BIOLOGICAL SETTING

Coastal temperate rainforests are rare—constituting only 3% of all the world's temperate forests. About half of the world's temperate rainforests are found on the north Pacific coast of North America, but this impressive forest has only recently clothed the area. Less than 10,000 years ago, most of the region as far south at Puget Sound in Washington State was covered with massive continental glaciers. In Southeast Alaska only a few small areas near the coast remained ice-free during those turbulent times. Despite the rigorous conditions, a few species of plants and animals survived the glacial period in those "refugia". With so much of the world's water locked up in ice, sea levels were much lower than they are today; many of today's islands were probably joined to the mainland when they first became ice-free, providing pathways for species dispersal.

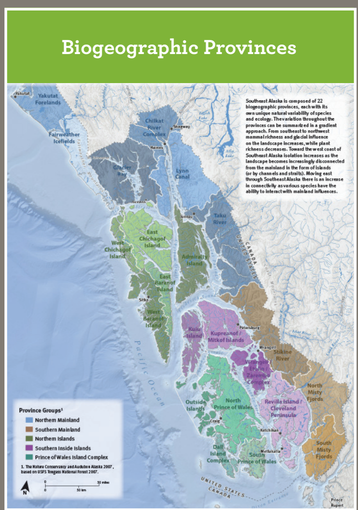
Islands, especially oceanic islands that were never connected to the mainland, have played a dominant role in the history of biology. Evolution often proceeds rapidly on islands because arriving species encounter, and must adapt to, ecosystems with far fewer species than on the mainland. Island colonists can evolve quickly because there is little or no gene flow from the mainland. Thus, even though Southeast Alaska's islands are young and are still close to the mainland, evolution has proceeded rapidly enough to generate genetically distinct populations of species on many of them. This is why dividing the area into biogeographic regions based on these distinct geographic distributions helps managers and conservation biologists develop plans for conserving the rich biodiversity of the region.

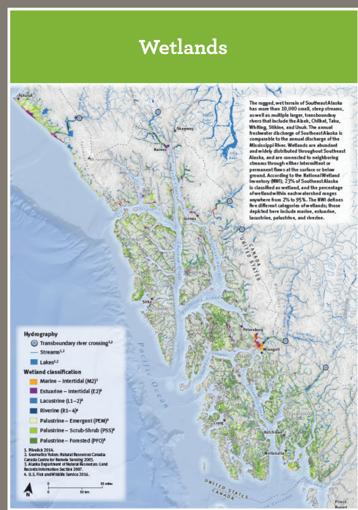
Colonization of the newly exposed lands in Southeast Alaska has been rapid and complex. Some species arrived from the south. Others entered the area from Canada following the rivers that penetrate the rugged coastal mountains. Some arrived from the northeast. As the climate of the region continues to warm, immigration continues, and some of the earlier colonizers (lemmings, caribou) have disappeared from the area as their suitable habitat vanished. This complex and rapidly unfolding history, which continues today, helps explain many of the otherwise peculiar distribution patterns of plants and animals in the region. For example, it explains why brown bears are found only on the region's northern islands, and black bears only on southern ones. Moreover, the distributions of fungi, insects, and soil animals are still mostly unknown.

