—	—	1,619.4	108.5
All ownerships	1,324.3	166.2	5,834.5	264.7	7,158.9	246.9	142.9	67.4	1,759.4	147.6	1,902.2	161.7	9,061.1	260.1

Note: Totals may be off because of rounding. Data are subject to sampling error.
— = no estimate, SE = standard error.

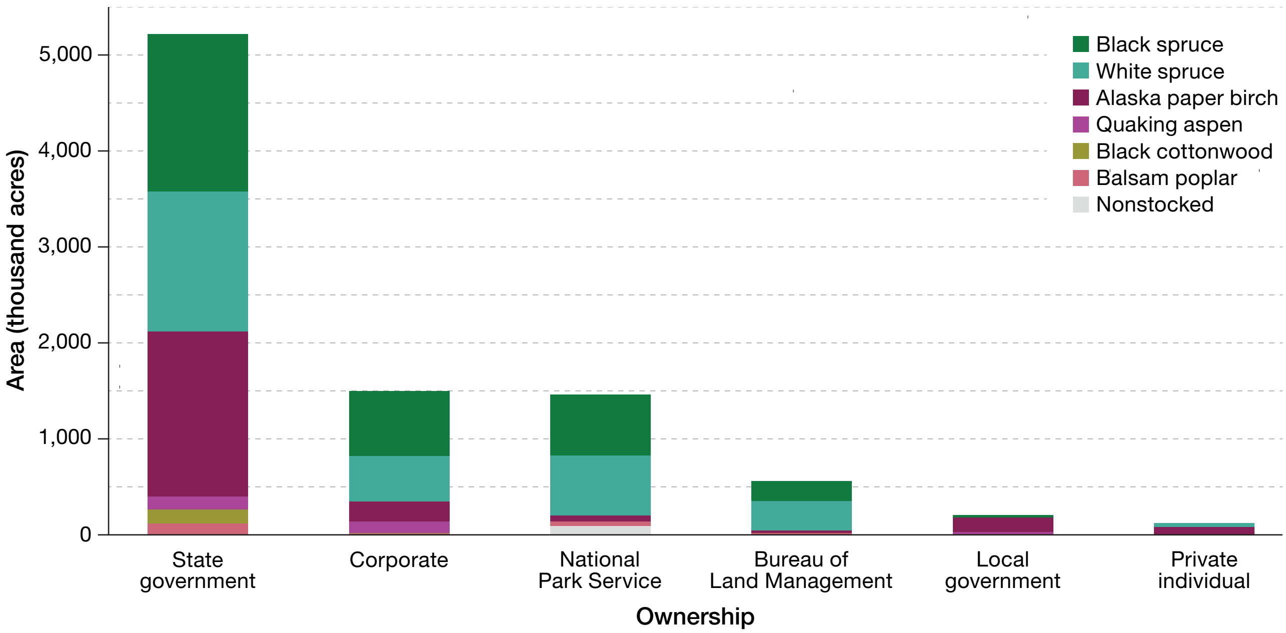

Figure 12—Forest land area by ownership and forest type in the Forest Service, Forest Inventory and Analysis Susitna-Copper Forest Inventory and Analysis unit, Alaska. Solid bars represent total area of ownership.

small, partly because the proportion of timberland in the area is relatively low (Marcille et al. 2021).

The State of Alaska is the largest landowner in both the Susitna River watershed and the upper Copper River watershed, managing 73 percent of all hardwood forest across the unit (2.1 of 2.9 million acres) and 51 percent of all softwood forest (3.1 of 6.1 million acres). The state also manages 75 percent of the unit's 1.3 million acres of timberland (productive, unreserved forest). The 1.5 million acres of corporate forest land includes land owned by Alaska Native corporations and villages and primarily comprises softwood forest types in the upper Copper River watershed; 78 percent of corporate land has a white spruce or black spruce forest type. Because of its proximity to the population centers of Anchorage and Wasilla, the Susitna River watershed contains nearly all 120,000 acres of forested noncorporate private land, 68 percent of which has a forest type of Alaska paper birch. Wrangell-St. Elias National Park and Preserve accounts for 72 percent of the forested federal land in the unit;[7] 86 percent of forested National Park Service land is black or white spruce (1.3 of 1.5 million acres). The National Park Service manages 77 percent of the Susitna-Copper FIA unit's 1.9 million acres of reserved forest land (table 2, fig. 13).

Forest Structure

Number of Trees

More than 5 billion live trees (≥1 inch DBH)[8] make up the Susitna-Copper FIA unit's 9.1 million forested acres, or about 563 trees per acre. While the softwoods balsam poplar, black cottonwood, and quaking aspen make up a small component of the overall number of trees (particularly in the larger diameter classes), most trees in the Susitna-Copper FIA unit are black spruce, white spruce, and Alaska paper birch (fig. 14). Live black spruce saplings <5 inches DBH make up more than 50 percent of the total, with 2.8 billion individuals. Although white spruce represents a larger proportion of live trees in larger diameter classes than does black spruce, most live trees ≥12 inches DBH are Alaska paper birch, a pattern that is the result of a large spruce beetle outbreak that coincided with the Susitna-Copper inventory, and which dramatically altered the composition of the area's forests. The outbreak, which began in about 2015 (Brannoch

[7] The boundaries of the Susitna-Copper FIA unit were adjusted in the northeast to accommodate the northern boundary of Wrangell-St. Elias National Park and Preserve and in the northwest to exclude the entirety of Denali National Park and Preserve, which is measured in the Tanana FIA unit. The southern portions of Wrangell-St. Elias National Park and Preserve are included in the Coastal Alaska FIA unit.

[8] Seedlings (trees less than 1 inch DBH) are counted on FIA plots, but are not reported here.

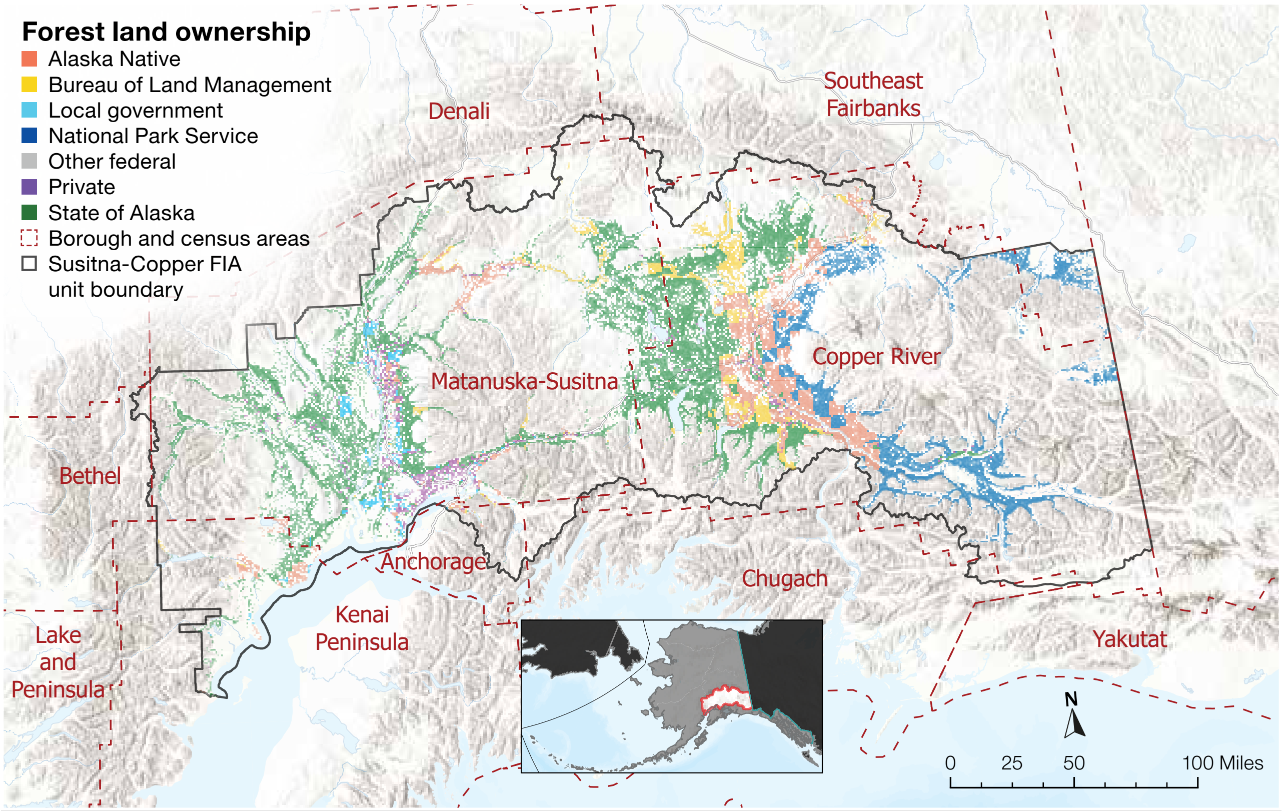

Figure 13—Forest land ownership in the Susitna-Copper Forest Inventory and Analysis (FIA) unit, Alaska. Continuous forest area map layer source: Jin et al. (2017); ownership data source: USDI BLM (2023); map base layer source: ESRI (2015, 2017).

and Moan 2021), caused significant mortality in spruce, particularly in the larger diameter trees preferred by the beetle (Werner et al. 2006). There are now 895 million standing dead trees in the unit, or nearly one dead tree per five live trees. White spruce represents more than 75 percent of snags ≥8 inches DBH in the Susitna-Copper FIA unit, though these trees are more prevalent in the Susitna River watershed than in the upper Copper River watershed (see the “Forest Health” section below).

Stand size, age, and structure

Soil temperature and moisture (often driven by the presence of permafrost), soil pH, slope, and aspect all strongly affect the composition of forests in the Susitna-Copper FIA unit (Hollingsworth et al. 2006). Stand size, which describes the predominant diameter class of live trees in a stand, was very small in the Susitna-Copper FIA unit, with 57 percent of forests classified as small-diameter stands, dominated by trees <5 inches DBH. Black spruce forests generally occupy low-productivity sites often underlain by permafrost, which results in slow growth rates and small stand sizes (Mann et al. 1995). About 95 percent of black spruce forests were classified as small-diameter (3 million of 3.1 million acres), although most of these forests (2.8 million acres, or 89 percent of all black spruce stands) were more than 60 years old, and the median stand age was 84.5 years. The warmer, more well-drained sites that are more often occupied by white spruce facilitate larger tree growth—44 percent of white spruce forests were classified as larger than 5 inches DBH. Despite their larger size, white spruce stands were generally younger than black spruce (median stand age of 75 years). The oldest and largest forests were Alaska paper birch and white spruce, which typify alluvial late-successional forests in the area (Helm and Collins 1997). Nearly two-thirds (1.5 million acres) of Alaska paper birch forests were classified as large-diameter stands (stands where most trees are ≥11 inches DBH) and the median stand age for Alaska paper birch forests was 86 years (fig. 15). Quaking aspen, black cottonwood, and balsam poplar forests were typically younger and smaller than Alaska paper birch forests (fig. 16).

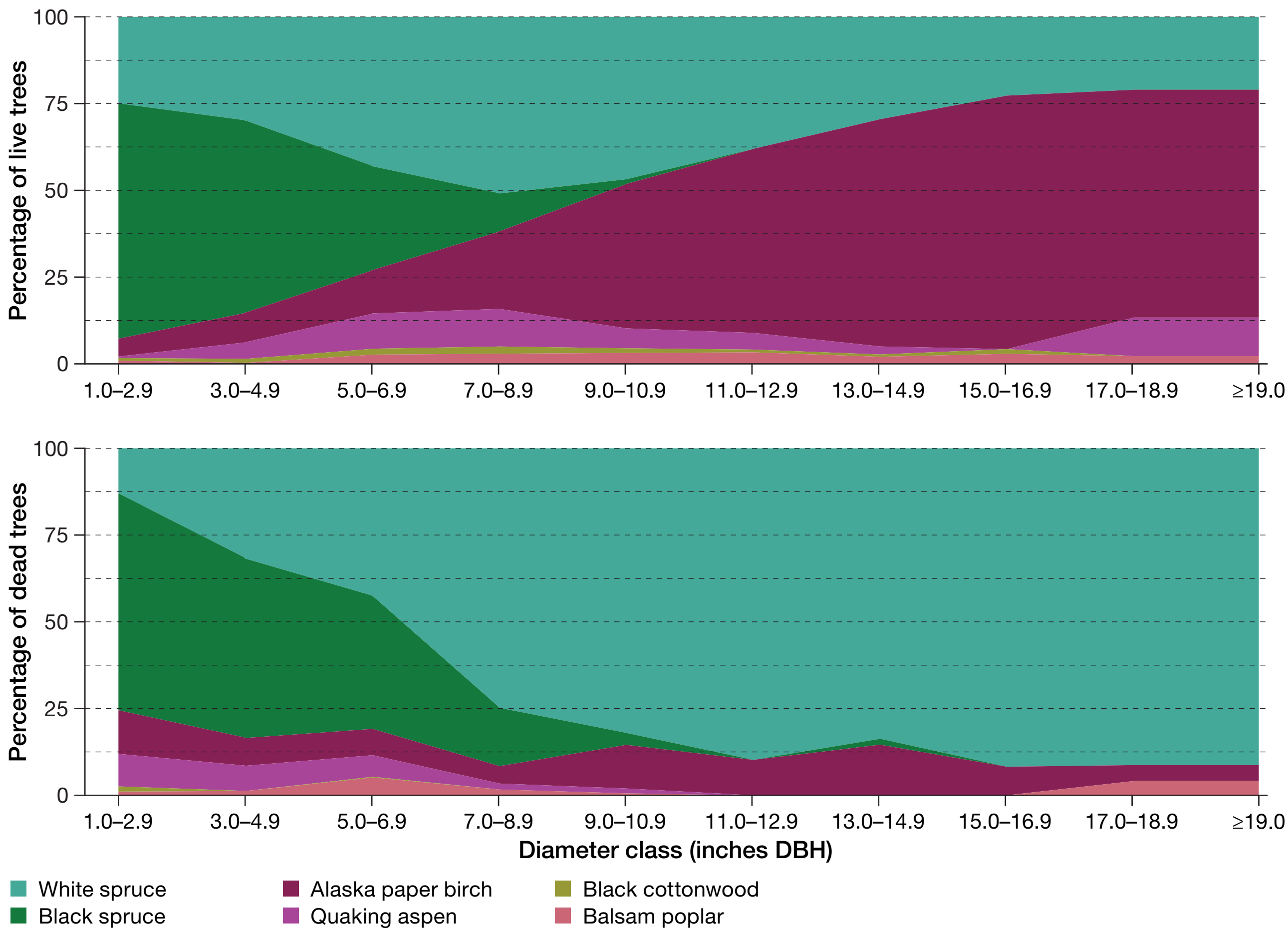

Figure 14—Proportional species composition for individual live and standing dead trees on forest land by diameter class, in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. DBH = diameter at breast height.

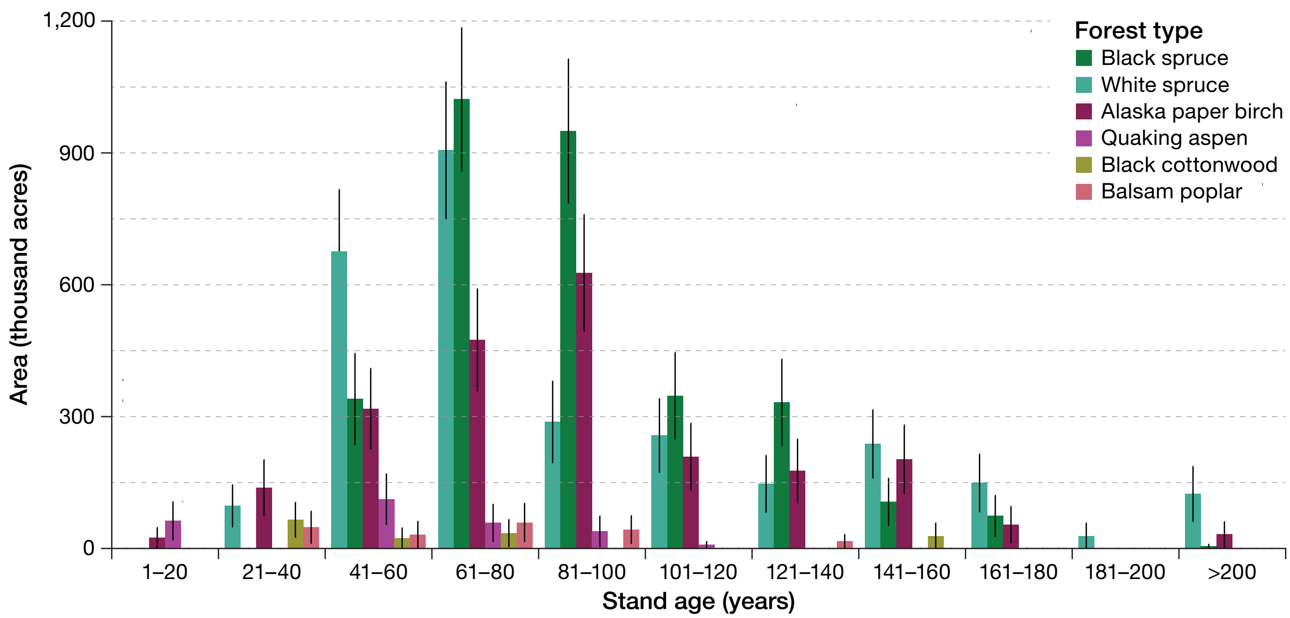

Figure 15—Stand age distributions for all forest types recorded in the Susitna-Copper Forest Inventory and Analysis unit. Solid bars represent the total; error bars are ± 1 standard error.

Figure 16—Crew members hike through a dense quaking aspen stand, Alaska. Quaking aspen stems frequently exhibit high stem density and younger stand age, as they are an early-successional species. USDA Forest Service photo by Sarah Ellison.

Forest Inventory and Analysis (FIA) Tree-Ring Analyses Indicate Importance of Winter Temperature and Precipitation for White Spruce Growth in Alaska Boreal Forests

Colin Maher and Sean Cahoon [1]

Our inventory of interior Alaska boreal forests included analyses of a collection of tree cores from U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) plots in the Tanana, Susitna-Copper, and Southwest FIA inventory units.

By linking tree-ring data with the spatially extensive FIA plot network, we can investigate how trees are responding to climate in ways not possible with most tree-ring studies nor with FIA inventory data alone. Tree-ring samples give us year-to-year growth records for a tree over decades or centuries, and the FIA sampling design gives us a balanced spatial representation. Combined, they provide unique insight into tree growth across large regions of forest. The interior Alaska FIA tree-ring collection protocol is a collaboration between the Forest Service, Pacific Northwest Research Station and the Environment and Natural Resources Institute (ENRI) at the University of Alaska Anchorage. Since 2016, tree cores have been regularly collected from FIA plots in the interior and coastal Alaska units, primarily from trees measured under FIA site and age protocols. All FIA tree cores are delivered to ENRI's tree-ring laboratory where they are processed, measured, and cross-dated if possible.

In our analyses, we focused on a subset of white spruce (*Picea glauca* (Moench) Voss) samples from 956 trees (from 307 FIA plots) collected in 2016–2022 that we subjected to a secondary computer-based cross-dating check to ensure our correlation results are as reliable as possible.