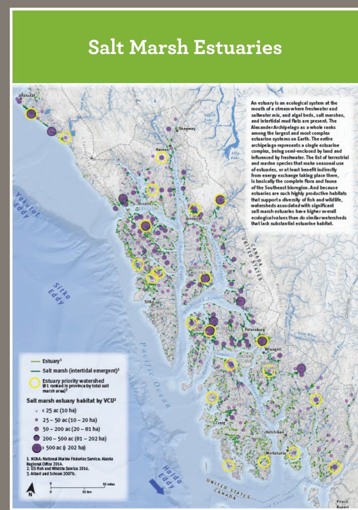
~ Gordon Orians

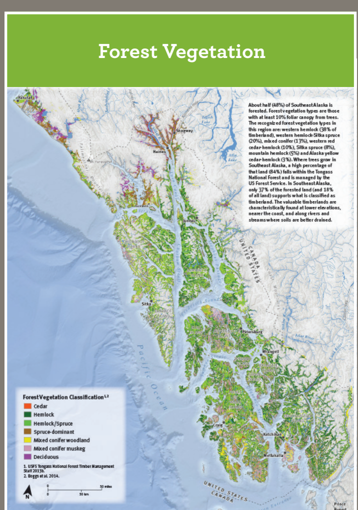
John Schoen

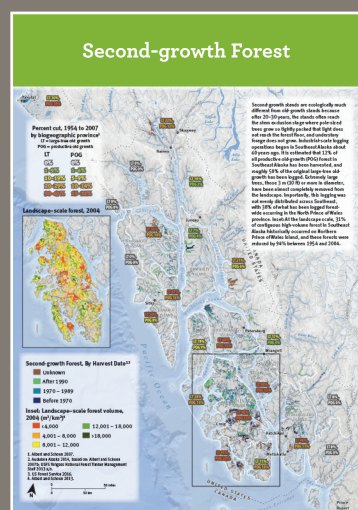
BIOLOGICAL SETTING MAPS INDEX

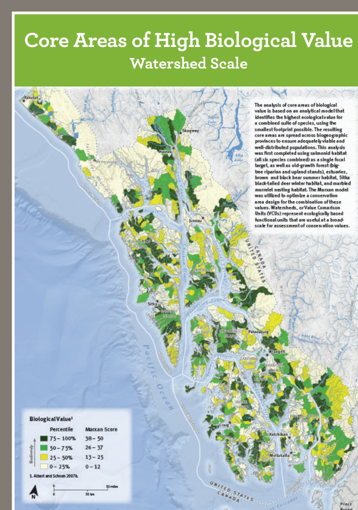


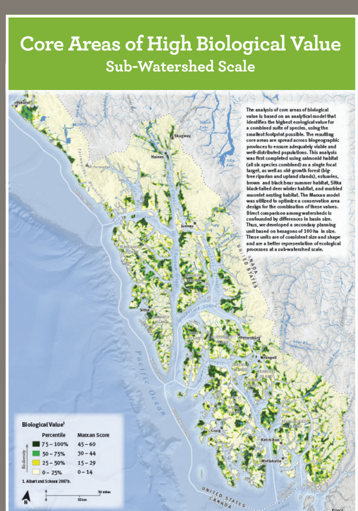


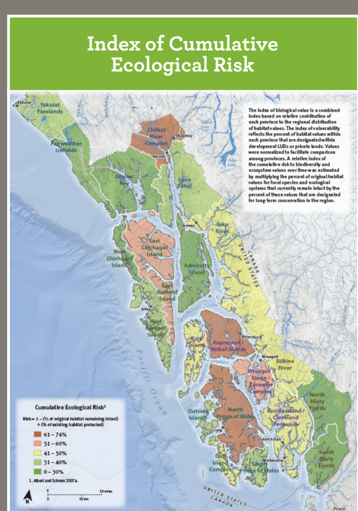












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BIOGEOGRAPHIC PROVINCES

John Schoen and David Albert
Revised by John Cannon

Biological variation throughout the Alexander Archipelago is due in part to the diversity created by island biogeography and mainland influences such as icefields and steep topography. Many of the islands have distinct climatic, floral, and faunal differences. Southeast Alaska is composed of 22 biogeographic provinces, each with its own unique natural variability of species and ecology. The variation throughout the provinces can be summarized in a gradient approach. From southeast to northwest mammal richness and glacial influence on the landscape increases, while plant richness decreases. Toward the west coast of Southeast Alaska isolation increases as the landscape becomes increasingly disconnected from the mainland in the form of islands (or by channels and straits). Moving east through Southeast Alaska there is an increase in connectivity as various species have the ability to interact with mainland influences.

NORTHERN MAINLAND GROUP

The Northern Mainland consists of the biogeographic provinces of the Yakutat Forelands, Fairweather, Glacier Bay, Chilkat River Complex, Lynn Canal, and the Taku River/Mainland. Each of these provinces is connected with the mainland, and displays high continental connectivity.

The northernmost **Yakutat Forelands Province** is a dramatic ice-draped landscape, with icefields and glaciers that cover over a third of the province. The forelands of this province consist of nearly level surficial deposits, raised marine sands, and silts that support a diverse forest and wetlands ecosystem. This landscape supports 27 mammal species, including two endemic subspecies of tundra vole (*Microtus oeconomus yakutatensis*) and ermine (*Mustela ermine alascensis*). The province supports healthy moose (*Alces alces*), brown bear (*Ursus arctos*), and wolf (*Canis lupis*) populations. In this province, 39% of the land area is legislatively protected under Land Use Designation II (LUD II) (Russell Fjord Wilderness and Yakutat Forelands LUD II) and 55% is protected under the Tongass Land Management Plan (TLMP).