Many tree-ring and climate analyses use a small set of predefined seasons, such as June–August temperature or November–April precipitation. This may answer questions about the influence of these very specific periods on tree growth, but it does not tell us what seasons have the strongest influence across a region. To answer this broader question, we developed the modendro package for R (Maher 2024) with a function that uses a data-driven approach to examine correlations with 78 possible

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Understory Vegetation[9]

Enhanced understanding of the species composition and structure of forest understory provides insight into forest health and resilience, carbon storage, wildlife habitat availability, underlying hydrological conditions, and species and vegetation community distributions across the landscape. On each forest and field-visited nonforest plot in the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) Susitna-Copper FIA unit, crews collected data on the dominant species composition and structure of understory vascular plant communities using methods described in the field manual vegetation protocol (USDA FS 2020). Structural data for understory species described aerial cover overall and by height layers for species grouped according to their growth habit: shrubs, forbs, and graminoids. Aerial cover of up to four vascular plant species within each growth habit was also recorded for each condition encountered by the crews, provided that aerial cover of the species met or exceeded a 3-percent threshold on the subplot.

Vascular vegetation cover in forest understories tended to be low across forested plots in the Susitna-Copper FIA unit (mean of all vascular growth habits combined: 20.67 ± 0.50 percent), although the degree of cover varied among forest types. Hardwood-dominated stands (particularly Alaska paper birch and black cottonwood stands) tended to have greater overall understory cover than softwood-dominated stands, a pattern attributable to greater forb cover in these forest types. Alaska paper birch and black

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monthly combinations of variables within a 12-month "relevant growth period" that covers October of the previous calendar year through September of the current calendar year of growth. We used monthly climate time series from ClimateNA (Wang et al. 2016) for the period 1960–present, extracted for each FIA plot location. To avoid problems with correlation analyses, we removed autocorrelation from both tree-ring and climate series by fitting ARIMA models and extracting residuals. This means that the data no longer contain trends and only retain the year-to-year variability. We repeated this analysis for each tree-ring series from 956 white spruce trees, yielding 74,568 total correlation results each for monthly temperature and precipitation variables. We identified the most important monthly combinations by counting the number of trees with statistically significant ($P \leq 0.05$) positive and negative Spearman rank correlations between ring-width indices and each monthly combination.

When mapped across the landscape, the data show how tree growth has responded to the same combinations of climate variables among FIA inventory units (fig. 17) (Susitna-Copper is highlighted with a bold white outline). Negative correlations with winter (January–April) mean temperatures (fig. 17: top left panel) were the most frequent correlations we found (152 significant negative, 2 significant positive) and were well distributed across the inventory units. The most frequent positive correlation was with summer (June–July) mean temperature (86 significant positive, 25 significant negative), mostly concentrated in the Susitna-Copper FIA unit, with some significant positive and negative correlations elsewhere (fig. 17: top right panel). The most frequent negative correlations with precipitation were with January totals (61 significant negative, 13 significant positive), mostly in the Susitna-Copper and Southwest FIA units (fig. 17: bottom left panel). Lastly, the most frequent positive correlations with precipitation were with late winter (February–March) totals (93 significant positive, 9 significant negative), again concentrated in the Susitna-Copper and Southwest FIA units (fig. 17: bottom right panel).

This analysis does not tell us if trends in tree growth are associated with trends in climate (e.g., increasing mean temperatures over time). Our analyses indicate that (1) years when winter temperature increases relative to the previous year tend to co-occur with similar decreases in growth in the subsequent growing season; (2) in the Susitna-Copper FIA unit—but not elsewhere—years when summer temperature increases relative to the previous year tend to co-occur with similar increases in growth; (3) years when total early spring–early fall precipitation increases relative to the previous year tend to co-occur with a similar decrease in growth—especially in the Susitna-Copper FIA unit; and (4) years when late-winter precipitation increases relative to the previous year tend to co-occur with similar increases in growth in the subsequent growing season. While the exact mechanisms that drive these correlations are still unknown, evidence does not indicate that summer drought has been a major factor affecting white spruce in interior Alaska. Instead, white spruce growth responses to changing climate may be more complex, with winter conditions playing a larger role than we previously thought.

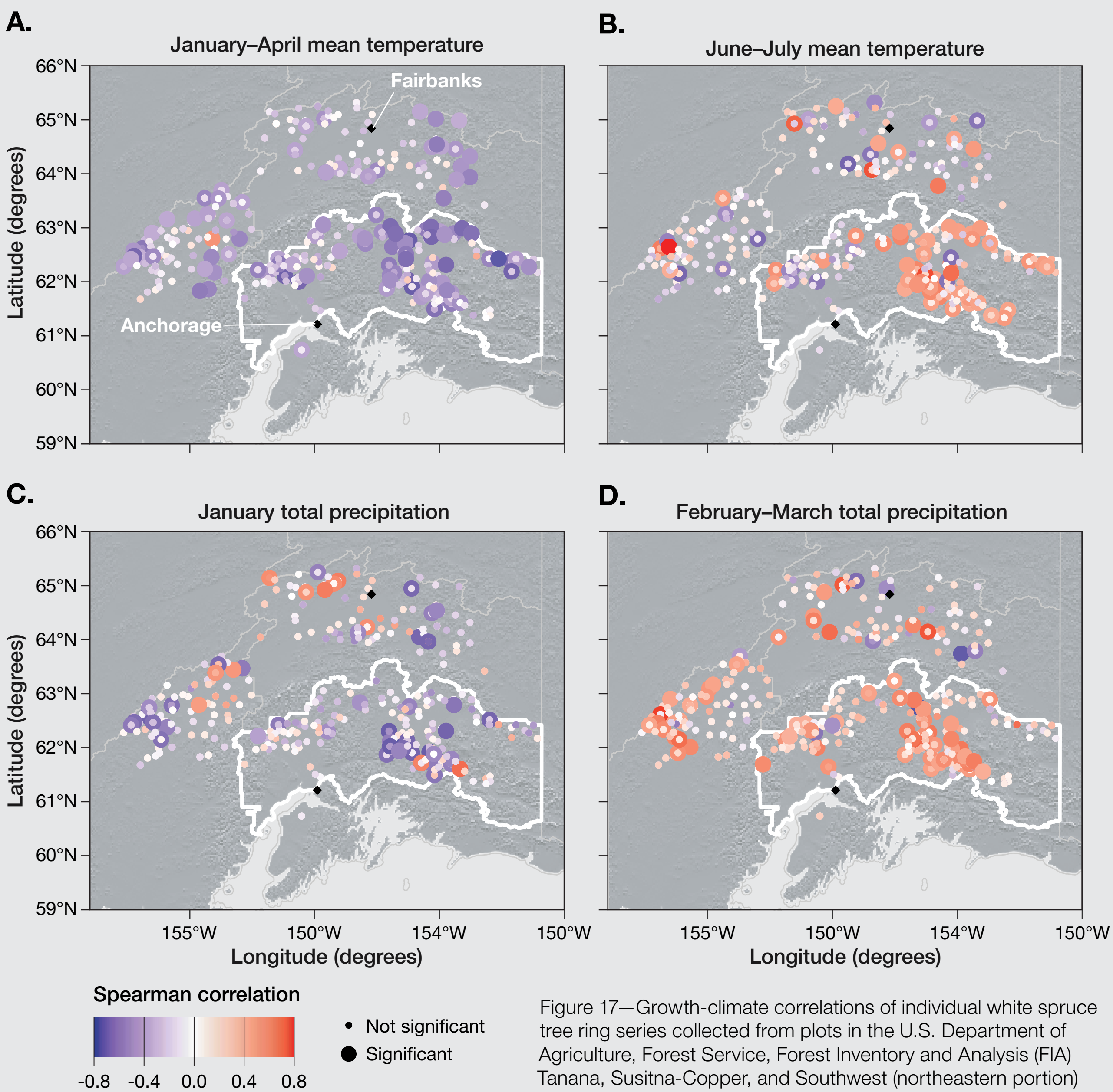

Figure 17—Growth-climate correlations of individual white spruce tree ring series collected from plots in the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) Tanana, Susitna-Copper, and Southwest (northeastern portion) units (956 white spruce trees sampled). All correlations are Spearman rank correlations between white spruce tree-ring growth and (A) January–April and (B) June–July mean temperature, and (C) January and (D) February–March total precipitation. Point locations represent public FIA plot locations. Red represents positive correlations; blue represents negative correlations. Significant correlations ($P \geq 0.05$) are indicated by larger points.

cottonwood forests had the greatest overall understory vascular plant cover (27.12 ± 1.09 and 24.64 ± 4.93 percent, respectively), while black spruce and balsam poplar stands had the lowest vascular plant understory cover of all forest types (16.80 ± 0.63 and 16.58 ± 4.32 percent, respectively). Shrubs represented the greatest proportion of understory cover in all forest types except Alaska paper birch forests, where forbs represented a greater proportion of understory cover. Overall, vascular plant cover tended to either increase with stand age or peak at an intermediate stand age for most forest types. Young, recently disturbed stands less than 40 years old had the highest forb cover, while shrub cover increased sharply in stands 20 or more years postdisturbance. The trajectory of overall understory vegetation cover postdisturbance mirrored that of shrub cover (fig. 18). For additional information, please see the online supplemental tables available for download via https://doi.org/10.2737/pnw-gtr-1037.

Ground Cover

FIA crews in the Susitna-Copper FIA unit measured the depth and cover of nonvascular ground layer functional groups within 32, 20- × 50-centimeter microquadrats at each plot (fig. 19). Functional groups measured under this protocol and their ecosystem functions are outlined in *Forest Resources of the Tanana Unit, Alaska: 2018* (Cahoon and Baer 2022) and in *Field Instructions for the Annual Inventory of Alaska, 2020* (USDA FS 2020) and include mosses, lichens, and liverworts. Calibration equations were applied to translate nondestructive field measurements into estimates of volume, dry biomass, total carbon content, and total nitrogen content for each functional group in the ground layer at the plot level (Smith et al. 2015).

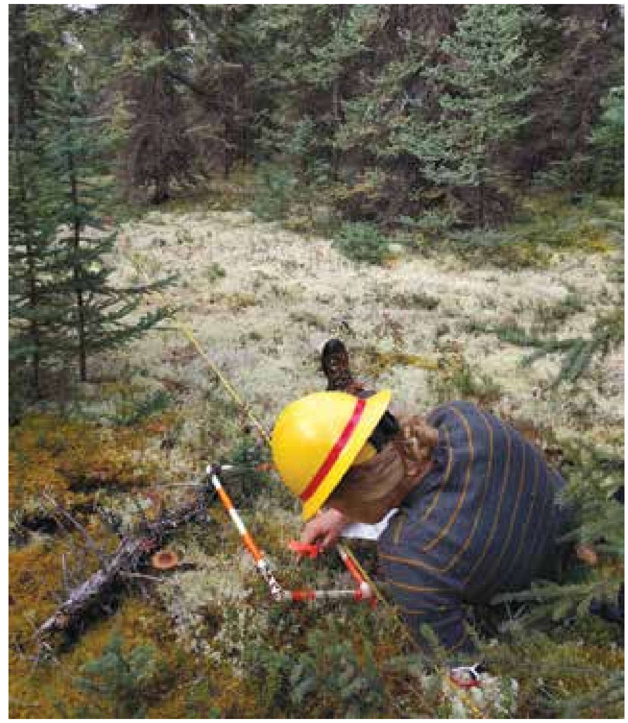

Figure 19—A crewmember evaluates dense lichens and feather mosses in a spruce forest in Alaska. Field crews assessed mosses, lichens, and liverworts by recording cover and depth of 13 ground layer functional groups within 32 microquadrats on each plot. USDA Forest Service by Sarah Ellison.

Across all forest types, nitrogen-fixing feather mosses contributed by far the most biomass per acre of any functional group (2.72 ± 0.16 tons per acre), with *Sphagnum* peat moss contributing the next highest amount of biomass (0.87 ± 0.13 tons per acre) (table 3). Coniferous forest types had substantially higher overall biomass in ground cover per acre than hardwood forest types (6.80 ± 0.30 tons per acre across softwood forest types; 1.42 ± 0.22 tons per acre across hardwood forest types). The black

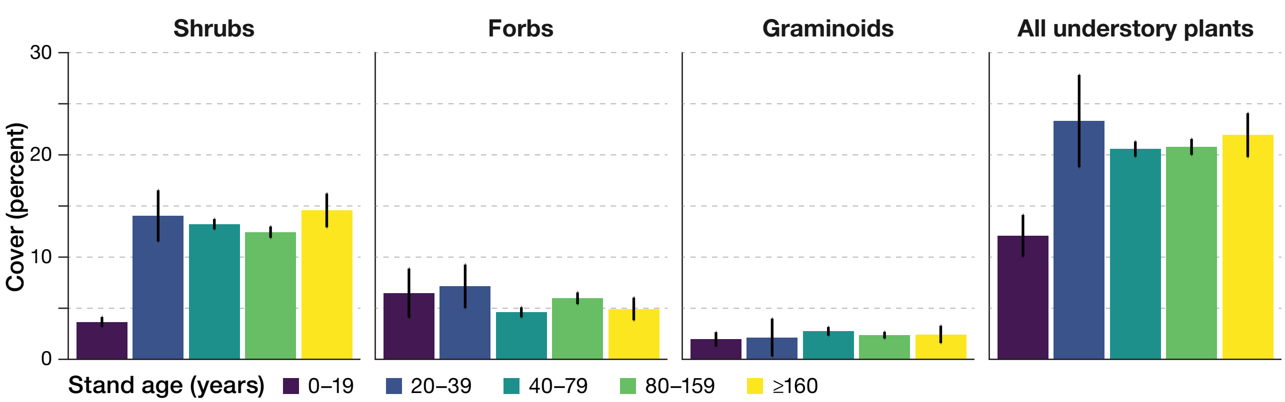

Figure 18—Aerial cover of understory vascular vegetation by growth habit (shrub, forb, graminoid) and forest stand age class. Solid bars represent the mean; error bars are ± 1 standard error. Credit: Kathryn Baer.

Table 3—Ground layer biomass per acre by forest type and functional group, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

	Ground layer functional groups																			
	Forage lichens		Nitrogen-fixing foliose lichens		Nitrogen-fixing fruticose lichens		Feather (branched) mosses		Nitrogen-fixing feather mosses		*Sphagnum* peat moss		Turf (upright) mosses		Stem-and-leaf liverworts		Other functional groups[a]		All functional groups	
Forest type	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE
	TONS PER ACRE																			
Softwoods																				
White spruce	0.14	0.02	0.06	0.01	0.03	0.00	0.50	0.10	3.72	0.37	0.45	0.14	0.52	0.10	0.06	0.03	0.01	0.00	5.48	0.43
Black spruce	0.59	0.07	0.08	0.01	0.06	0.01	0.75	0.12	3.83	0.25	1.87	0.31	0.74	0.10	0.03	0.01	0.02	0.01	7.97	0.38
All softwoods	0.38	0.04	0.07	0.00	0.04	0.01	0.63	0.08	3.78	0.22	1.20	0.18	0.64	0.07	0.05	0.01	0.02	0.00	6.80	0.30
Hardwoods																				
Alaska paper birch	—	—	—	—	—	—	0.41	0.13	0.57	0.15	0.27	0.13	0.14	0.03	—	—	—	—	1.41	0.26
Quaking aspen	0.06	0.05	0.11	0.07	0.02	0.01	0.45	0.24	0.43	0.23	—	—	0.75	0.46	0.02	0.02	—	—	1.83	0.63
Black cottonwood	—	—	—	—	—	—	0.12	0.06	0.77	0.70	—	—	0.04	0.01	—	—	0.01	0.01	0.94	0.71
Balsam poplar	0.01	0.01	0.04	0.03	—	—	0.23	0.08	0.80	0.43	—	—	0.25	0.11	—	—	—	—	1.35	0.56
All hardwoods	0.01	0.01	0.02	0.01	—	—	0.38	0.11	0.59	0.13	0.21	0.10	0.20	0.06	0.01	0.00	—	—	1.42	0.22
Other nonstocked																				
<10 percent live-tree stocking	—	—	0.01	0.01	—	—	—	—	0.02	0.01	0.08	0.08	1.01	0.01	—	—	—	—	1.13	0.05
All forest types	0.26	0.03	0.05	0.00	0.03	0.00	0.55	0.06	2.72	0.16	0.87	0.13	0.50	0.05	0.03	0.01	0.01	0.00	5.03	0.24

Note: Data are subject to sampling error; per acre averages were calculated using a ratio of means formula across plots within forest types.

— = no estimate, SE = standard error.

[a] Five ground cover functional groups were combined as they were estimated to have less than 0.005 tons per acre in any forest type: flat (thalloid) liverworts, other foliose lichens, other fruticose lichens, orange crustose lichens, and biotic soil crusts.

spruce forest type had the most ground cover biomass of any forest type, and *Sphagnum* peat moss had the highest biomass per acre in this forest type. Average ground cover biomass per acre was relatively consistent across hardwood forest types, with quaking aspen having the highest ground cover biomass and black cottonwood the least (1.83 ± 0.63 and 0.94 ± 0.71 tons per acre, respectively).

Forest Volume, Biomass, and Carbon

Volume on Forest Land and Timberland

FIA volume estimates are generated from a tree's measured diameter and height, using equations developed from destructive sampling (Westfall et al. 2024). Forest volume provides a measure of commercial value and productivity of forests. Sound volume deducts cubic feet for portions of the stem that are rotten (live trees) and missing (both live and dead trees), with no volume deductions taken for poor form. Sound volume reported here is computed for the merchantable bole, defined as the central stem from a 1-foot stump to a minimum 4-inch diameter outside bark. In the Susitna-Copper FIA unit, total live-tree volume for trees ≥5 inches DBH on forest land was 4.8 ± 0.4 billion cubic feet (total and standard error), or 524 ± 38 cubic feet per acre on average. Per acre, this value is extraordinarily low—comparatively, coastal Alaska has an average sound volume of live trees per acre of 3,785 ± 76 cubic feet per acre. The relatively low live-tree volume in the unit is primarily because of the predominance of black spruce, a slow growing, low-productivity species adapted to the poor site conditions common to the area (fig. 20). Ninety-six percent of individual black spruce trees in the Susitna-Copper FIA unit were <5 inches DBH and therefore did not meet the minimum diameter threshold used to estimate live-tree volume. Despite being 35 percent of forest land by area, black spruce forests accounted for only 8 percent of all live-tree volume.

Timberland, a subset of forest land, represents the most productive portion of the forest; it comprises 29 percent of all live-tree sound volume in the Susitna-Copper FIA unit (1,363 ± 228 million cubic feet). Most of the live-tree volume (56 percent) is on unreserved, low-productivity forest land (2,661 ± 300 million cubic feet). Only 4 percent of live-tree volume is on reserved, productive forest land. The proportion of forest land volume that was on timberland differed dramatically among forest types, demonstrating the relatively low productivity of

Figure 20—A black spruce forest in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Black spruce forests are often very dense. Despite this, slow growth caused by poor site conditions results in low volume of live trees for this forest type. USDA Forest Service photo.

most forests in the Susitna-Copper FIA unit (fig. 21). The Alaska paper birch forest type contains half of the volume of all forest land and is the only forest type with significant timberland. These forests alone represent 80 percent of live-tree volume across all timberland (1,084 ± 215 million cubic feet of 1,363 ± 228 million cubic feet). By area, about half of all Alaska paper birch forests in the unit are timberland (1.1 ± 0.2 of 2.3 ± 0.2 million acres). No black spruce forests are considered timberland.