The **Fairweather Province** is one of the wildest regions of Southeast Alaska, with the least human presence, and 99% of this region is legislatively protected as part of Glacier Bay National Park and Preserve. The province contains Southeast Alaska's highest and most rapidly rising mountains, with Mount Fairweather as the highest peak at 15,300 ft (4,665 m). A combination of these mountains and Pacific moisture creates an extremely wet climate, resulting in vast icefields and glaciers that cover 46% of the province. The Alsek and Tatshenshini rivers make up the greatest river basin of the province, with the Alsek providing a wildlife corridor that allowed for moose to populate the Yakutat Forelands only a half century ago.

The **Glacier Bay Province** is 41% ice-covered, and the Gustavus Forelands within the province is a wetland region that provides an important habitat for migratory waterfowl, shorebirds, and sandhill cranes (*Grus canadensis*). Since the bay was deglaciated, a low-lying mountain pass between the upper Adams Inlet and the Excursion River has become a major migratory corridor that has allowed for the colonization of moose in the province from Lynn Canal. Thirty known mammal species are present in this region, along with three endemic subspecies that include a hoary marmot (*Marmota caligata vigilis*), a red-backed vole (*Clethrionomys rutilus glacialis*), and an ermine, as well as an endemic species that includes the Glacier Bay water shrew (*Sorex alaskanus*). Riparian forests with anadromous fish values are 85% protected in watershed or sub-watershed reserves.

The **Chilkat River Complex** lies at the end of the Inside Passage and consists of nine glacially fed rivers. Overlap of coastal and interior flora produces Alaska's highest vascular plant species richness, and the Chilkat River watershed is one of the highest value watersheds for salmon habitat (all five species) in Southeast Alaska. In late fall and early winter thousands of Bald Eagles (*Haliaeetus leucocephalus*) congregate from hundreds of miles away for a late run of chum salmon (*Oncorhynchus keta*). This province has the highest mammal diversity in Southeast Alaska due to an overlap of coastal and interior species, with 38 species recorded, including an endemic species of weasel (*Mustela ermine alascensis*). Only 2% of the province is legislatively protected and 10% is administratively protected.

The **Lynn Canal Province** consists of very steep fjordland topography with high mountains and some of the deepest inland waters in Southeast Alaska. There are 31 mammal species present, two of which are endemic. Berners Bay, a site for recently proposed developments, is a productive watershed that provides early-season feeding opportunities for various bird and terrestrial species, as well as one of Southeast Alaska's best coho (*Oncorhynchus kisutch*) rearing watersheds.

The **Taku River/Mainland Province** is characterized by deep fjords, tidewater glaciers, active glacial rivers, and steep mountains that isolate wildlife populations. The only major wildlife migratory corridor in this region is along the Taku River, and is critical for migrating fish, mammals, and birds. The province has 36 mammal species, and is commonly known to have Southeast Alaska's highest bird diversity. The province is the northern limit for deer populations due to wolf predation and snowier winters. The Taku River is the top-ranked watershed for the amount of freshwater salmon habitat, and is also important for both brown and black bear (*Ursus americanus*) populations. A portion of this province is legislatively protected in the form of the Tracy Arm /Endicott Arm Wilderness.

SOUTHERN MAINLAND GROUP

The Southern Mainland is comprised of the Stikine River, North Misty Fjords, and South Misty Fjords provinces.

The **Stikine River Province** is highlighted by the presence of the Stikine River, the largest river corridor connecting Southeast Alaska with the interior, and the Stikine River Delta, the largest river delta and tidal estuary in Southeast Alaska. The corridor created by the Stikine River has Alaska's greatest amphibian species richness and has allowed for moose to migrate into this region and further to the islands of Mitkof, Kupreanof, and Kuiu. All five species of Pacific salmon are present in the Stikine, and about 1,000 bald eagles gather at the Stikine each April for the eulachon (*Thaleichthys pacificus*) run. The Stikine River Delta is used in the spring by 15 shorebird species, and may be one of only two major Southeast Alaska stopover sites for a large portion of the Pacific population of western sandpipers (*Calidris mauri*). It is a globally significant Important Bird Area recognized by BirdLife International and the National Audubon Society. In the province 25% of land is legislatively protected through the Stikine-LeConte Wilderness, 55% is administratively protected under TLMP, and 20% is managed for development.

The **North Misty Fjords Province** is primarily comprised of steep-walled granitic fjords, narrow valleys, and fragmented sections of conifer forest. The Unuk River watershed, comprised of a smaller transboundary river, has the highest value salmon habitat (for all five species) south of the Stikine River, and is ranked as the eighth watershed in Southeast Alaska for combined salmon habitat. Bears and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) both have lower populations in this region compared to other provinces, but mountain goats are present in the steep and rocky high-elevation habitat. Ninety percent of the province is legislatively protected in the form of the northern portion of the Misty Fjords National Monument/Wilderness.

The **South Misty Fjords Province** makes up the southern portion of the Misty Fjords National Monument/Wilderness, apart from the 20% of the province withdrawn to non-wilderness status to allow for

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The Taku River valley is the major wildlife migratory corridor in the Taku River/Mainland Province. The river itself is spawning habitat for all five species of Pacific salmon.

mineral development at the Quartz Hill molybdenite deposit. Due to gentler topography, this province has nearly twice as much estuary and productive old growth as the North Misty Fjords Province, along with greater habitat value and connectivity for most wildlife species. Deer and black bears are more common in South Misty than in North Misty, and mountain goat populations extend into this province as well. Wilson Lake, Mink Bay, Marten River, Keta River, Blossom River, and Tombstone Bay are six of the best watersheds in Southeast Alaska for pink salmon (*Oncorhynchus gorbuscha*).

NORTHERN ISLANDS GROUP

The Northern Islands are comprised of West Chichagof, East Chichagof, West Baranof, East Baranof, and Admiralty Island provinces.

The **West Chichagof Island Province** is characterized by a dramatic and complex shoreline, and is highly exposed to Pacific storms. Thirteen mammal species are present on Chichagof Island as a whole, including two endemic subspecies that include a tundra vole (*Microtus oeconomus sitkensis*) and an ermine (*Mustela ermine initis*). Deer populations periodically increase due to an absence of wolves and rare periods of deep snow, and brown bears occur in moderate numbers. Legislative protection applies to 87% of the province through the West Chichagof Wilderness and LUD II regions, and less than 3% of the province is available for development.

The adjoining **East Chichagof Island Province** is characterized by granitic rocks and less productive forest ecosystems in the western portion, and high-quality karst features and carbonate rocks in the eastern portion that allow for productivity of large-tree forests. U-shaped valleys formed from previous glacial ice provide high-quality habitat for salmon and steelhead, which in turn provide habitat that is among the most productive areas for brown bears in Southeast. However, a combination of timber harvest and road construction has reduced overall habitat for brown bears and has enhanced human access to brown bear habitat. The top watershed for deer habitat also falls within this province. Approximately 6% of the province is congressionally protected wilderness, and 25% is protected as LUD II.

The **West Baranof Island Province** is a highly rugged region of Southeast Alaska. The angular andesitic rocks on Saint Lazaria Island are a globally significant Important Bird Area that provides nesting habitat for hundreds of thousands of seabirds. Saint Lazaria Island is also part of the Alaska National Maritime Wildlife Refuge. Baranof Island has 13 mammal species, and shares the endemic subspecies also present on Chichagof Island. Only 16% of the province is managed for development, but the northern portion of the province ranks second behind adjoining East Baranof for the most intensive high-grading of large trees in Southeast Alaska.

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The neighboring **East Baranof Island Province** is the highest and most rugged of all island topography in Southeast Alaska, and is one of the wettest regions as well. The northern portion of the province has higher productivity forests due to lower elevations and a mixture of sedimentary and volcanic rocks. As mentioned previously, this province is the most intensively high-graded region for large-tree old growth in Southeast Alaska, and contains the highest percentage of logging within riparian forests associated with anadromous fish of any province in the region. Legislative protection applies to 23% of the province in the form of the South Baranof Wilderness, and 50% is administratively protected under the TLMP.