Alaska paper birch and white spruce are economically important species for Alaska. Primarily used for house logs, fuelwood, and biomass/energy, white spruce and birch species combined account for 90 percent of non-sawlog timber harvest in the state by volume (Simmons et al. 2024). Normalized by area, average live-tree sound volume per acre across the entire unit was much higher in hardwood stands than in softwood stands (hardwoods: 1,017 ± 82 cubic feet per acre; softwoods: 299 ± 37 cubic feet per acre). With the exception of live trees in white spruce forests, all forest types had a higher average live-tree sound volume per acre in the Susitna-Copper FIA unit than they did in the Tanana FIA unit, likely as a result of warmer temperatures and reduced fire disturbance in the Susitna-Copper FIA unit (fig. 22). Despite the bark

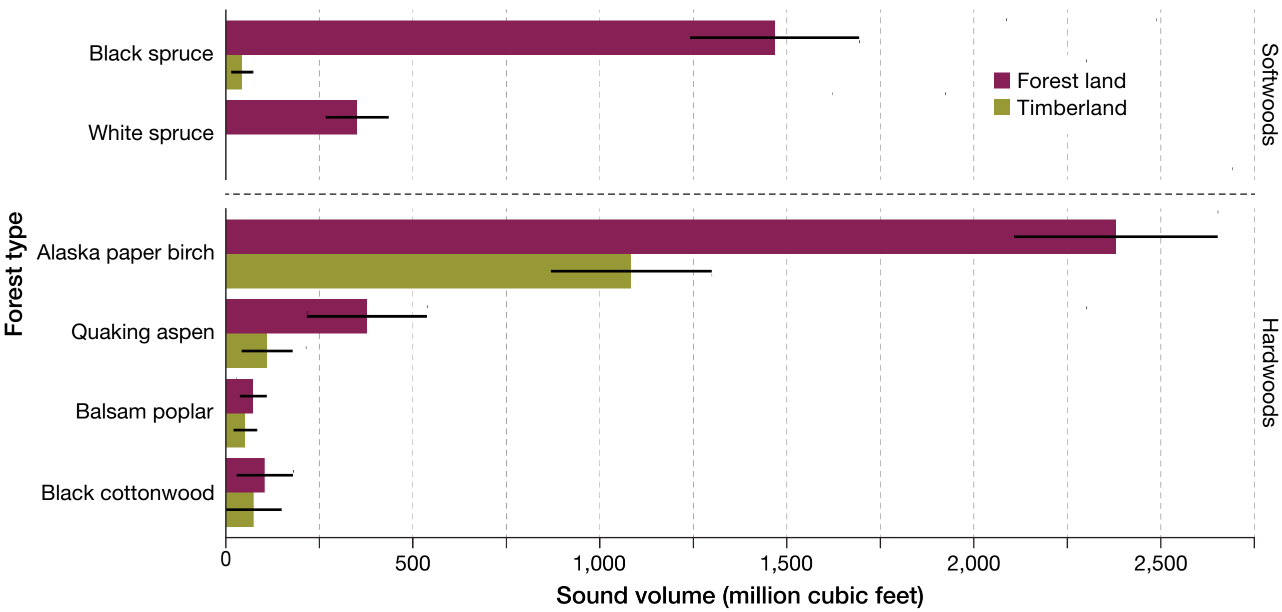

Figure 21—Sound volume of live trees ≥5 inches diameter at breast height by forest type for forest land and timberland (capable of producing >20 cubic feet per acre per year) in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Dashed horizontal line separates softwoods (spruce) from hardwoods. Solid bars represent the total volume; error bars are ± 1 standard error.

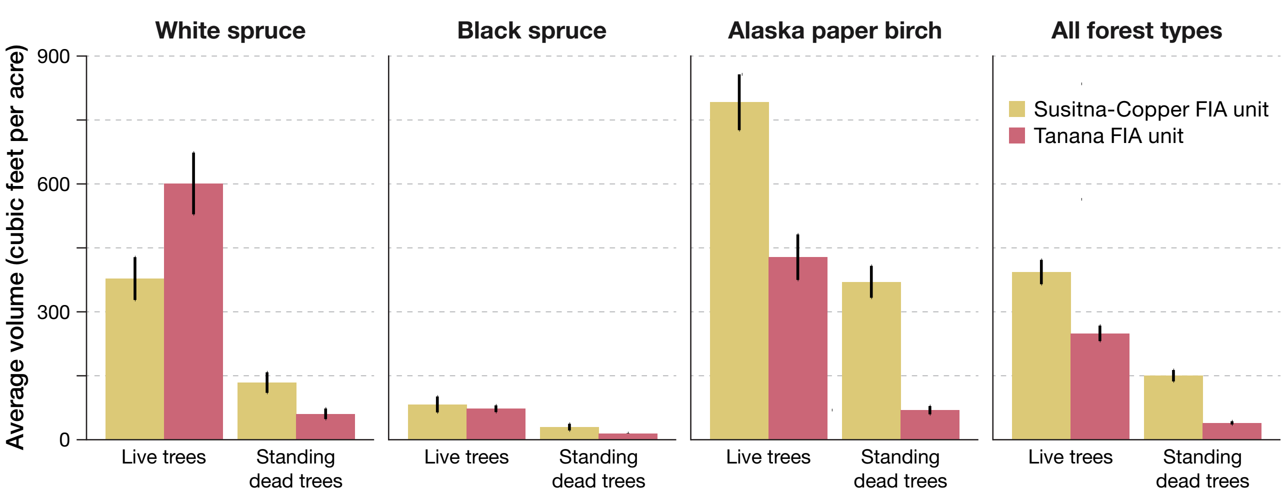

Figure 22—Sound volume per acre of the three most common forest types in the Susitna-Copper and Tanana Forest Inventory and Analysis (FIA) units (trees ≥5 inches diameter at breast height). Solid bars represent the mean; error bars are ± 1 standard error.

beetle outbreak, the average live-tree volume per acre in the white spruce forest type (504 ± 67 cubic feet per acre) remained much higher than standing dead white spruce volume per acre (179 ± 32 cubic feet per acre), a result of the large number of live white spruce (1,144,000 ± 138,000) compared to dead white spruce (145,000 ± 27,000). The pattern of forest volume across the Susitna-Copper FIA unit consists of higher volume hardwood stands (primarily Alaska paper birch) occupying the warmer Susitna watershed, with lower volume softwood stands (black and white spruce) dominating the cold, poorly drained soils of the upper Copper River watershed (fig. 23).

With regard to ownership status, state and local governments manage 62 percent of the overall volume of live trees ≥5 inches DBH and 82 percent of growing-stock trees on timberland (overall volume: 2,947 ± 261 million cubic feet; growing-stock volume: 1,031 ± 179 million cubic feet). Private ownerships, including corporations, manage 24 percent of the overall volume of live trees ≥5 inches DBH (1,160 ± 223 million cubic feet), with private individuals owning 12 percent of growing-stock trees on timberland (157 ± 113 million cubic feet) (fig. 24). Among large land ownerships (ownerships with >2 million acres of forest land) managing both types of land, there were not large differences in live-tree sound volume between land reserved from timber management practices and land where timber management practices were allowed (fig. 25).

Aboveground Biomass and Carbon

Forests in the Susitna-Copper FIA unit have 148 million tons of aboveground live-tree biomass plus an additional 45 million tons of aboveground biomass in standing dead trees. Sixty-one percent of live-tree biomass is on state or local government land, and 23 percent is owned by corporations or individuals (table 4). Alaska paper birch and white spruce have about equal amounts of live biomass (Alaska paper birch: 57 ± 6 million tons, white spruce: 54 ± 6 million tons), and because of the spruce beetle outbreak, white spruce represents 83 percent of standing dead-tree biomass in the unit (white spruce: 38 ± 4 million tons; all other species: 8 million tons of standing dead biomass) (fig. 26). Hardwood forest types have

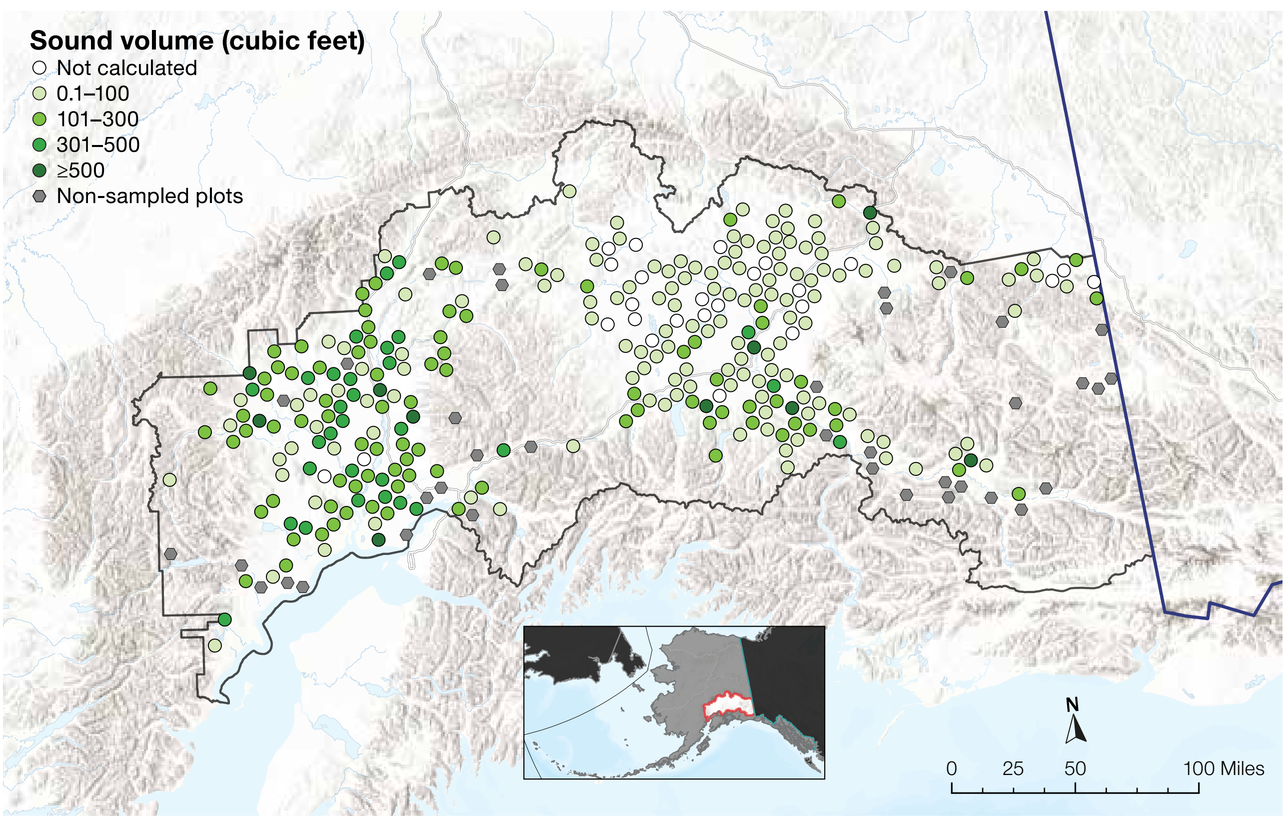

Figure 23—Per-plot totals of sound volume for live trees ≥5 inches diameter at breast height across the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) Susitna-Copper FIA unit. The warmer Susitna watershed in the western portion of the unit supported higher tree volume than the cooler upper Copper River watershed in the eastern portion of the unit. Plot locations are approximate to meet confidentiality requirements. Map base layer source: ESRI (2015, 2017).

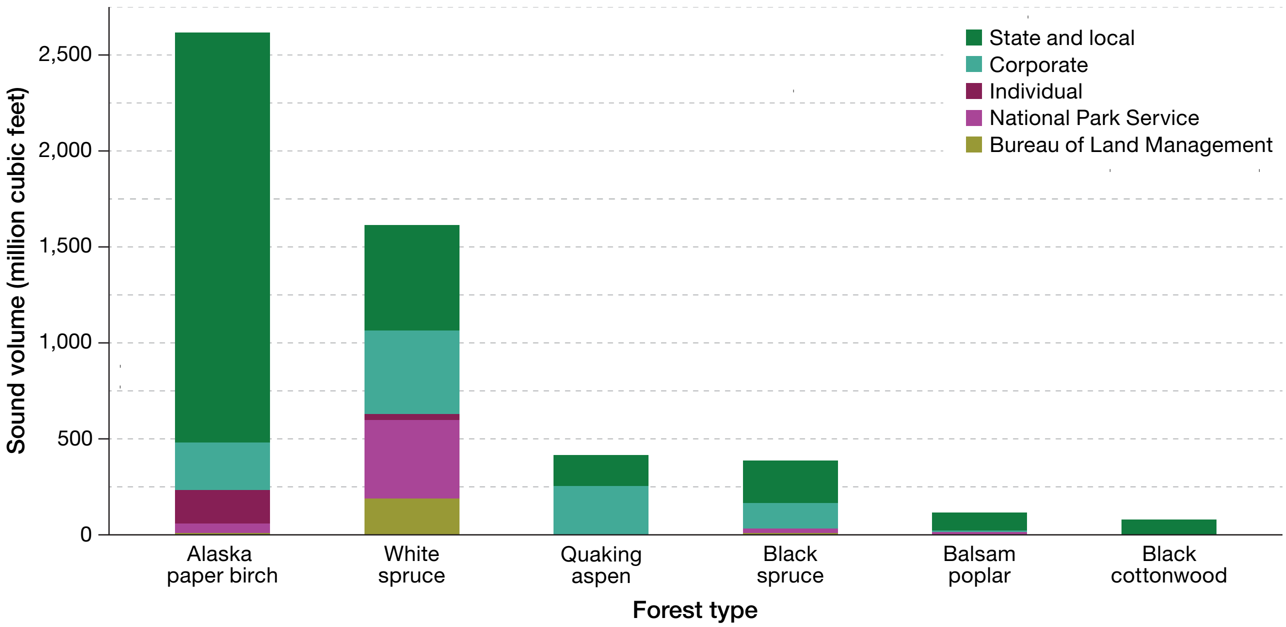

Figure 24—Sound volume of live trees ≥5 inches diameter at breast height by forest type and major ownership in the Susitna-Copper Forest Inventory and Analysis unit. Solid bars represent the total volume.

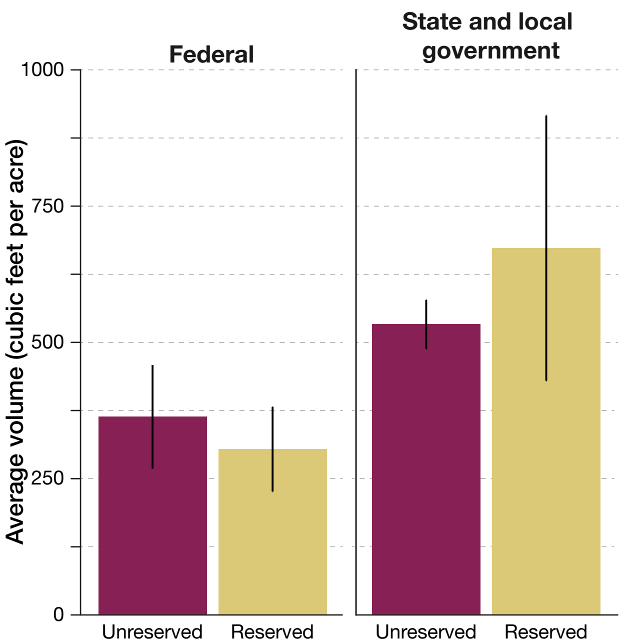

Figure 25—Average sound volume of live trees ≥5 inches diameter at breast height by reserved and unreserved forest land for large land ownerships (ownerships with >2 million acres of forest land) in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Solid bars represent the mean; error bars are ± 1 standard error.

Figure 26—Spruce beetle-caused mortality in the Susitna River watershed, Alaska. This stand experienced near total mortality in large-diameter spruce. Photo courtesy of Geneva Preston, State of Alaska.

Table 4—Aboveground biomass of live trees on forest land by ownership and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Ownership group	Forest land status													
	Unreserved forest						Reserved forest							
	Timberland		Other forest		All unreserved		Productive		Other forest		All reserved		All forest land	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	THOUSAND TONS													
Federal government														
National Park Service	—	—	—	—	—	—	—	—	16,787	3,334	16,787	3,334	16,787	3,334
Bureau of Land Management	—	—	6,500	1,482	6,500	1,482	—	—	298	296	298	296	6,798	1,450
All federal	—	—	6,500	1,482	6,500	1,482	—	—	17,084	3,347	17,084	3,347	23,584	3,636
State and local government														
State	25,687	4,712	51,553	5,847	77,240	6,485	4,644	2,918	3,125	1,408	7,769	3,229	85,009	6,824
Local	4,357	2,183	978	768	5,335	2,291	—	—	—	—	—	—	5,335	2,291
All state and local	30,045	4,963	52,531	5,848	82,575	6,478	4,644	2,918	3,125	1,408	7,769	3,229	90,344	6,769
Private														
Corporate	1,918	1,064	26,889	5,040	28,807	5,095	—	—	—	—	—	—	28,807	5,095
Individual	4,860	2,980	702	638	5,563	3,022	—	—	—	—	—	—	5,563	3,022
All private	6,779	3,147	27,591	5,006	34,370	5,385	—	—	—	—	—	—	34,370	5,385
All ownerships	36,824	5,894	86,622	7,717	123,445	8,243	4,644	2,918	20,210	3,625	24,854	4,646	148,299	8,978

Note: Includes all live trees ≥1 inch diameter at breast height, consisting of growing-stock, rough-cull, and rotten-cull tree classes. Totals may be off because of rounding; data are subject to sampling error.

— = no estimate, SE = standard error.

more live biomass per acre than softwood forest types (hardwoods: 27.5 ± 2.0 tons per acre; softwoods: 11.3 ± 0.9 tons per acre), with quaking aspen having the highest density of live biomass of all forest types. The same pattern is true for standing dead biomass, with hardwood forest types holding 9.5 ± 1.0 tons per acre and softwoods 3.0 ± 0.5 tons per acre.

Carbon mass of live trees is proportional to biomass, but species-specific carbon fractions determine the amount of biomass held in carbon, with between 42 and 54 percent of the biomass converted to carbon in the NSVB equations (Westfall et al. 2024). At a landscape level, key determinants of forest carbon stocks include forest type, site aspect, and wildfire regime (Cahoon et al. 2022). In total, Susitna-Copper forests contain 66 million megagrams of aboveground carbon in live trees, and 21 million megagrams of aboveground carbon in standing dead trees. Except for black spruce and quaking aspen (which are dominated by forests in the small stand size), all forest types have the most aboveground live-tree carbon in medium stand sizes, because very few trees grow to the largest diameter classes. Standing dead-tree carbon in the Susitna-Copper FIA unit is dominated by white spruce and black spruce, particularly in larger diameter classes—94 percent of standing dead-tree carbon in the Susitna-Copper FIA unit is one of these two species (fig. 27).

Comparing distributions of carbon among ecosystem carbon pools (live trees, standing dead trees, down woody material, ground layer, and soil) between the Susitna-Copper FIA unit and the Tanana FIA unit revealed some subtle but important differences. For example, where the black spruce forest type dominated aboveground live-tree carbon in the Tanana FIA unit, the Alaska paper birch forest type comprised the largest total aboveground live-tree carbon pool in the Susitna-Copper FIA unit, with a similar amount of aboveground carbon, despite a smaller area of Alaska paper birch forests (2.3 million acres of forest with 28.0 ± 3.1 million megagrams of aboveground live-tree carbon) than reported in the Tanana FIA unit (4.0 million acres of forest with 28.4 ± 2.8 million megagrams). This difference is likely due to larger trees in the Susitna-Copper FIA unit, as evidenced by greater volume per acre estimates (fig. 22). Larger birch trees in this unit could be due to more favorable growing conditions (i.e., longer and warmer summers) (fig. 7) that have allowed birch to reach maturity and accumulate more aboveground carbon, as well as a lack of recent widespread stand-replacing fires in the Susitna-Copper FIA unit. Moreover, standing dead trees in birch stands comprised a larger portion of total ecosystem carbon in the Susitna-Copper FIA unit (9 percent) compared to the Tanana FIA unit (2 percent), which likely reflects both the larger trees in the Susitna-Copper FIA unit as well as the presence of recent mortality of white spruce trees within birch stands caused by the spruce beetle outbreak. Overall, aboveground live-tree carbon comprised 17 percent of all ecosystem carbon in the Susitna-Copper FIA unit.

Down Woody Material Carbon and Biomass

Down woody material includes dead, woody plant material in all stages of decay (fig. 28). Alaska paper birch forests had the highest density of down woody material, as well as the most biomass overall. Although softwood forest types had a lower density of down woody material biomass per acre (softwoods: 2.2 ± 0.3 tons per acre; hardwoods: 4.4 ± 0.4 tons per acre), white spruce and black spruce forests combined held more down woody material overall than hardwood forests (13.2 ± 1.7 million tons of biomass). Overall, the amount of carbon in down woody material was about 60 percent of the amount of aboveground carbon in standing dead trees, and about 20 percent the amount of aboveground carbon stored in live trees. Because of the spruce beetle outbreak, it is likely that the amount of down woody material will soon rise, particularly in white spruce and black spruce forests.

Soil Carbon[10]

Belowground carbon is a major component of the boreal forest (Malhi et al. 1999, Ping et al. 2015) accounting for up to 90 percent of total ecosystem carbon in some locations (Cahoon and Baer 2022). Boreal forest soils

[10] Author: **Sean M.P. Cahoon** is a research ecologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 161 E 1st Avenue, Door 8, Anchorage, AK 99501.

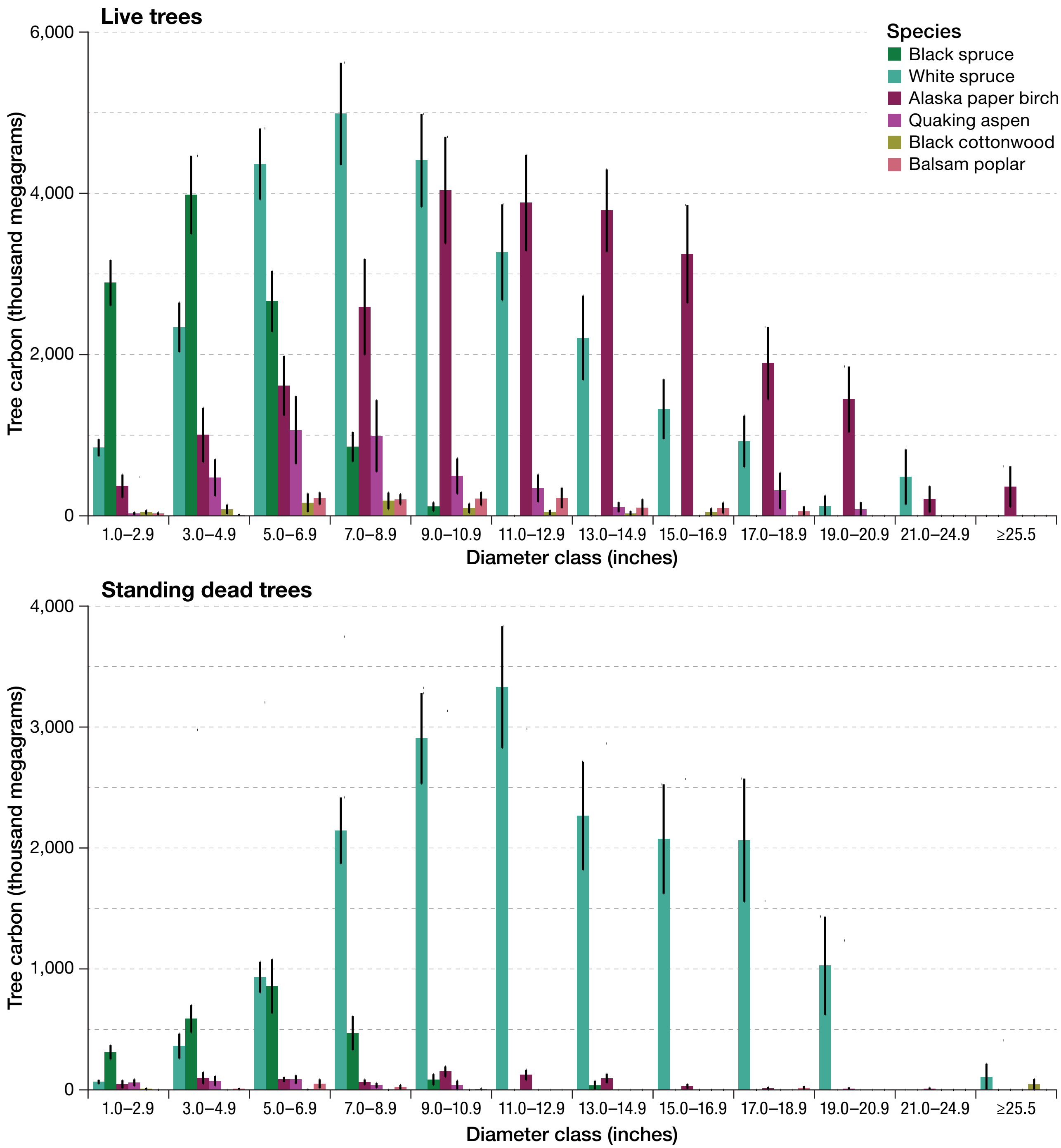

Figure 27—Total live and standing dead whole-tree carbon by diameter class and species in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Solid bars represent the total in diameter class; error bars are ± 1 standard error.

contain about 27 percent of the global soil carbon pool (Jackson et al. 2017), providing the essential ecosystem services of carbon sequestration and storage. In these northern ecosystems, decomposition of plant parts is hampered by cool, often anaerobic conditions, resulting in deep organic layers that have accumulated over centuries and even millennia (DeLuca and Boisvenue 2012). The presence of permafrost can further reduce decomposition, while physically redistributing organic layers deeper into the soil profile through the process of cryoturbation. Although the boreal soil carbon pool has been relatively stable, recent disturbances from increasing fire severity and size, thawing permafrost, and climate change threaten this globally important carbon

Figure 28—State of Alaska crew members measure down woody material on a Forest Service, Forest Inventory and Analysis (FIA) plot. Measured down woody material includes coarse woody debris (≥3 inches diameter) and fine woody debris (<3 inches diameter) intersected by eight 24-foot transects per FIA plot. Photo courtesy of Joe Vorderbruggen, State of Alaska.

stock and may significantly influence atmospheric CO_2 concentration (Genet et al. 2018).

Improving estimates of soil carbon from remote, undersampled portions of Alaska's boreal forest is a fundamental goal of the interior Alaska FIA program. The estimates provided for the Susitna-Copper FIA unit follow the same protocol and stratification procedures first produced for the Tanana FIA unit in 2014–2018. Briefly, cores were collected from all forested plots using a drill and a 2-inch-diameter stainless steel corer until the core reached mineral soil or an obstruction. Layers were identified and separated in the field, then sent to the Forest Soils Lab at the University of Alaska Fairbanks, where samples were oven dried, homogenized, and analyzed for carbon and nitrogen concentrations (percentages) using a LECO CN628 Elemental Analyzer. Because the active layer can often be shallow early in the field season, some samples did not reach mineral soil because of frozen soils, which may bias soil carbon estimates by under-sampling near-surface organic layers. Therefore, we excluded cores that did not include a mineral layer at the bottom of the core to provide confidence that the entire organic portion of the profile was included. In total, soil carbon analysis for the Susitna-Copper unit included 625 soil cores collected from 235 forested plots.

Across the unit, forested ecosystems contained about 280 million megagrams of belowground carbon. Black spruce, white spruce, and Alaska paper birch forest types each contributed about one-third of the total belowground carbon pool in the unit, with aspen, black cottonwood, and balsam poplar forest types each contributing less than 5 percent. This pattern differs from the Tanana FIA unit, where the black spruce forest type comprised about 55 percent of the total below-ground carbon pool, illustrating the significantly higher proportion of the black spruce forest type in the Tanana FIA unit and the spatial variability in habitats between the two units. Black spruce forest types contained the most soil carbon overall in the Susitna-Copper FIA unit (93.1 million megagrams), followed by white spruce (83.6 million megagrams), and Alaska paper birch (79.8 million megagrams); the same pattern held for soil carbon on a per hectare basis (fig. 29). Black spruce is an iconic boreal species, known for its tolerance of cool, permafrost-affected soils—conditions that limit organic matter decomposition and lead to substantial carbon stocks (Van Cleve et al. 1983). Although black spruce is an unproductive timber species in the boreal forest, improving our understanding of the spatial variability of belowground carbon stocks could serve to refine conservation goals aimed at preserving and promoting the ecosystem service of carbon sequestration in this important habitat.

Among common landowners, state and local governments manage nearly two-thirds of the belowground carbon pool in the Susitna-Copper FIA unit (172.0 ± 9.7 million megagrams), while private landowners and the federal government manage 20 percent (56.6 ± 6.3 million megagrams) and 18 percent (51.3 ± 10.2 million megagrams), respectively. Overall, the concentration of

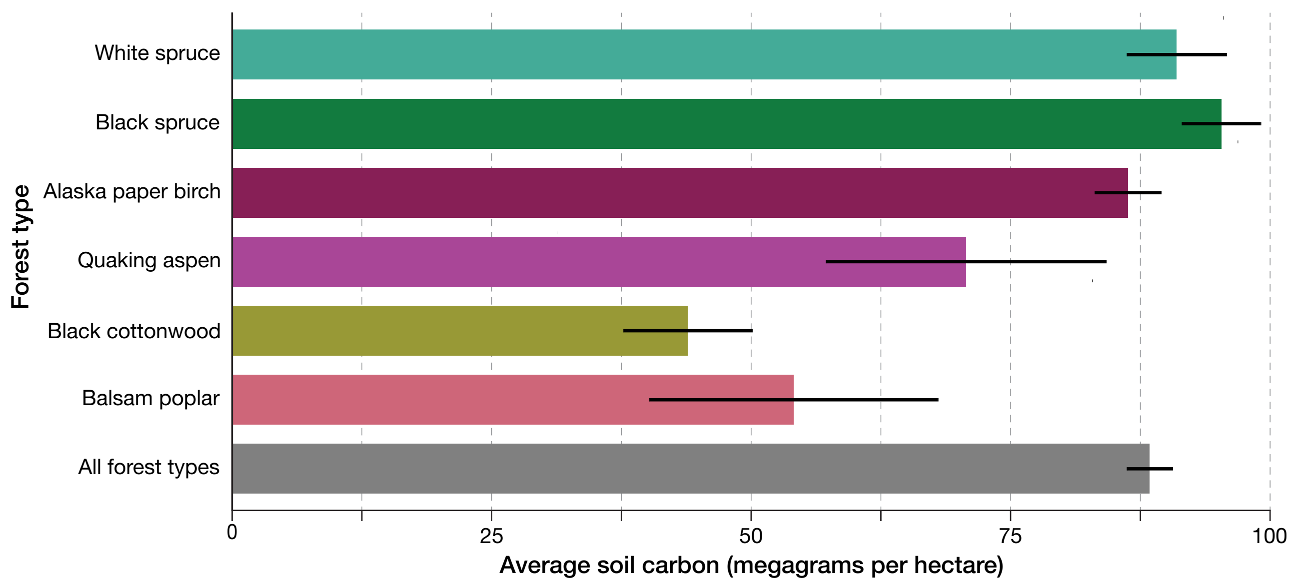

Figure 29—Average amount of soil carbon by forest type in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Solid bars represent the mean; error bars are ± 1 standard error.

belowground carbon (i.e., megagrams per hectare) was similar on all forest land among ownerships (87.0–90.9 megagrams per hectare), although average soil carbon was generally lower on timberland forests (82.9 megagrams per hectare on state- and locally managed timberland and 67.4 megagrams per hectare on privately owned timberland, which includes Alaska Native corporation land) (see supplemental tables 44 and 45). This difference between forest land and timberland may reflect warm, well-drained soils that are favorable site conditions leading to increased tree growth on timberland, while also promoting soil organic matter decomposition and reduced soil carbon pools.

The Susitna-Copper FIA unit soil carbon analysis shown here broadly aligns with patterns observed in the Tanana FIA unit, showing that most of the total ecosystem carbon is belowground (fig. 30), although there was variation among forest types in the distribution of above- versus belowground carbon pools. For example, average aboveground live-tree carbon was roughly three times higher in hardwood forest types (Alaska paper birch and quaking aspen: 35.0 megagrams per hectare of live-tree carbon) compared to softwood (black spruce and white spruce: 12.9 megagrams per hectare of live-tree carbon), but coniferous stands exceeded deciduous stands in average soil carbon by 19 percent (93.2 and 78.5 megagrams per hectare in average soil carbon, respectively). Differences in carbon pools among forest types demonstrate the heterogeneity of boreal forest ecosystems and reveal the spatial variation in successional stages across the landscape. Softwood stands, with high belowground carbon content and substantial ground layer, dominate later successional stages, whereas deciduous species often colonize favorable locations following fire (Johnstone et al. 2010). The FIA program's balanced sampling design captures boreal ecosystems at various stages of successional recovery, demonstrating how disturbance history can create a mosaic of forest types and carbon pools across the landscape.

The data provided in these surveys capture landscape-scale variation in ecosystem carbon, highlighting the importance of maintaining the detailed soil sampling protocol in interior Alaska. These data are also used to support research investigating the effects of fire, thawing permafrost, development, and changing climate on this important carbon pool (e.g., Cahoon et al. 2022). As the Pacific Northwest FIA program expands into even more remote regions of Alaska, belowground carbon data will contribute to a more holistic forest carbon inventory (e.g., Domke et al. 2017) and provide foundational information to promote conservation and research goals.

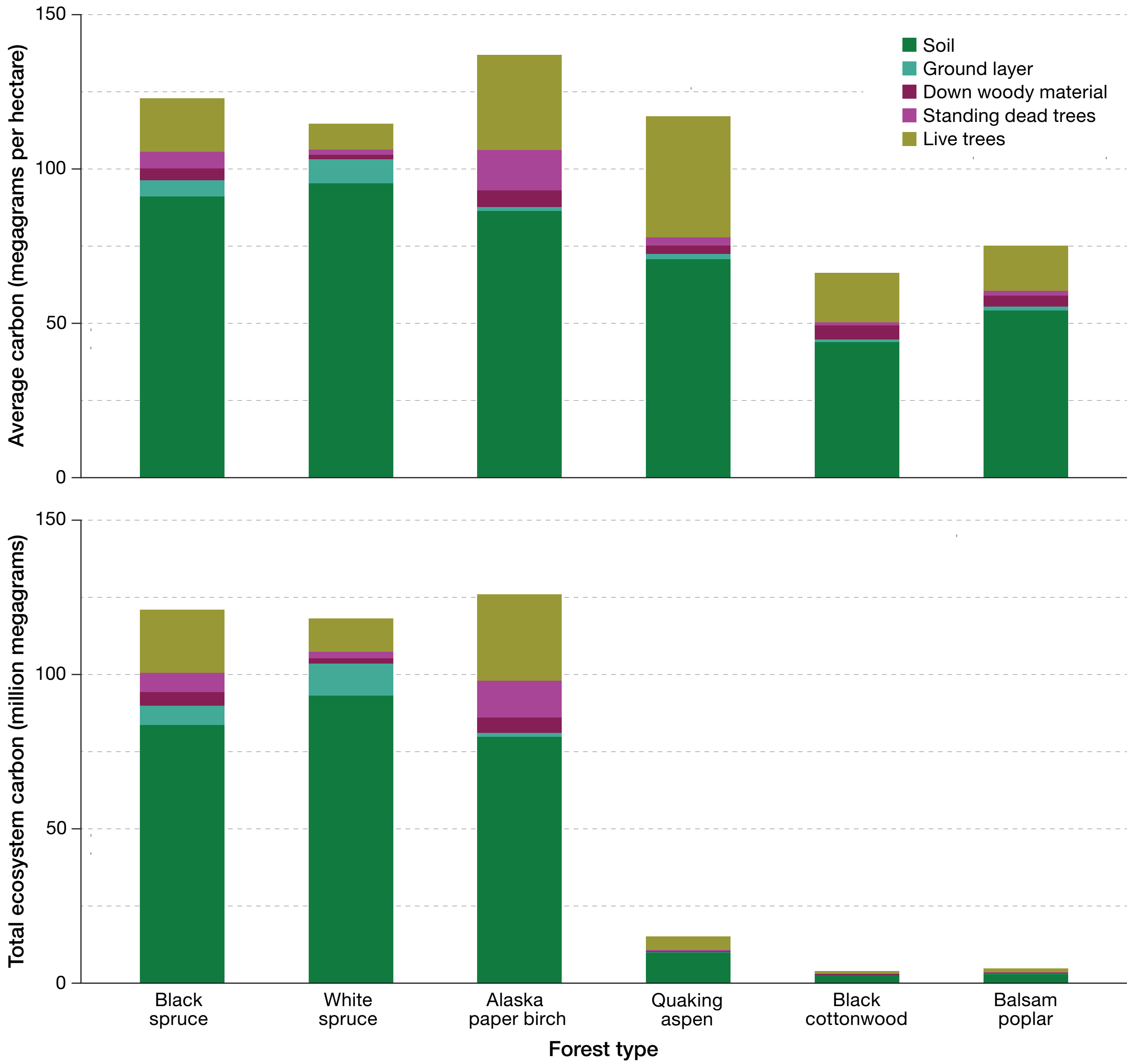

Figure 30—Area-adjusted ecosystem carbon per hectare by carbon pool and forest type (top) and summed ecosystem carbon by carbon pool and forest type (bottom) in the Susitna-Copper Forest Inventory and Analysis unit. Solid bars represent total value (top) and mean value (bottom).

Forest Health

Tree Damages

Although many factors affect the health of each tree, physical signs of stress or damage can often be attributed to a primary agent. Damage can occur from several factors, including animals, insects, disease, weather, and physical defects. Most of the damages assessed by the FIA program are natural agents that play a role in forest succession. Detecting trends in tree damages at the stand level can aid in assessments of a forest's future composition and resiliency. FIA field crews assess each measured live tree for damaging agents and each stand for stand-level disturbances; each tree damage agent and stand-level disturbance must meet a minimum threshold to be recorded.

About one-fourth of live trees in the Susitna-Copper FIA unit were affected by damage or defect (1.4 million). As older, larger trees are more likely to be affected by damage or disease, the affected trees represent 66 percent of total live-tree volume in the unit (table 5). The most common damage agents, affecting 18 percent of all live trees, were physical damages and form defects, including broken, dead, and forked tops; open wounds; and crooks

Interagency Partnership to Support the Inventory in the Susitna-Copper FIA Unit With Airborne Remote Sensing

Hans-Erik Andersen[1]

U.S. Department of Agriculture, Forest Service and National Aeronautics and Space Administration scientists are working together to bring high-resolution, airborne Goddard's LiDAR Hyperspectral and Thermal imager (G-LiHT) remote-sensing data to interior Alaska's forest inventory (fig. 31). G-LiHT is a multisensor instrument that collects complementary remote-sensing measurements, including light detection and ranging (LiDAR) to assess 3D canopy structure and multispectral imaging to assess vegetation composition and health. Field crews also use ultra-high-resolution G-LiHT images to determine if forest conditions might exist at a plot location prior to visiting it—valuable information that can prevent an unnecessary expensive helicopter trip to a remote location. G-LiHT data can also support more precise estimations of key inventory attributes, such as tree biomass and carbon. G-LiHT data are collected in a linear swath over the grid of Forest Service, Forest Inventory and Analysis (FIA) plots; these data can then be used to more precisely model national forest inventory estimates, while maintaining the defining properties of design-based inventories, including unbiased estimations and quantifications of uncertainty. In a recent collaborative study (Andersen et al. 2024), FIA program scientists presented a new set of model-assisted estimators for domain-level attributes in sampling designs for areas such as interior Alaska, where remote sensing is collected in strips covering the field plots, including new estimators for densities (e.g., tree biomass per forested acre); they compared the performance of these estimators with the standard poststratified estimators that are similar to those used in *Forests of the Susitna-Copper Unit, Alaska, 2020: Forest Inventory and Analysis Report*. Simulation-based evaluation indicated that (1) all model-assisted estimators were generally unbiased, and (2) the use of LiDAR in a sampling mode increased the precision of domain-level estimators. In general, these results indicate that airborne remote-sensing data can be used as a sampling tool to increase the efficiency of national forest inventories in remote regions. Based on these findings, closer integration of G-LiHT with FIA estimation procedures in interior Alaska will be a focus going forward.

[1] **Hans-Erik Andersen** is a research forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 400 N 34th Street, Suite 201, Seattle, WA 98103.

Figure 31— Goddard's LiDAR Hyperspectral and Thermal imager (G-LiHT) point cloud, colored by high-resolution imagery. Susitna-Copper Forest Inventory and Analysis unit, Alaska. Image by Hans-Erik Andersen.

Table 5—Gross volume of live trees with common damages by species and damage type, Susitna-Copper Forest Inventory and Analysis (FIA) unit, Alaska, 2020

Tree species	Damage agent													
	Insects				Diseases									
	Bark beetles		Defoliators		Stem decay		Root/butt diseases		Physical damages		No damage recorded		All trees	
	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE	Total	SE
	THOUSAND CUBIC FEET													
Softwoods														
White spruce	356,506	73,998	47,747	21,075	16,069	8,749	29,541	10,807	610,046	82,480	917,595	126,692	1,837,599	222,874
Black spruce	64,489	25,052	—	—	797	472	349	273	74,065	11,690	172,953	27,508	306,310	48,947
All softwoods	420,995	77,439	47,747	21,075	16,866	8,758	29,889	10,837	684,111	84,524	1,090,547	133,202	2,143,910	229,642
Hardwoods														
Quaking aspen	—	—	69,680	39,347	13,677	10,030	10,080	7,304	61,629	22,334	187,344	66,462	366,470	119,787
Alaska paper birch	—	—	1,271,351	179,905	549,710	86,699	277,709	63,437	1,189,865	155,781	338,170	79,618	2,323,312	266,288
Balsam poplar	—	—	533	484	13,866	7,929	7,856	6,201	57,318	29,886	44,733	13,881	112,104	39,805
Black cottonwood	—	—	—	—	304	229	—	—	11,017	7,653	34,700	18,534	47,905	25,245
All hardwoods	—	—	1,341,564	183,462	577,557	87,509	295,646	63,964	1,319,830	160,363	604,947	106,437	2,849,790	285,365
All tree species	420,995	77,439	1,389,312	184,248	594,422	88,014	325,535	67,512	2,003,941	183,578	1,695,494	179,001	4,993,700	370,912

Note: Totals may be off because of rounding, and may not match the sum, as multiple damages can be recorded on a single tree. Data are subject to sampling error. Only the top five damages by total gross volume are shown. Other damages recorded include sucking insects, boring insects, cankers, foliage diseases, broom rusts, fire, animal damage, and abiotic damages (e.g., lightning, snow/ice, and wind). For a complete accounting of damages recorded in the Susitna-Copper FIA unit, see the supplemental tables that are available online.

— = no estimate, SE = standard error.

or sweeps. Defoliating insects affected 7 percent of all live trees but primarily were found in Alaska paper birch trees, with 58 percent of all individuals of that species affected to a minimum threshold of 20 percent of their affected foliage. The primary defoliating insects noted were the invasive, amber-marked birch leaf miner (*Profenusa thomsoni*), and birch leaf roller (*Epinotia solandriana*). While both species have a widespread distribution in the area, neither species are known to cause mortality in birch species (Snyder et al. 2007) and neither have been considered an outbreak in the area.

Wildfire

Although wildfire is the primary disturbance in boreal forests (Macias Fauria and Johnson 2008), wildfire is much less common in the Susitna-Copper FIA unit than in other boreal forests in Alaska. The Cook Inlet and Copper Plateau have a wetter, more maritime climate than the continental climate north of the Alaska Range and therefore experience fewer of the lightning strikes associated with high-pressure systems. As lightning is the primary ignition source for fires in interior Alaska, the Susitna-Copper FIA unit experiences substantially fewer fires than elsewhere in Alaska's boreal forests, a finding that is borne out by paleoecological and dendrochronological records (Lynch et al. 2002). About 0.3 percent of the total unit area was recorded as being within an active fire perimeter from 2014 to 2021, the period in which fires would have been recorded as a disturbance were they encountered on a plot (National Interagency Fire Center 2024). However, because of their relative infrequency and the low density of FIA plots, no fire disturbances were encountered on FIA plots in the Susitna-Copper FIA unit.

Spruce Beetle[11]

Spruce beetle, *Dendroctonus rufipennis*, is the leading insect-caused mortality agent of spruce trees in much of Alaska. Spruce beetle occurs throughout the range of spruce in Alaska and has historically affected white spruce forests and Lutz spruce (*Picea lutzii* Little, hybrid of white spruce and Sitka spruce [*Picea sitchensis* (Bong.) Carrière]) forests south of the Alaska Range. Outbreaks have occurred in white spruce in interior Alaska and in Sitka spruce in southeast Alaska, although those outbreaks have typically been shorter lived and more limited in geographical effect. Southcentral Alaska has been experiencing a spruce beetle outbreak that was first detected in 2016 and has affected roughly 2.2 million acres of forests across the region through 2023. Spruce beetle and other forest health activity is documented through annual aerial detection surveys conducted by the Forest Service, Forest Health Protection Aviation Program's Aerial Survey unit and State, Private, and Tribal Forestry organization in collaboration with the Alaska Department of Natural Resources, Division of Forestry and Fire Protection. These surveys allow forest health professionals to look at what damage is occurring and where it is occurring in any given year. FIA data further inform our understanding of damage agents, such as spruce beetle, by providing stand-level information on the resource affected over a longer temporal scale.

Between 2016 and 2021, elevated spruce beetle activity was concentrated in the western part of the Susitna-Copper FIA unit, with occasional small, scattered pockets of activity in the central part of the unit. Generally, spruce beetle-caused mortality peaked in 2018 in the western portion of the Susitna-Copper FIA unit. In 2022 and 2023, activity in the western portion of the Susitna-Copper FIA unit had substantially declined and a few larger pockets of activity in the central portion of the unit were observed. FIA crews measured the Susitna-Copper FIA unit in 2019 and 2020, after activity had peaked. Damage recorded during FIA measurements reflects the declining nature of the outbreak, especially in the western part of the unit.

As a mortality agent, spruce beetle is unique in that when Aerial Survey program crews document mortality through aerial detection surveys, they are documenting the effects of activity that occurred in the previous year because of the nature of the damage and when it is visible from the air. Key signs of damage are needle color change and how the canopy fades; these signs typically occur in the year after a tree is mass attacked (fig. 32). FIA methodology differs from that of the Aerial Survey program in that it is a ground assessment. Therefore, in addition to documenting trees affected prior to the time of measurement (as captured by the Aerial Survey program), FIA crews also document activity that is occurring at the time of measurement but that may not be visible from the air. For spruce beetle, this may include trees that are actively

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Figure 32—A spruce beetle-attacked forest site characterized by the dramatic change in needle color. USDA Forest Service photo by Daniel "Vic" Anderson.

under attack yet would not be showing signs of needle color change. Key signs of damage at this stage are spruce beetle entrance holes characterized by a reddish-brown sawdust and pitch accumulating around the attack site. By capturing already dead as well as attacked but not-yet dead trees, we can gain further insight into spruce beetle activity in the area in the long term.

Estimates of FIA data from the Susitna-Copper FIA unit indicated the presence of 47.4 million live white spruce and 34.3 million live black spruce individuals with spruce beetle damage, or 3.3 percent and 1.2 percent of all live white spruce and black spruce trees, respectively. In total, the FIA program estimates that 3.3 million acres (± 226,000 acres) of forest land in the unit exhibited some type of insect damage that affected at least 25 percent of the trees in a stand; based on tree-level damage data, this damage is almost entirely caused by spruce beetle. Additionally, crews recorded substantial numbers of dead white spruce and black spruce trees throughout the western portion of the unit, particularly in the larger diameter classes (figs. 14 and 27). Because these plots were new installations, snags were not assigned a mortality agent; therefore, while it is likely that this mortality was due to spruce beetle, estimated cause of death was not recorded. FIA measurements are corroborated by forest health surveys in 2020 and 2021.

Forest health surveys documented about 64,000 and 141,000 acres of spruce beetle-affected forests in the Susitna-Copper FIA unit in 2020 and 2021, respectively. Generally, spruce beetle-affected acreage is documented during Aerial Survey program aerial detection surveys; however, in 2020, data was collected using manual photo interpretation, an alternate method from previous or subsequent years, and areas with imagery were limited. The 2020 survey coverage was less than in previous or subsequent years, so comparisons between 2020 and other years should not be interpreted as a population trend. Acres of forest affected by spruce beetles in the Susitna-Copper FIA unit[12] between 2018 and 2021 were as follows:

Year	Acres affected
2018	504,400
2019	113,300
2020	64,000[13]
2021	141,000
2022	5,400
2023	26,700

As land managers and foresters look to the future, baseline FIA data in the Susitna-Copper FIA unit and remeasurement of this unit will help us better understand the effects of this spruce beetle outbreak at the landscape scale and the resources it affects.

[12] The area analyzed included the Matanuska-Susitna Borough and the Copper River Census Area. This area is substantially similar to the Susitna-Copper Forest Inventory and Analysis (FIA) unit but excludes a small portion of the northern Anchorage borough that is included in the Susitna-Copper FIA unit, which had some forested area affected by bark beetles during the years shown.

[13] The 2020 data were collected using alternate methodology; for more information see Brannoch and Moan (2021); appendix 1.

Invasive Species[14]

Invasions by nonnative plants can have important consequences for forest health and resilience via disruption of recipient communities and ecosystem processes (Pyšek et al. 2012). Forest inventory data can offer a snapshot of the status of ongoing invasions in forested areas and identification of new areas of invasion by recognized nonnative invasive plants. To this end, FIA crews recorded any occurrence of nonnative invasive plants listed on the FIA invasive species list for Alaska, regardless of aerial cover. Forested conditions within the Susitna-Copper FIA unit had particularly low levels of invasion compared to other Pacific Northwest states (Gray et al. 2021); only 0.3 percent of measured conditions contained invasive species, yielding an estimate of only 264 acres of forest land affected by nonnative vascular plants in the unit. Three invasive species were recorded in forested conditions: common dandelion (*Taraxacum officinale* F.H. Wigg; 70 ± 76 acres of cover), clover (*Trifolium* L.; 79 ± 79 acres of cover), and European bird cherry (*Prunus padus* L.; 116 ± 97 acres of cover (see supplemental tables). Ornamental shrubs and trees in the *Prunus* genus, including European bird cherry and the closely related chokecherry (*Prunus virginiana* L.), may outcompete and displace native trees as well as tall shrub layers, such as willows, that serve as important wildlife forage (ANHP 2011, Flagstad et al. 2010) and produce a cyanogenic glycoside that may be toxic to ruminants, such as moose, possibly resulting in their illness or death (Harms 2011, Mulligan and Munro 1981, Yulvianti and Zidorn 2021). While invasions are more common in urban riparian corridors, birds readily disperse large numbers of seeds into adjacent natural areas that appear to support germination, survival, and growth of the species (ANHP 2011, Roon et al. 2014). FIA field crews also inventoried invasive species on nonforest conditions when they were encountered on a field-visited plot; crews encountered nonforest conditions 168 times within the Susitna-Copper FIA unit, and 10 (6 percent) of these encounters revealed nonnative invasive species. This yielded an estimated total of 6,593 nonforest acres occupied by nonnative invasive plants on measurable FIA conditions[15] (fig. 33). The higher instance of nonnative invasive species in nonforested than in forested conditions is likely attributable to human disturbances in the former. Six of the ten nonforest conditions containing invasive plants occurred in areas of intense human activity, and the other four occurred in rights-of-way, such as improved roads, power lines, or railway corridors.

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[15] Note that this estimate does not represent total cover of nonnative invasive plants across the sampled area, as the FIA program does not systematically ground-visit nonforest locations.

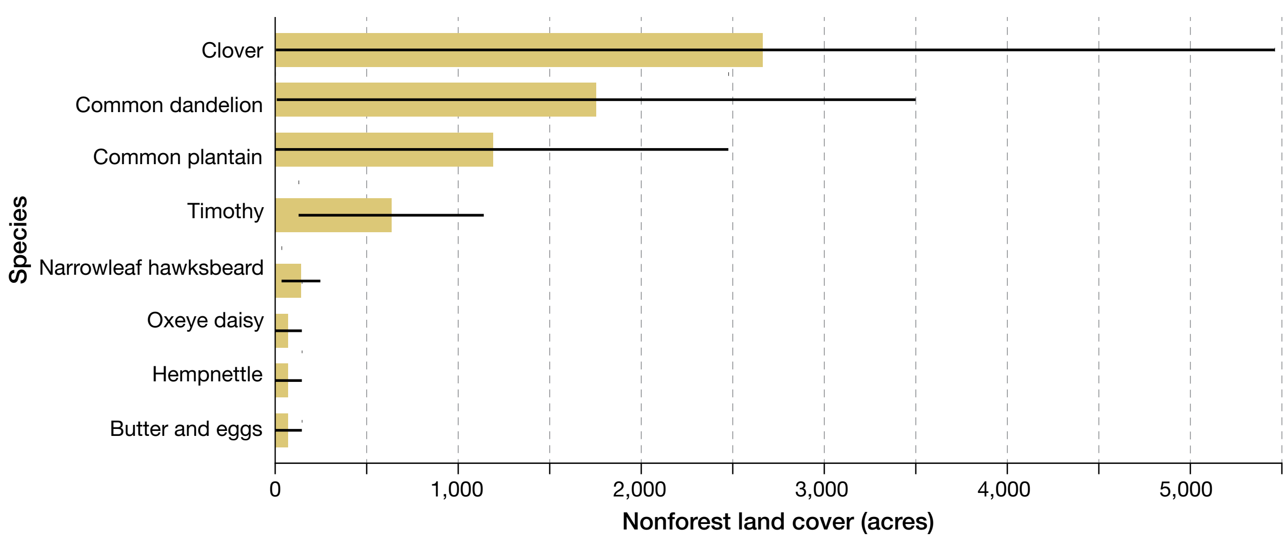

Figure 33—Total nonnative invasive plant cover on nonforest land by species. Solid bars represent the total species cover; error bars are ± 1 standard error. Credit: Kathryn Baer.

Forest Productivity

Timber Products Output[16]

In addition to conducting forest inventory, the FIA program reports on statistics tied to the status of the forest products industry for each state. This allows the FIA program to connect basic information from the forest inventory to local economies that use forest products. The FIA's Timber Products Output (TPO) program completes surveys of primary wood-using mills in each state to compile statistics about local forest products industries. To date, the most recent survey of Alaska's primary forest producers focused on operating year 2019 and was completed by the University of Montana, College of Business, Bureau of Business and Economic Research through a joint venture agreement with the FIA program at the Forest Service, Pacific Northwest Research Station. Results of the survey were reported by Simmons et al. (2024) and include statistics describing the economics and capacity of Alaska's timber industry, the flow of timber within and across state lines, and the volume of Alaska's timber harvest in 2019.

Timber harvest data are based on the operating year in which the survey was conducted—in this case, 2019—and therefore differ from the summary estimates provided by the FIA program that represent data collected in 2019 and 2020. Resource areas reported by the TPO program do not align with FIA unit boundaries. Therefore, to align with the Susitna-Copper FIA unit boundary as closely as possible, statistics reported here on timber product outputs are gathered only from mills using timber resources harvested in Alaska's Matanuska-Susitna Borough and Copper River Census Area (fig. 13). These areas include portions of the Southcentral and the Western Alaska TPO resource areas. This area will be referred to as the Susitna-Copper TPO resource area for this report and is not reported on elsewhere in TPO literature. The Susitna-Copper TPO resource area roughly overlaps the Susitna-Copper FIA unit and encompasses nearly the entirety of the populated areas and road system there, while excluding population centers and road areas that fall outside of the boundaries of the Susitna-Copper FIA unit.

In 2019, the total volume of timber harvested in the state was 178,658 thousand board feet (MBF) Scribner. Of this total volume, less than 1 percent (1,424 MBF Scribner) was estimated to have originated in the Susitna-Copper TPO resource area. In the same 2019 survey, primary Susitna-Copper TPO resource area processing mills received 1,233 MBF Scribner of timber volume, all of which came from within the resource area. About 190 MBF Scribner of timber that was harvested in the Susitna-Copper TPO resource area was processed in the adjacent Anchorage borough. During 2019, five active and two inactive timber processing facilities were located within the resource area, compared to seven active and three inactive facilities in 2015. Six facilities (five from the resource area and one from the Anchorage Borough) processed timber harvested from within the Susitna-Copper TPO resource area in 2019 and included four sawmills and two house log producers. Although facilities are assigned a mill type aligning with the primary wood products they make, Alaska's wood products facilities commonly have the capacity to use a variety of log products for multiple finished products. Products from timber harvested in the Susitna-Copper TPO resource area included lumber, timbers, house logs, firewood, and woodchips. White spruce was the predominant single tree species used for these products, representing 37 percent of all products produced (526 MBF Scribner) and demonstrating the important role this species plays in the forest products industry of interior and southcentral Alaska (table 6). Most residual materials generated by facilities were used for other products, but about 27 percent were unused and disposed of onsite.

Overall, during 2019, the Susitna-Copper TPO resource area's facilities (active and inactive) had 2,259 MBF Scribner of timber-processing capacity for all products. Between 2015 and 2019, timber-processing capacity at facilities in the resource area declined 32 percent (from 3,354 to 2,259 MBF Scribner), while capacity utilization increased from 30 percent to 47 percent (1,070 of 2,259 MBF Scribner utilized in 2019). Timber-processing capacity and utilization levels can be useful measures to gauge a wood products industry's ability to respond favorably to changes in timber supplies as well as an indicator of an industry under stress. Declining timber-processing capacities or low-capacity utilization can be indicators of potential future mill closures, particularly if timber supplies decline.

Most of Alaska's forest products industry lies within the heavily forested and more productive coastal region of southeast Alaska. Although timber volume and

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Table 6—Alaska timber harvest by Timber Products Output (TPO) resource area, species, and log product, 2019

TPO resource area	Species	Sawlogs[a]	House logs	Fuelwood	Other products[b]	All products
		Thousand board feet Scribner				
Southeast						
	Sitka spruce	50,146	27	34	2	50,210
	Western hemlock[c]	46,388		12	1	46,401
	Western red cedar[c]	19,348	8	0	257	19,612
	Alaska yellow cedar[c]	3,500			2	3,502
	White spruce		50			50
	Birch species	2				2
	All species	119,384	84	46	262	119,776
Southcentral and Western						
	Sitka spruce	50,654	105			50,760
	White spruce	184	372	48	34	637
	Other species[d]	478	29	51	39	597
	Birch species	186	37	31	39	293
	Western red cedar		13			13
	All species	51,501	555	131	112	52,299
Interior						
	White spruce	1,794	324	686	2,687	5,491
	Birch species	94	17	606	299	1,015
	Other species[d]	16	4	50		70
	All species	1,904	345	1,342	2,985	6,576
All areas[e]		172,789	992	1,519	3,359	178,658

Note: The Susitna-Copper TPO resource area (including the Matanuska-Susitna Borough and Copper River Census Area) includes only portions of both the Southcentral and Western resource areas; only data from the Susitna-Copper TPO resource area are used in this report.

[a] Sawlogs include logs harvested in and exported from Alaska.

[b] Other products include cedar products and tonewood logs.

[c] Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.); western red cedar (*Thuja plicata* Donn ex D. Don); Alaska yellow cedar (*Callitropsis nootkatensis* (D. Don) Oerst. ex D.P. Little).

[d] Other species include black cottonwood, quaking aspen, black spruce, and balsam poplar.

[e] Columns may not sum to totals because of rounding.

Source: Simmons et al. (2024).

production were minimal compared with southeast Alaska, the Susitna-Copper TPO resource area's wood products industry is diverse and produces lumber from the highest-quality log to the use of mill residuals and low-quality timber for fuelwood products. This demonstrates the important role that the forest products industry plays in supporting subsistence livelihoods throughout the region. The FIA program will continue to collect the information needed to assess both the region and the state's forest products industry.

Nontimber Forest Products[17]

Along with providing ecosystem services such as carbon storage and wildlife habitat, many species of understory vascular plants may be classified as nontimber forest products (NTFPs), indicating that they are harvested for commercial, subsistence, cultural, or medicinal uses.

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NTFPs are highly valued in the Susitna-Copper FIA unit; they may be vitally important from both cultural and food security standpoints. Several NTFPs were among the most recorded understory vegetation species on Susitna-Copper forest land. The most commonly recorded NTFPs were shrubs or subshrubs and included lingonberry (*Vaccinium vitis-idaea* L.), bog blueberry (*Vaccinium uliginosum* L.), black crowberry (*Empetrum nigrum* L.), bog Labrador tea (*Ledum groenlandicum* Oeder), and various species and subspecies of alder (*Alnus viridis* (Chaix.) DC.; *A. viridis* ssp. *crispa* (Aiton) Turrill, *fruticosa* (Rupr.) Nyman, and *sinuata* (Regel) Á. Löve & D. Löve; *A. incana* (L.) Moench; and *A. incana* ssp. *tenuifolia* (Nutt.) Breitung) (fig. 34). NTFPs with a forb growth habit were less common but included cloudberry (*Rubus chamaemorus* L.), arctic raspberry (also known as nagoonberry; *Rubus arcticus* L.), claspleaf twistedstalk (also known as watermelon berry; *Streptopus amplexifolius* (L.) DC.), and alpine sweetvetch (also known as Eskimo potato; *Hedysarum alpinum* L.).

Conclusion

This report provides a detailed summary of forest inventory data collected across forests in two major watersheds in Alaska: the Susitna River watershed and the upper Copper River watershed. Most of the forests in this area are under public ownerships, with the State of Alaska and local governments managing the majority of lands, followed by the federal government. As elsewhere in Alaska's boreal forests, tree species diversity was low, with black spruce being the most common forest type by area, followed closely by white spruce, then Alaska paper birch. The remaining three forest types (quaking aspen, balsam poplar, and black cottonwood) were relatively uncommon. Compared to the Tanana FIA unit, live-tree volume, biomass, and carbon were higher in the Susitna-Copper FIA unit because of the warmer climate and lower frequency of stand-replacing fires there. A very small percentage of the forest land was considered highly productive timberland, with minimal timber volume and outputs compared to southeast

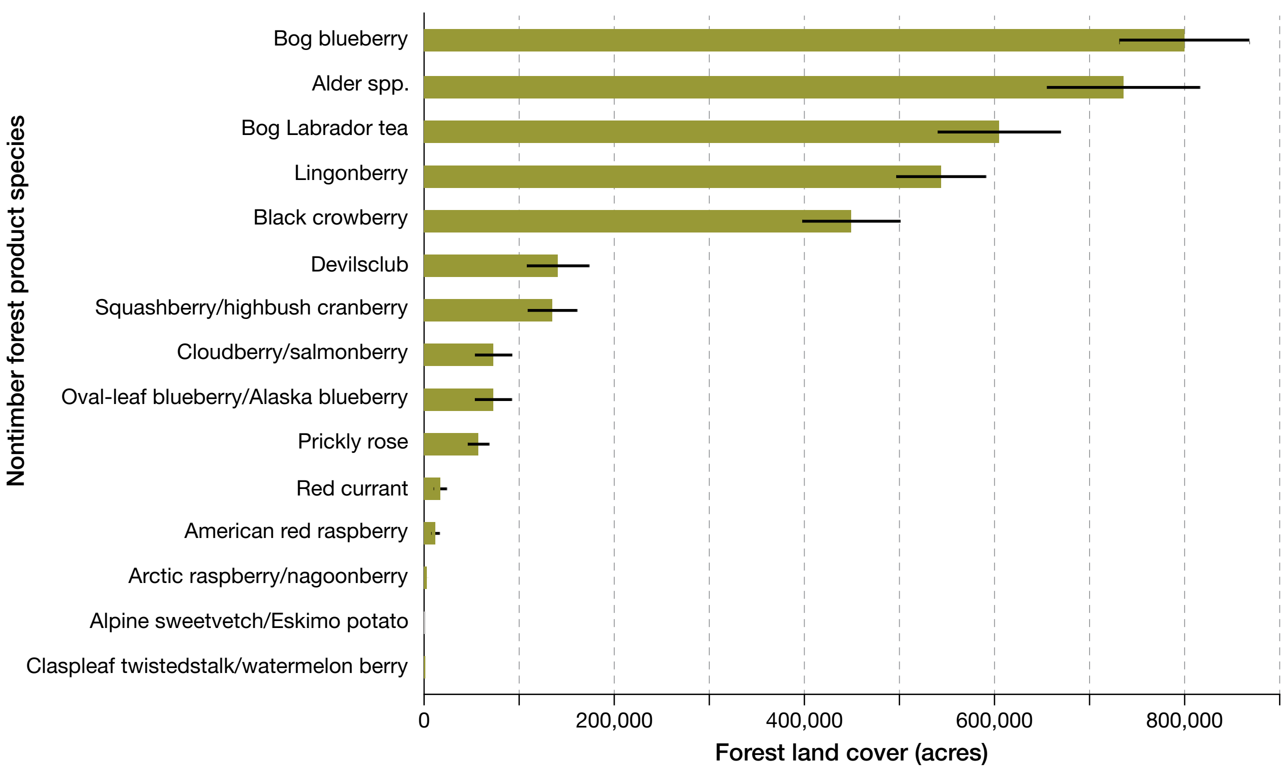

Figure 34—Total cover on forest land by common name of nontimber forest product species in the Susitna-Copper Forest Inventory and Analysis unit, Alaska. Details regarding the most commonly recorded species by growth habit in the Susitna-Copper FIA unit are reported in the text. Refer to the online supplemental tables (table 56) for detailed acreage estimates. Solid bars represent the total; error bars are ± 1 standard error. Credit: Kathryn Baer.

Alaska. White spruce was the most significant species for timber production. The spruce beetle outbreak coincident with plot measurement resulted in a very high number and volume of standing dead white spruce and black spruce trees, particularly in larger diameter classes. Belowground (soil) carbon comprised 70 percent of all ecosystem carbon, highlighting the importance of accounting for belowground carbon when assessing boreal forest carbon stocks.

The successful completion of data collection in the Susitna-Copper FIA unit is a significant achievement for the national FIA program, finishing the first measurement of the second of six interior Alaska FIA inventory units. Continual remeasurement of the permanent FIA plots in interior Alaska will contribute an important dataset to facilitate our understanding of boreal forest dynamics, as the boreal ecosystem is both particularly responsive to climate warming and experiencing some of the greatest increases in air temperature in North America (Hinzman et al. 2013). Studies have suggested that warming temperatures drive changes in forest dynamics in this region. Significant region-wide changes in temperature and precipitation regimes have caused rapid increases in spruce growth in some regions (Dial et al. 2022), and declines in others (Barber et al. 2000, Sullivan et al. 2015). Regionally, warmer temperatures could drive a shift toward a boreal ecosystem dominated by deciduous trees, grasses, and shrubs (Mack et al. 2021), as well as other more diverse effects (Jorgenson et al. 2015). In addition to the direct effects of warming temperatures, biome shifts may be driven by climate-induced changes leading to fires of greater severity and intensity in some parts of Alaska (Mack et al. 2021, Smith et al. 2021), and a rapid degradation of permafrost (Brodie et al. 2019, Lloyd et al. 2003). The diverse and substantial effects of climate warming highlight the importance of continuing to assess the status and trends of interior Alaska's boreal forests through a comprehensive, long-term, repeat inventory, such as that of the FIA program.

Figure 35—A field crew hikes through a shrub field toward a black spruce forest. USDA Forest Service photo by Mike Ausman.

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We thank all the field staff for their incredible efforts to collect the data from numerous plots for this report: Elizabeth Furman (66 plots), Charles Wilton (62 plots), Tom Cheney (61 plots), John McClure (61 plots), Dorothy O'Donnell (60 plots), Sarah Lilly (59 plots), Jayce Williamson (58 plots), Alana Stickney (55 plots), Gina LaBar (54 plots), Daniel "Vic" Anderson (51 plots), Doug Amidon (48 plots), Christopher Hall (48 plots), Misha Yatskov (48 plots), David Rhodes (48 plots), Liv Bly (47 plots), James Winter (46 plots), Tim Sharp (45 plots), Christopher Ferguson (42 plots), Shannon Busby (41 plots), Cade Kellam (40 plots), Bonnie Finnesand (37 plots), Elyse Bongiovanni (36 plots), Kevin Breitenbach (33 plots), Andrew Allaby (20 plots), Christina Craemer (17 plots), Jonathan Kummer (17 plots), Geneva Preston (17 plots), Kate Legner (16 plots), Joe Vorderbruggen (16 plots), Rose Donlon (13 plots), Monica Kopp (13 plots), Elizabeth Fernandez (12 plots), Samuel Knapp (9 plots), and Erica Goad (6 plots). Geneva Preston, Sarah Lilly, Mike Ausman, Joe Vorderbruggen and Daniel "Vic" Anderson provided excellent photographs for this report.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	0.3048	Meters
Miles	1.609	Kilometers
Acres	0.405	Hectares
Square feet	0.0929	Square meters
Square miles	2.59	Square kilometers
Cubic feet	0.0283	Cubic meters
Cubic feet per acre	0.06997	Cubic meters per hectare
Tons per acre	2.242	Megagrams per hectare
Trees per acre	2.47	Trees per hectare

U.S. Standard Equivalents

When you know:	Multiply by:	To find:
Megagrams	1.102	Tons
Megagrams per hectare	.446	Tons per acre

Online Supplemental Tables

A set of summary data tables accompanies this report as an online supplemental document. The online document is available for download at https://doi.org/10.2737/pnw-gtr-1037. The 57 data tables are listed below for reference.

Forest Area

Table 1—Area of forest land by forest type, owner group, and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 2—Area of forest land by forest type and site productivity class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 3—Area of timberland by forest type and stand-size class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 4—Area of forest land by forest type and stand age class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 5—Area of forest land by ecoregion and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 6—Area of sampled land and water by land status and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Number of Trees

Table 7—Number of growing-stock trees on timberland by species and diameter class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 8—Number of live trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 9—Number of standing dead trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 10—Average number of live trees per acre on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 11—Average number of standing dead trees per acre on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Tree Volume

Table 12—Sound volume of live trees on forest land by ownership and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 13—Sound volume of live trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 14—Sound volume of live trees on forest land by species and diameter class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 15—Sound volume of growing-stock trees on timberland by species and diameter class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 16—Average sound volume per acre of live trees on forest land by forest type and stand age class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 17—Average sound volume per acre of live trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 18—Average sound volume per acre of standing dead trees on forest land by forest type and stand age class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 19—Average sound volume per acre of standing dead trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 20—Sound volume of growing-stock trees on timberland by species and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 21—Sound volume of sawtimber-sized trees on timberland by species and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 22—Sound volume of standing dead trees on forest land by ownership and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 23—Sound volume of standing dead trees on forest land by forest type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 24—Sound volume of standing dead trees on forest land by species and diameter class, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Tree Biomass

Tree Carbon

Soil Carbon

Down Woody Material

Table 46—Carbon mass of down wood on forest land by forest type, owner group, and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 47—Biomass of down wood on forest land by forest type, owner group, and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 48—Average biomass of down wood on forest land by forest type, owner group, and land status, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Ground Layer

Table 49—Ground layer biomass, carbon, and nitrogen per acre and total on forest land by forest type, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 50—Ground layer biomass, carbon, and nitrogen per acre and total on forest land by functional group, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 51—Ground layer biomass per acre on forest land by forest type and functional group, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Disturbance

Table 52—Area of disturbance on forest land by disturbance type and ownership, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 53—Gross volume of live trees with damage on forest land by species and damage type, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Understory Vegetation

Table 54—Average cover of understory vegetation on forest land by forest type and life form, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 55—Average cover of understory vegetation on forest land by forest type, age class group, and growth habit, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Table 56—Area of forest land covered by vascular nontimber forest products by plant group and species, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Invasives

Table 57—Area of forest and nonforest land covered by invasive species, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Literature Cited

Agricultural Research, Extension, and Education Reform Act. 1998. 112 Stat. 523; Public Law 105–185.

Alaska Department of Fish and Game. 2025. Community Subsistence Information System (CSIS) data downloader [Database]. Juneau, AK. https://www.adfg.alaska.gov/sb/CSIS/. (December 10, 2025).

Alaska Natural Heritage Program [ANHP]. 2011. European bird cherry: *Prunus padus* L. Anchorage, AK. https://accs.uaa.alaska.edu/wp-content/uploads/Prunus_padus_BIO_PRPA5.pdf. (August 1, 2024).

Andersen, H.-E.; Pattison, R.; Gray, A.; Schulz, B.; Jovan, S.; Smith, R.; Manies, K.; Thompson, T. 2019. Section 2: forest resources of interior Alaska and U.S.-affiliated jurisdictions of the insular Caribbean and Pacific. In: Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A., coords. Forest resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA assessment. Gen. Tech. Rep. WO-GTR-97. Washington, DC: U.S. Department of Agriculture, Forest Service. 21–26. https://doi.org/10.2737/WO-GTR-97.

Andersen, H.-E.; Ståhl, G.; Cook, B.D.; Morton, D.C.; Finley, A.O. 2024. Model-assisted estimation of domain totals, areas, and densities in two-stage sample survey designs. Canadian Journal of Forest Research. 54(12): 1425–1442. https://doi.org/10.1139/cjfr-2024-0039.

Barber, V.A.; Juday, G.P.; Finney, B.P. 2000. Reduced growth of Alaskan white spruce in the twentieth century from temperature-induced drought stress. Nature. 405(6787): 668–673. https://doi.org/10.1038/35015049.

Barrett, T.M.; Christensen, G.A. 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. https://doi.org/10.2737/PNW-GTR-835.

Bechtold, W.A.; Patterson, P.L. 2005. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-GTR-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p. https://doi.org/10.2737/SRS-GTR-80.

Brannoch, S.; Moan, J. 2021. Forest health conditions in Alaska 2020. R10-PR-046. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 76 p.

Brodie, J.F.; Roland, C.A.; Stehn, S.E.; Smirnova, E. 2019. Variability in the expansion of trees and shrubs in boreal Alaska. Ecology. 100(5): e02660. https://doi.org/10.1002/ecy.2660.

Burrill, E.A.; DiTommaso, A.M.; Turner, J.A.; Pugh, S.A.; Christensen, G.A.; Kralicek, K.M.; Perry, C.J.; Lepine, L.C.; Walker, D.M.; Conkling, B.L. 2024. The Forest Inventory and Analysis Database, FIADB user guides, volume: database description (version 9.3), nationwide forest inventory (NFI). U.S. Department of Agriculture, Forest Service. 1026 p. https://research.fs.usda.gov/understory/forest-inventory-and-analysis-database-user-guide-nfi. (July 17, 2025).

Cahoon, S.M.P.; Baer, K.C., tech eds. 2022. Forest resources of the Tanana unit, Alaska: 2018. Gen. Tech. Rep. PNW-GTR-1005. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 92 p. https://doi.org/10.2737/PNW-GTR-1005.

Cahoon, S.M.P.; Kuegler, O.; Christensen, G.A., tech. eds. 2020. Coastal Alaska's forest resources, 2004–2013: Ten-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-979. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 73 p. https://doi.org/10.2737/PNW-GTR-979.

Cahoon, S.M.P.; Sullivan, P.F.; Gray, A.N. 2022. Interactions among wildfire, forest type and landscape position are key determinants of boreal forest carbon stocks. Journal of Ecology. 110(10): 2475–2492. https://doi.org/10.1111/1365-2745.13963.

Carroll, G.L.; Setzer, T.S.; Mead, B.R. 1985. Timber resource statistics for the Beluga block, Susitna River basin multiresource inventory unit, Alaska, 1980. Resour. Bull. PNW-RB-121. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 48 p. https://doi.org/10.2737/PNW-RB-121.

Daly, C.; Smith, J.; Halbleib, M. 2018. 1981–2010 high-resolution temperature and precipitation maps for Alaska Final Report. Corvallis, OR: PRISM Climate Group, Oregon State University. Replace with https://prism.oregonstate.edu/normals_other/public/alaska/report/ak_final_report_8110.pdf. (May 9, 2025).

Deluca, T.H.; Boisvenue, C. 2012. Boreal forest soil carbon: distribution, function and modelling. Forestry. 85(2): 161–184. https://doi.org/10.1093/forestry/cps003.

Dial, R.J.; Maher, C.T.; Hewitt, R.E.; Sullivan, P.F. 2022. Sufficient conditions for rapid range expansion of a boreal conifer. Nature. 608: 546–551. https://doi.org/10.1038/s41586-022-05093-2.

Domke, G.M.; Perry, C.H.; Walters, B.F.; Nave, L.E.; Woodall, C.W.; Swanston, C.W. 2017. Toward inventory-based estimates of soil organic carbon in forests of the United States. Ecological Applications. 27(4): 1223–1235. https://doi.org/10.1002/eap.1516.

Ellison, S.B.Z.; Kuegler, O. [2025]. Updates to forest resources of the Tanana Unit, Alaska: 2018. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 69 p. https://doi.org/10.2737/pnw-gtr-1038.

ESRI. 2015. World hillshade [Map layer source]. https://www.arcgis.com/home/item.html?id=1b243539f4514b6ba35e7d995890db1d. (August 1, 2024).

ESRI. 2017. World terrain base [Map layer source]. https://www.arcgis.com/home/item.html?id=33064a20de0c48d2bb61efa8faca93a8. (August 1, 2024).

Flagstad, L.A.; Cortes-Burns, H.; Roberts, T.L. 2010. Invasive plant inventory and bird cherry control trials phase II: bird cherry distribution, demography and reproduction biology along the Chester and Campbell Creek trails, Anchorage, Alaska. Anchorage, AK: Alaska Natural Heritage Program. 61 p. https://accs.uaa.alaska.edu/wp-content/uploads/Invasive_Plant_Inventory_and_Bird_Cherry_Control_Trials_Phase_II.pdf. (May 9, 2025).

Genet, H.; He, Y.; Lyu, Z.; McGuire, A.D.; Zhuang, Q.; Clein, J.; D'Amore, D.; Bennett, A.; Breen, A.; Biles, F.; Euskirchen, E.S.; Johnson, K.; Kurkowski, T.; (Kushch) Schroder, S.; Pastick, N.; Rupp, T.S.; Wylie, B.; Zhang, Y.; Zhou, X.; Zhu, Z. 2018. The role of driving factors in historical and projected carbon dynamics of upland ecosystems in Alaska. Ecological Applications. 28(1): 5–27. https://doi.org/10.1002/eap.1641.

Gray, A.N.; Baer, K.C.; Witt, C. 2021. Invasive Plants. In: Barrett, T.M.; Robertson, G.C., eds. Disturbance and sustainability in forests of the Western United States. Gen. Tech. Rep. PNW-GTR-992. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 161–189. Chapter 8. https://research.fs.usda.gov/treesearch/62126.

Harms, C. 2011. Moose die from chokecherry poisoning. Press Release No. 11-09. Juneau, AK: Alaska Department of Fish and Game. https://www.adfg.alaska.gov/index.cfm?adfg=pressreleases.pr02152011. (August 1, 2024).

Hegg, K.M. 1970. Forest resources of the Susitna Valley, Alaska. Resour. Bull. PNW-RB-032. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 42 p. https://www.fs.usda.gov/research/treesearch/26731.

Hegg, K.M. 1975. Timber resource statistics for the Copper River inventory unit, Alaska, 1968. Resour. Bull. PNW-RB-062. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 68 p. https://www.fs.usda.gov/research/treesearch/26286.

Helm, D.J.; Collins, W.B. 1997. Vegetation succession and disturbance on a boreal forest floodplain, Susitna River, Alaska. The Canadian Field-Naturalist. 111(4): 553–566. https://doi.org/10.5962/p.358257.

Hinzman, L.D.; Deal, C.J.; McGuire, A.D.; Mernild, S.H.; Polyakov, I.V.; Walsh, J.E. 2013. Trajectory of the Arctic as an integrated system. Ecological Applications. 23(8): 1837–1868. https://doi.org/10.1890/11-1498.1.

Hollingsworth, T.N.; Walker, M.D.; Chapin, F.S., III; Parsons, A.L. 2006. Scale-dependent environmental controls over species composition in Alaskan black spruce communities. Canadian Journal of Forest Research. 36(7): 1781–1796. https://doi.org/10.1139/x06-061.

Jackson, R.B.; Lajtha, K.; Crow, S.E.; Hugelius, G.; Kramer, M.G.; Piñeiro, G. 2017. The ecology of soil carbon: pools, vulnerabilities, and biotic and abiotic controls. Annual Review of Ecology, Evolution, and Systematics. 48: 419–445. https://doi.org/10.1146/annurev-ecolsys-112414-054234.

Jin, S.; Yang, L.; Zhu, Z.; Homer, C. 2017. A land cover change detection and classification protocol for updating Alaska NLCD 2001 to 2011. Remote Sensing of Environment. 195: 44–55. https://doi.org/10.1016/j.rse.2017.04.021.

Johnstone, J.F.; Chapin, F.S.; Hollingsworth, T.N.; Mack, M.C.; Romanovsky, V.; Turetsky, M. 2010. Fire, climate change, and forest resilience in interior Alaska. Canadian Journal of Forest Research. 40(7): 1302–1312. https://doi.org/10.1139/X10-061.

Jorgenson, M.T.; Marcot, B.G.; Swanson, D.K.; Jorgenson, J.C.; DeGange, A.R. 2015. Projected changes in diverse ecosystems from climate warming and biophysical drivers in northwest Alaska. Climatic Change. 130(2): 131–144. https://doi.org/10.1007/s10584-014-1302-1.

Lloyd, A.H.; Yoshikawa, K.; Fastie, C.L.; Hinzman, L.; Fraver, M. 2003. Effects of permafrost degradation on woody vegetation at arctic treeline on the Seward Peninsula, Alaska. Permafrost and Periglacial Processes. 14(2): 93–101. https://doi.org/10.1002/ppp.446.

Lynch, J.; Clark, J.; Bigelow, N.; Edwards, M.; Finney, B. 2002. Geographic and temporal variations in fire history in boreal ecosystems of Alaska. Journal of Geophysical Research: Atmospheres. 108(D1): 8152. https://doi.org/10.1029/2001JD000332.

Macias Fauria, M.; Johnson, E.A. 2008. Climate and wildfires in the North American boreal forest. Philosophical Transactions of the Royal Society B: Biological Sciences. 363(1501): 2317–2329. https://doi.org/10.1098/rstb.2007.2202.

Mack, M.C.; Walker, X.J.; Johnstone, J.F.; Alexander, H.D.; Melvin, A.M.; Jean, M.; Miller, S.N. 2021. Carbon loss from boreal forest wildfires offset by increased dominance of deciduous trees. Science. 372(6539): 280–283. https://doi.org/10.1126/science.abf3903.

Maher, C. 2024. modendro: more dendro (tree ring) functions, version 0.7.0. https://github.com/ctmaher/modendro.

Malhi, Y.; Baldocchi, D.D.; Jarvis, P.G. 1999. The carbon balance of tropical, temperate and boreal forests. Plant, Cell and Environment. 22(6): 715–740. https://doi.org/10.1046/j.1365-3040.1999.00453.x.

Mann, D.H.; Fastie, C.L.; Rowland, E.L.; Bigelow, N.H. 1995. Spruce succession, disturbance, and geomorphology on the Tanana River floodplain, Alaska. Écoscience. 2(2): 184–199. https://doi.org/10.1080/11956860.1995.11682283.

Marcille, K.; Berg, E.; Morgan, T.; Christensen, G. 2021. Alaska's forest products industry and timber harvest, 2015—Part 1: Timber harvest, products, and flow. Resour. Bull. PNW-RB-271-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p. https://www.fs.usda.gov/pnw/pubs/pnw_rb271-1.pdf. (April 30, 2025).

Mead, B.R.; Setzer, T.S.; Carroll, G.L. 1985. Timber resource statistics for the Upper Susitna block, Susitna River basin multiresource inventory unit, Alaska, 1980. Resour. Bull. PNW-RB-122. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 47 p. https://doi.org/10.2737/PNW-RB-122.

Mulligan, G.A.; Munro, D.B. 1981. The biology of Canadian weeds: 51. *Prunus virginiana* L. and *P. serotina* Ehrh. Canadian Journal of Plant Science. 61(4): 977–992. https://doi.org/10.4141/cjps81-144.

National Interagency Fire Center. 2024. Interagency fire perimeter history all years. https://data-nifc.opendata.arcgis.com/datasets/nifc::interagencyfireperimeterhistory-all-years-view/about. (October 1, 2024).

Nowacki, G.J.; Spencer, P.; Fleming, M.D.; Brock, T.; Jorgenson, T. 2003. Unified ecoregions of Alaska: 2001. Open-File Report 2002–297. U.S. Department of the Interior, U.S. Geological Survey. https://pubs.usgs.gov/publication/ofr2002297. (April 11, 2024).

Pastick, N.J.; Jorgenson, M.T.; Wylie, B.K.; Nield, S.J.; Johnson, K.D.; Finley, A.O. 2015. Distribution of near-surface permafrost in Alaska: estimates of present and future conditions. Remote Sensing of Environment. 168: 301–315. https://doi.org/10.1016/j.rse.2015.07.019.

Pattison, R.; Andersen, H.-E.; Gray, A.; Schulz, B.; Smith, R.J.; Jovan, S. 2018. Forests of the Tanana Valley State Forest and Tetlin National Wildlife Refuge, Alaska: results of the 2014 pilot inventory. Gen. Tech. Rep. PNW-GTR-967. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 80 p. https://doi.org/10.2737/PNW-GTR-967.

Ping, C.L.; Jastrow, J.D.; Jorgenson, M.T.; Michaelson, G.J.; Shur, Y.L. 2015. Permafrost soils and carbon cycling. SOIL. 1(1): 147–171. https://doi.org/10.5194/soil-1-147-2015.

Pugh, S.A.; Turner, J.A.; Burrill, E.A.; David, W. 2018. The Forest Inventory and Analysis Database: population estimation user guide. U.S. Department of Agriculture, Forest Service. 166 p. https://research.fs.usda.gov/understory/fiadb-population-estimation-user-guide. (May 12, 2025).

Pyšek, P.; Jarošík, V.; Hulme, P.E.; Pergl, J.; Hejda, M.; Schaffner, U.; Vilà, M. 2012. A global assessment of invasive plant impacts on resident species, communities and ecosystems: the interaction of impact measures, invading species' traits and environment. Global Change Biology. 18(5): 1725-1737. https://doi.org/10.1111/j.1365-2486.2011.02636.x.

Roon, D.; Wipfli, M.; Wurtz, T.L. 2014. Distribution of invasive European bird cherry (*Prunus padus*) in riparian forests along urban Alaskan streams. In: Heutte, T.; Dubois, G., eds. Forest health conditions in Alaska, 2014. R10-PR-36. U.S. Department of Agriculture, Forest Service, Alaska Region Forest Health and Protection: 40–43.

Setzer, T.S.; Carroll, G.L.; Mead, B.R. 1984a. Timber resource statistics for the Talkeetna block, Susitna River basin multiresource inventory unit, Alaska, 1979. Resour. Bull. PNW-RB-115. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 47 p. https://doi.org/10.2737/PNW-RB-115.

Setzer, T.S.; Mead, B.R.; Carroll, G.L. 1984b. Timber resource statistics for the Willow block, Susitna River basin multiresource inventory unit, Alaska, 1978. Resour. Bull. PNW-RB-114. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 47 p. https://doi.org/10.2737/PNW-RB-114.

Simmons, E.A.; Dillon, T.; Berg, E.C.; Daniels, J.M.; Morgan, T.A.; Christensen, G.A.; Koch, L.P. 2024. Alaska's timber harvest and forest products industry, 2019. Gen. Tech. Rep. PNW-GTR-1023. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p. https://doi.org/10.2737/pnw-gtr-1023.

Smith, C.W.; Panda, S.K.; Bhatt, U.S.; Meyer, F.J.; Badola, A.; Hrobak, J.L. 2021. Assessing wildfire burn severity and its relationship with environmental factors: a case study in interior Alaska boreal forest. Remote Sensing. 13(10): 1966. https://doi.org/10.3390/rs13101966 .

Smith, R.J.; Benavides, J.C.; Jovan, S.; Amacher, M.; McCune, B. 2015. A rapid method for landscape assessment of carbon storage and ecosystem function in moss and lichen ground layers. The Bryologist. 118(1): 32–45. https://doi.org/10.1639/0007-2745-118.1.032.

Snyder, C.; MacQuarrie, C.J.K.; Zogas, K.; Kruse, J.J.; Hard, J. 2007. Invasive species in the Last Frontier: distribution and phenology of birch leaf mining sawflies in Alaska. Journal of Forestry. 105(3): 113–119. https://doi.org/10.1093/jof/105.3.113.

Sullivan, P.F.; Ellison, S.B.Z.; McNown, R.W.; Brownlee, A.H.; Sveinbjörnsson, B. 2015. Evidence of soil nutrient availability as the proximate constraint on growth of treeline trees in northwest Alaska. Ecology. 96(3): 716–727. https://doi.org/10.1890/14-0626.1.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2019. Field instructions for the annual inventory of Alaska 2020. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 414 p. https://research.fs.usda.gov/pnw/understory/2020-pnw-fia-alaska-field-manual. (December 6, 2024).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2024. FIA DataMart. v2.1.0. https://research.fs.usda.gov/products/dataandtools/fia-datamart.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2025a. Forest Inventory and Analysis. https://research.fs.usda.gov/programs/fia. (April 17, 2025).

U.S. Department of Agriculture, Forest Service [USDA FS]. 2025b. EVALIDator. [API Version: 2.1.5]. https://apps.fs.usda.gov/fiadb-api/evalidator.

U.S. Department of Agriculture, Forest Service, Northern Research Station [USDA FS NRS]. 2024. Forest Inventory and Analysis DataMart. [Forest Inventory and Analysis Database]. St. Paul, MN. https://apps.fs.usda.gov/fia/datamart/datamart.html.

U.S. Department of the Interior, Bureau of Land Management, Geospatial Business Platform [USDI BLM]. 2023. BLM AK Administered Lands. https://gbp-blm-egis.hub.arcgis.com/datasets/BLM-EGIS::blm-ak-administered-lands/about. (August 1, 2024).

U.S. Department of the Interior, Geological Survey [USDI GS]. 2020. NLCD [National Land Cover Database] 2016 land cover (Alaska). [Ver. 2.0, July 2020]. Multi-Resolution Land Characteristics Consortium. https://www.mrlc.gov/data/nlcd-2016-land-cover-alaska. (August 1, 2024).

Van Cleve, K.; Dyrness, C.T.; Viereck, L.A.; Fox, J.; Chapin, F.S., III; Oechel, W. 1983. Taiga ecosystems in interior Alaska. BioScience. 33(1): 39–44. https://doi.org/10.2307/1309243.

Wang, T.; Hamann, A.; Spittlehouse, D.; Carroll, C. 2016. Locally downscaled and spatially customizable climate data for historical and future periods for North America. PLOS ONE. 11(6): e0156720. https://doi.org/10.1371/journal.pone.0156720.

Werner, R.A.; Holsten, E.H.; Matsuoka, S.M.; Burnside, R.E. 2006. Spruce beetles and forest ecosystems in south-central Alaska: A review of 30 years of research. Forest Ecology and Management. 227(3): 195–206. https://doi.org/10.1016/j.foreco.2006.02.050.

Westfall, J.A.; Coulston, J.W.; Gray, A.N.; Shaw, J.D.; Radtke, P.J.; Walker, D.M.; Weiskittel, A.R.; MacFarlane, D.W.; Affleck, D.L.R.; Zhao, D.; Temesgen, H.; Poudel, K.P.; Frank, J.M.; Prisley, S.P.; Wang, Y.; Sánchez Meador, A.J.; Auty, D.; Domke, G.M. 2024. A national-scale tree volume, biomass, and carbon modeling system for the United States. Gen. Tech. Rep. WO-GTR-104. Washington, DC: U.S. Department of Agriculture, Forest Service. 37 p. https://doi.org/10.2737/WO-GTR-104.

Westfall, J.A.; Coulston, J.W.; Moisen, G.G.; Andersen, H.-E. 2022. Sampling and estimation documentation for the Enhanced Forest Inventory and Analysis Program: 2022. Gen. Tech. Rep. NRS-GTR-207. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 129 p. https://doi.org/10.2737/NRS-GTR-207.

Woodall, C.W.; Heath, L.S.; Domke, G.M.; Nichols, M.C. 2011. Methods and equations for estimating aboveground volume, biomass, and carbon for trees in the U.S. forest inventory, 2010. Gen. Tech. Rep. NRS-GTR-88. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 30 p. https://doi.org/10.2737/NRS-GTR-88.

Yulvianti, M.; Zidorn, C. 2021. Chemical diversity of plant cyanogenic glycosides: an overview of reported natural products. Molecules. 26(3): 719. https://doi.org/10.3390/molecules26030719.

Glossary

abiotic—Pertaining to nonliving environmental attributes, such as temperature, moisture, and wind.

annual inventory—A sample design where an evenly spatially distributed portion of plots within an area are measured each year. Most U.S. states, and the Coastal Alaska FIA unit, are measured as an annual inventory.

aspect—Compass direction that a slope faces.

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.

biomass—The quantity of wood fiber, for trees ≥ 1.0-inch diameter at breast height or at root collar expressed as green or oven-dry weight. It includes aboveground portions of trees (bole/stem [trunk], bark, and branches). Foliage is excluded. Biomass estimates can be computed for live or standing dead trees.

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.

coarse woody material—Down, dead, tree and shrub boles; large limbs; and other woody pieces >1-inch diameter at the point of intersection 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.

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

crown—The part of a tree or woody plant bearing live branches or foliage.

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 (DBH)—The diameter of a tree stem, located at 4.5 feet above the ground (breast height) on the uphill side of a tree. The point of diameter measurement may vary on abnormally formed trees.

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

down woody material—Down, dead, tree and shrub boles; large limbs; and other woody pieces of any size that are severed from their original source of growth. Down woody material also includes dead trees that are supported by roots, severed from roots, or uprooted and leaning >45 degrees from vertical.

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

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.

forb—A broad-leaved herbaceous plant as distinguished from graminoids, shrubs, and trees.

forest land—Land that currently or formerly (within 30 years) has at least 10-percent cover of trees of any size and not currently developed for nonforest use. Forests must be ≥1 acre in size, with a width ≥120 feet.

forest type—A classification of forest land based on and named for the tree species that forms the plurality of non-overtopped live-tree stocking.

graminoid—Grasses (family Gramineae or Poaceae) and grasslike plants, such as sedges (family Cyperaceae) and rushes (family Juncaceae).

growing stock—All live trees ≥5 inches diameter at breast height that are considered merchantable in terms of sawlog length and grade, excluding rough and rotten cull trees.

hardwood—Tree species belonging to the botanical division Magnoliophyta, class Magnoliopsida, often referred to as angiosperms or dicots, usually broad-leaved and deciduous.

house log— Roundwood timber used to construct log homes. Products manufactured from house logs can be sawn, scribed by hand, notched, or milled by lathe to meet customer construction needs. House log timber is often dead (by choice, because “green” logs usually require drying before they can be used for construction) and of lower value than sawlogs.

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. Invasive vascular plants surveyed in this inventory are listed in the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program field manual.

live trees—All living trees, including all size classes, all tree classes, and both commercial and noncommercial species of tree species listed in the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program field manual.

mineral soil—A soil consisting predominantly of products derived from the weathering of rocks (e.g., sands, silts, and clays).

net volume—The gross volume in cubic feet, less deductions for rotten and missing portions, roughness, and poor form. Volume is computed for the central stem from a 1-foot stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

noncensus water—Lakes, reservoirs, ponds, and similar bodies of water 1.0 to 4.5 acres in size and rivers, streams, canals, etc., 30.0- to 200-feet wide.

nonforest land— Land that does not support, or has never supported, forests, and lands formerly forested where use for timber management is precluded by development for other uses. Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining rights-of-way, power line clearings of any width, and census and noncensus water. If intermingled in forest areas, unimproved roads and nonforest strips must be >120 feet wide, and clearings, etc. must be >1 acre in size to qualify as nonforest land.

nonstocked—Forested areas that currently have <10 percent stocking of live trees but were considered forested areas within the past 30 years and do not have nonforest land uses that would prevent the area from returning to forest land in the future.

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

organic soil—The layer of soil that begins with the live moss or litter layer at the ground surface and extends to the mineral soil (also known as the organic [O] layer).

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

owner class/ownership class—A variable that classifies land into categories of ownership. Current owner classes are listed in the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program field manual.

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.

periodic inventory—A sample design where all plots within an area are measured before a new area is measured. In the case of the Interior Alaska FIA inventory, all plots within a unit (e.g., the Susitna-Copper FIA unit) are measured before measurement begins on a new unit.

permafrost—ground (soil or rock and included ice or organic material) that remains at or below 0 °C for at least 2 consecutive years.

productive forest land—Forest land that is producing or capable of producing more than 20 cubic feet per acre per year of wood at culmination of mean annual increment without regard to reserved status.

public land—All owner groups excluding the private owner group; this includes all federal, state, county, and municipal land.

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 (natural seeding, coppice, or root suckers) or artificially (direct seeding or planting).

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.

reserved forest land—Land permanently reserved from management for the production of wood products by statute. Examples include national wilderness areas, national parks and monuments, and state parks.

sampling error—Difference between a population value and a sample estimate that is attributable to the sample, as distinct from errors because of bias in estimation, errors in observation, etc. Sampling error is measured as the standard error of the sample estimate.

sapling—A live tree 1.0 to 4.9 inches diameter.

sawlog—A log meeting minimum standards of diameter, length, and defect for manufacture into lumber or plywood. The definition includes logs with a minimum diameter outside bark of 7 inches for softwoods and 9 inches for hardwoods.

sawtimber trees—Live softwood trees of commercial species ≥9.0 inches diameter at breast height (DBH) and live hardwood trees of commercial species ≥11.0 inches DBH. 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 sawlog with a ≥7-inch top diameter outside bark; hardwood trees must contain at least one 8-foot sawlog with a ≥9-inch top diameter outside bark.

Scribner rule—The common board-foot log rule used to determine sawtimber volume. Scribner volume is estimated in terms of 32-foot logs for softwoods and 16-foot logs for hardwoods.

seedlings—Live trees <1.0 inch diameter at breast height and ≥6 inches in height for softwoods or ≥12 inches in height for hardwoods.

shrub—Perennial, multistemmed woody plant, usually <16 feet in height; under certain environmental conditions, shrubs may be single-stemmed or >16 feet.

slope—Measure of change in surface value over distance, expressed in degrees or as a percentage.

snag—Standing dead tree ≥5 inches diameter at breast height and ≥4.5 feet in length, with a lean of <45 degrees from vertical. Dead trees leaning >45 degrees from vertical are considered coarse woody material. Standing dead material <4.5 feet in length is considered a stump.

sound volume—The gross volume in cubic feet, less deductions for rotten and missing portions (live trees) or missing portions (dead trees). Volume is computed for the central stem from a 1.0-foot stump to >4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

stand age—Average age of the live dominant and codominant trees in the predominant stand-size class.

stand-size class—A classification of stands based on tree size. Large-diameter stands have the majority of trees ≥11.0 inches diameter at breast height (DBH) for hardwoods and ≥9.0 inches DBH for softwoods. Medium-diameter stands have the majority of trees ≥5.0 inches DBH but not as large as large-diameter trees; and small-diameter stands have the majority of trees <5.0 inches DBH.

state land—An owner class of public lands owned or managed by states or lands leased by states for more than 50 years.

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.

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.

Susitna-Copper Forest Inventory and Analysis (FIA) unit—One of seven subunits of the Alaska U.S. Department of Agriculture, Forest Service, FIA inventory (table 1) primarily covering the Susitna River watershed and the upper Copper River watershed (fig. 1). Although this area of Alaska is more commonly defined as part of the southcentral region, it is measured in the interior FIA unit under a periodic inventory.

Susitna-Copper Timber Products Output (TPO) resource area—A reporting unit designed to report timber products output statistics for this publication, encompassing Alaska's Matanuska-Susitna Borough and Copper River Census Area (fig. 13). The Susitna-Copper TPO resource area roughly overlaps the Susitna-Copper Forest Inventory and Analysis (FIA) unit and encompasses nearly the entirety of the populated areas and road system there, while excluding population centers and road areas outside of the boundaries of the Susitna-Copper FIA unit.

timberland—Forest land that is producing or capable of producing >20 cubic feet per acre per year of wood at culmination of mean annual increment. Timberland excludes reserved forest lands.

transect—A narrow sample strip or a measured line laid out through vegetation chosen for study.

tree—A woody perennial plant, typically large, with a single well-defined stem carrying a definite crown with a height of ≥15 feet at maturity. For the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis, any plant on the tree list in its current field manual is measured as a tree.

understory—All forest vegetation growing under an overstory.

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 more than 20 cubic feet per acre per year of industrial wood in natural stands.

vascular plant—A plant possessing a well-developed system of conducting tissue to transport water, mineral salts, and sugars. This includes plants in the subkingdom Tracheobionta and excludes bryophytes and algae.

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. Legally designated wilderness areas are considered reserved land by U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis.

wildfire (wildland fire)—Any uncontained fire occurring on wildland.

Appendix 1: Volume, Biomass, and Carbon Estimate Method Comparison

The following tables summarize changes in estimates of volume and biomass across the U.S. Department of Agriculture, Forest Service's Susitna-Copper Forest Inventory and Analysis (FIA) unit for each species recorded in these units. These changes occurred because the FIA program changed the former methods of estimating volume and biomass to the current National-Scale Volume and Biomass (NSVB) methods in September 2023. Prior to NSVB, FIA databases offered two volume and biomass calculations: Component Ratio Method (CRM) and Regional, which relied on local equations. Nationally, most FIA products used the CRM calculations, while within the Pacific Northwest FIA program, most products reported the Regional equations. Change analysis provided by Westfall et al. (2024) is based on the CRM calculations.

To convert between the older Regional and the current NVSB methods of calculating volume, biomass, and carbon values, multiply the percentage change for a category by the pre-NSVB value to estimate the NSVB value for that category, or divide the post-NSVB value by the change estimate to estimate the Regional method value. All estimates available through EVALIDator are also provided using the NSVB equations.

Table A1.1—Sound volume estimates on forest land for live and standing dead trees by species and estimation method, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Species	Volume estimation method									
	Live					Standing dead				
	Sound volume (Regional)		Sound volume (NSVB)			Sound volume (Regional)		Sound volume (NSVB)		
	Total	SE	Total	SE	Change in live volume	Total	SE	Total	SE	Change in standing dead volume
	Cubic feet (millions)				Percent	Cubic feet (millions)				Percent
Softwoods										
White spruce	1,659	199	1,815	221	9	1,377	144	1,527	160	11
Black spruce	282	45	304	49	8	126	31	139	34	10
All softwoods	1,941	205	2,119	228	9	1,503	146	1,666	162	11
Hardwoods										
Quaking aspen	335	108	359	118	7	20	8	22	10	13
Alaska paper birch	1,953	235	2,121	249	9	89	14	98	16	11
Balsam poplar	90	35	106	39	18	10	6	14	8	46
Black cottonwood	37	19	48	25	30	12	13	13	14	11
All hardwoods	2,415	252	2,634	270	9	131	22	148	24	14
All species	4,356	328	4,752	357	9	1,634	148	1,814	165	11

Note: National-Scale Volume and Biomass (NSVB) sound volume includes wood in the merchantable bole for trees ≥5 inches diameter at breast height, not including portions that are rotten (live trees) or missing (both live and standing dead trees). No deductions are made for rough cull.

Table A1.2—Aboveground biomass estimates on forest land for live and standing dead trees by species and estimation method, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Species	Live: Total biomass (Regional) Total	Live: Total biomass (Regional) SE	Live: Total biomass (NSVB) Total	Live: Total biomass (NSVB) SE	Change in live biomass	Standing dead: Total biomass (Regional) Total	Standing dead: Total biomass (Regional) SE	Standing dead: Total biomass (NSVB) Total	Standing dead: Total biomass (NSVB) SE	Change in standing dead biomass
	Thousand tons				Percent	Thousand tons				Percent
Softwoods										
White spruce	38,777	4,576	47,555	5,565	23	24,626	2,565	37,033	3,960	50
Black spruce	9,237	1,424	8,340	1,251	–10	2,973	719	3,177	769	7
All softwoods	48,014	4,822	55,895	5,728	16	27,598	2,630	40,209	3,995	46
Hardwoods										
Quaking aspen	7,558	2,405	7,803	2,490	3	387	167	383	167	–1
Alaska paper birch	55,616	6,461	53,426	6,175	–4	1,372	219	1,341	212	–2
Balsam poplar	2,350	765	2,541	871	8	227	136	217	125	–4
Black cottonwood	1,043	556	1,284	675	23	151	124	113	85	–25
All hardwoods	66,568	6,729	65,054	6,523	–2	2,137	337	2,053	319	–4
All species	114,583	8,313	120,949	8,708	6	29,735	2,661	42,262	4,019	42

Note: National-Scale Volume and Biomass (NSVB) aboveground biomass reported here is the oven-dry biomass in the aboveground portion, excluding foliage, of live and standing dead trees ≥5.0 inches diameter at breast height.

Table A1.3—Aboveground carbon estimates on forest land for live and standing dead trees by species and estimation method, Susitna-Copper Forest Inventory and Analysis unit, Alaska, 2020

Species	Live: Total carbon (Regional) Total	Live: Total carbon (Regional) SE	Live: Total carbon (NSVB) Total	Live: Total carbon (NSVB) SE	Change in live carbon	Standing dead: Total carbon (Regional) Total	Standing dead: Total carbon (Regional) SE	Standing dead: Total carbon (NSVB) Total	Standing dead: Total carbon (NSVB) SE	Change in standing dead carbon
	Thousand tons				Percent	Thousand tons				Percent
Softwoods										
White spruce	19,389	2,288	24,348	2,849	26	12,313	1,282	18,573	1,985	51
Black spruce	4,619	712	4,003	600	–13	1,486	359	1,594	385	7
All softwoods	24,007	2,411	28,351	2,924	18	13,799	1,315	20,166	2,003	46
Hardwoods										
Quaking aspen	3,779	1,203	3,738	1,193	–1	193	83	181	79	–7
Alaska paper birch	27,808	3,230	25,431	2,939	–9	686	109	638	101	–7
Balsam poplar	1,175	382	1,225	420	4	113	68	103	59	–9
Black cottonwood	522	278	619	325	19	76	62	54	41	–29
All hardwoods	33,284	3,364	31,012	3,109	–7	1,069	169	976	151	-9
All species	57,291	4,156	59,363	4,283	4	14,868	1,331	21,142	2,014	42

Note: National-Scale Volume and Biomass (NSVB) aboveground carbon reported here is the carbon in the aboveground portion, excluding foliage, of live and standing dead trees ≥5.0 inches in diameter at breast height.

Appendix 2: Species Common and Scientific Names

The following is a list of species most commonly encountered by U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis field crews in the Susitna-Copper Forest Inventory and Analysis unit, as recorded in the understory vegetation profile.

Growth Habit	Common name	Scientific name	USDA PLANTS symbol
Trees:	Alaska paper birch, resin birch[a]	*Betula neoalaskana* Sarg.	BENE4
	Balsam poplar	*Populus balsamifera* L. ssp. *balsamifera*	POBAB2
	Bebb willow[b]	*Salix bebbiana* Sarg.	SABE2
	Black cottonwood	*Populus balsamifera* ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw	POBAT
	Black spruce	*Picea mariana* (Mill.) Britton, Sterns & Poggenb.	PIMA
	Chokecherry	*Prunus virginiana* L.	PRVI
	European bird cherry	*Prunus padus* L.	PRPA5
	Littletree willow[b]	*Salix arbusculoides* Andersson	SAAR3
	Quaking aspen	*Populus tremuloides* Michx.	POTR5
	Scouler's willow[b]	*Salix scouleriana* Barratt ex Hook.	SASC
	White spruce	*Picea glauca* (Moench) Voss	PIGL
Shrubs:	American red raspberry	*Rubus idaeus* L.	RUID
	Beauverd spirea	*Spiraea stevenii* (C.K. Schneid.) Rydb	SPST3
	Black crowberry	*Empetrum nigrum* L.	EMNI
	Bog blueberry	*Vaccinium uliginosum* L.	VAUL
	Bog Labrador tea	*Ledum groenlandicum* Oeder	LEGR
	Devilsclub	*Oplopanax horridus* (Sm.) Miq.	OPHO
	Gray alder[b]	*Alnus incana* (L.) Moench	ALIN2
	Green alder[b]	*Alnus viridis* (Chaix.) DC.	ALVI5
	Lingonberry	*Vaccinium vitis-idaea* L.	VAVI
	Marsh Labrador tea	*Ledum palustre* L. ssp. *decumbens* (Aiton) Hultén	LEPAD
	Mountain alder[b]	*Alnus viridis* (Chaix.) DC. ssp. *crispa* (Aiton) Turrill	ALVIC
	Oval-leaf blueberry	*Vaccinium ovalifolium* Sm.	VAOV
	Prickly rose	*Rosa acicularis* Lindl.	ROAC
	Red currant	*Ribes triste* Pall.	RITR
	Red fruit bearberry	*Arctostaphylos rubra* (Rehder & Wilson) Fernald	ARRU
	Resin birch	*Betula glandulosa* Michx.	BEGL
	Siberian alder[b]	*Alnus viridis* (Chaix) DC. ssp. *fruticosa* (Rupr.) Nyman	ALVIF
	Sitka alder[b]	*Alnus viridis* (Chaix) DC. ssp. *sinuata* (Regel) Á. Löve & D. Löve	ALVIS
	Stiff clubmoss	*Lycopodium annotinum* L.	LYAN2
	Squashberry	*Viburnum edule* (Michx.) Raf.	VIED
	Thinleaf alder[b]	*Alnus incana* (L.) Moench ssp. *tenuifolia* (Nutt.) Breitung	ALINT
Forbs:	Alpine sweetvetch	*Hedysarum alpinum* L.	HEAL
	Arctic raspberry	*Rubus arcticus* L.	RUAR
	Arctic sweet coltsfoot	*Petasites frigidus* (L.) Fr.	PEFR5
	Bunchberry dogwood	*Cornus canadensis* L.	COCA13

Growth Habit	Common name	Scientific name	USDA PLANTS symbol
	Butter and eggs	*Linaria vulgaris* Mill.	LIVU2
	Claspleaf twistedstalk	*Streptopus amplexifolius* (L.) DC.	STAM2
	Cloudberry	*Rubus chamaemorus* L.	RUCH
	Clover	*Trifolium* L.	TRIFO
	Common dandelion	*Taraxacum officinale* F.H. Wigg	TAOF
	Common ladyfern	*Athyrium filix-femina* (L.) Roth	ATFI
	Common plantain	*Plantago major* L.	PLMA2
	Cloudberry	*Rubus chamaemorus* L.	RUCH
	False toadflax	*Geocaulon lividum* (Richardson) Fernald	GELI2
	Field horsetail	*Equisetum arvense* L.	EQAR
	Fireweed	*Chamerion angustifolium* (L.) Holub ssp. *angustifolium*	CHANA2
	Hempnettle	*Galeopsis* L.	GALEO
	Meadow horsetail	*Equisetum pratense* Ehrh.	EQPR
	Nagoonberry	*Rubus arcticus* L.	RUAR
	Narrowleaf hawksbeard	*Crepis tectorum* L.	CRTE3
	Oxeye daisy	*Leucanthemum vulgare* Lam.	LEVU
	Purple marshlocks	*Comarum palustre* L.	COPA28
	Spreading woodfern	*Dryopteris expansa* (C. Presl) Fraser-Jenkins & Jermy	DREX2
	Strawberryleaf raspberry	*Rubus pedatus* Sm.	RUPE
	Tall bluebells	*Mertensia paniculata* (Aiton) G. Don	MEPA
	Twinflower	*Linnaea borealis* L.	LIBO3
	Western oakfern	*Gymnocarpium dryopteris* (L.) Newman	GYDR
	Woodland horsetail	*Equisetum sylvaticum* L.	EQSY
Graminoids:	Altai fescue	*Festuca altaica* Trin.	FEAL
	Bigelow’s sedge	*Carex bigelowii* Torr. ex Schwein.	CABI5
	Bluejoint	*Calamagrostis canadensis* (Michx.) P. Beauv.	CACA4
	Northwest Territory sedge	*Carex utriculata* Boott	CAUT
	Northern bog sedge	*Carex gynocrates* Wormsk. ex Drejer	CAGY2
	Panicled bulrush	*Scirpus microcarpus* J. Presl & C. Presl	SCMI2
	Red cottongrass	*Eriophorum russeolum* Fr. ex Hartm.	ERRU2
	Round sedge	*Carex rotundata* Wahlenb.	CARO7
	Sheathed sedge	*Carex vaginata* Tausch	CAVA2
	Tall cottongrass	*Eriophorum angustifolium* Honck.	ERAN6
	Timothy	*Phleum pratense* L.	PHPR3
	Tussock cottongrass	*Eriophorum vaginatum* L.	ERVA4
	Water sedge	*Carex aquatilis* Wahlenb.	CAAQ
	Wideleaf polargrass	*Arctagrostis latifolia* (R. Br.) Griseb.	ARLA2

[a] While the USDA PLANTS database (USDA NRCS, n.d.) lists resin birch as a common name for both *Betula neoalaskana* and *B. glandulosa*, resin birch is more commonly used to refer to *B. glandulosa*, and Alaska paper birch is more commonly used to refer to *B. neoalaskana*.

[b] According to the USDA PLANTS database (USDA NRCS, n.d.), these species and subspecies can display either tree or shrub growth habits. Each species or subspecies is listed under the growth habit that was most commonly recorded by Forest Service, Forest Inventory and Analysis (FIA) crews in the Susitna-Copper FIA unit.

Appendix 3: Standard Error

We report standard error (SE) for every estimate in this report, and it is crucial for assessing reliability of the estimate. The smaller the SE value compared to the estimate, the more reliable the estimate.

The value of SE added to and subtracted from the estimate creates a range (low value to high value) of confidence in which the true value of the population is likely to occur. If we repeatedly sampled the population and constructed a confidence interval in such a way, the true value would be within these confidence intervals about 68 percent of repeats. An approximately 95-percent confidence level interval can be created by multiplying the SE by 2 (and adding to and subtracting from the estimate). SE can be used to create intervals with any confidence level, as needed, using a statistical reference table (T table).

The U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program follows a strict protocol to ensure the high quality of data collected, including quality assurance and control procedures for measurements, data entry, and processing. Although the program makes considerable effort to minimize them, measurement errors; species misidentifications; and mistakes in data entry, processing, and analysis still occur.

Appendix 4: FIA Database Instructions for Interior Alaska Data Users

It is essential for users of U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) data to understand that Alaska FIA data needs to be filtered to differentiate between coastal Alaska data and different units of interior Alaska data (accessible through the FIA DataMart [USDA FS 2025]). When accessing the data, the following can be consulted to help identify the data of interest:

<table>
<tr><th>Data</th><th>EVALID[a]</th><th>Tanana FIA unit identifier</th><th>Susitna-Copper FIA unit identifier</th></tr>
<tr><td>Area; stand- and tree-level estimates</td><td>21921</td><td rowspan="4">ESTN_UNIT[b] = 1</td><td rowspan="4">ESTN_UNIT = 2</td></tr>
<tr><td>Down woody materials estimates</td><td>21927</td></tr>
<tr><td>Ground layer estimates</td><td>21933</td></tr>
<tr><td>Soils estimates</td><td>21931</td></tr>
</table>

FIA = Forest Inventory and Analysis.

A field in the POP_PLOT_STRATUM_ASSGN table identifying the specific geographic area that is stratified. To select a group of plots in a unit within an EVALID, link the POP_PLOT_STRATUM_ASSGN table to the plot table (POP_PLOT_STRATUM_ASSGN.PLT_CN = PLOT.CN) and filter by the EVALID and ESTN_UNIT of interest (for example, WHERE EVALID = 21921 AND ESTN_UNIT = 1 for Tanana FIA unit area estimates).

[a] Evaluation identifier, representing an aggregation of data. EVALID is a data item in Forest Inventory and Analysis Database (see Burrill et al. 2024).

Note that while these data items are accurate at the time of publication, the FIA Database evolves dynamically to suit client needs. For assistance with accessing the interior Alaska database, please e-mail the Forest Service, Pacific Northwest Research Station FIA program at sm.fs.pnw_iram@usda.gov.

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