Much of the **Admiralty Island Province** is made up of nutrient-rich soils that support high-productivity large-tree forests, and represents the most significant unfragmented expanses of productive old growth remaining in Southeast Alaska. There are 15 mammal species present within the province, including three endemic subspecies: a beaver (*Castor canadensis phaeus*), a meadow vole (*Microtus pennsylvanicus admiraltiae*), and an ermine (*Mustela ermine salva*), as well as an endemic lineage of the Pacific marten (*Martes caurina*). The brown bears of Admiralty Island, along with those of Chichagof and Baranof Islands, are identified as an evolutionary distinct lineage based on differences in mitochondrial DNA (Talbot and Shields 1996b, Talbot and Shields 1996a). Admiralty Island also has one of the highest brown bear densities in Alaska, along with one of the highest bald eagle densities in the world. With the absence of wolves, deer populations in the province at times reach high densities. Also, Admiralty has the only island populations of king salmon (*Oncorhynchus tshawytscha*) in Southeast Alaska. In the form of the Admiralty Island National Monument and Kootznoowoo Wilderness, 90% of the island is legislatively protected, and 4% is managed in development status.

SOUTHERN INSIDE ISLANDS GROUP

The Southern Inside Islands include the Kuiu Island, Kupreanof/Mitkof Islands, Wrangell/Etolin/Zarembo Complex, and the Revilla Island/Cleveland Peninsula provinces.

The **Kuiu Island Province** is comprised of Kuiu Island along with a few neighboring islands, and the landscape is characterized by fjords that nearly divide the island. The province has one of the highest density black bear populations in North America, while wolf predation and removal of high-quality winter habitat through timber harvesting have kept deer numbers relatively low. Prior to large-scale timber harvests, Kuiu Island had the fourth most extensive distribution of large-tree old growth in Southeast Alaska. Legislative protection applies to 28% of the province in the form of Tebenekof Bay and Kuiu wilderness areas, 35% is administratively protected under the TLMP, and 37% is managed in development status.

The **Kupreanof/Mitkof Islands Province** consists primarily of low-lying, poorly drained, unproductive forest and peatland, except for the northwest corner that once supported extensive large-tree forest. The province is home to 21 mammal species, including an endemic population of flying squirrels. Mammal species richness is the second highest for any island province in the region, primarily due to the proximity to the Stikine River corridor. The province is ranked fourth for high-quality salmon habitat. Only 5% of the lands are protected by Congress, and another 65% are for development purposes.

The **Wrangell/Etolin/Zarembo Complex Province** also experienced high-grade logging, the same as on Kupreanof and Mitkof Islands. There are 23 mammal species present in the province, the second highest for any of the island provinces, and there is an endemic red-backed vole (*Clethrionomys gapperi wrangeli*). Elk (*Cervus canadensis*) were introduced to Etolin Island in 1985, making it the only island in Southeast Alaska to host three cervids, and creating concern over potential competition with deer. Seventeen percent of the province is legislatively protected in the South Etolin Wilderness; 26% is administratively protected under the TLMP; and 58% is managed as development lands.

The **Revilla Island/Cleveland Peninsula Province** includes Revillagigedo, Gravina, Annette and Duke Islands, along with a few smaller adjacent islands. The province has the highest diversity of any Southeast Alaska island province—with 28 known mammal species—and there is an endemic red-backed vole (*Clethrionomys gapperi solus*) that is present on Revillagigedo Island. The Kruckeberg's holly fern (*Polystichum kruckebergii*) is an endemic plant species present on the Cleveland Peninsula, and the province has the third highest amount of productive old growth in Southeast Alaska. Even with a history of high-grade logging in the province, the Cleveland Peninsula remains largely intact and provides an opportunity for watershed-scale protection of a highly ecologically valuable region. For all islands combined, 23% is protected through the Misty Fjords Wilderness, Naha LUD II, and Anan LUD II; 35% is administratively protected through the TLMP; 42% of land is open for development; and Annette Island falls within the Annette Island Indian reservation.

PRINCE OF WALES ISLAND COMPLEX

The Prince of Wales Island Complex consists of the biogeographic provinces of North Prince of Wales, South Prince of Wales, Outside Islands, and Dall Island Complex. The island complex is a center of endemism (Cook and MacDonald 2001, Cook et al. 2006), including subspecies of spruce grouse (*Falcipennis canadensis isleibi*) and flying squirrel (*Glaucomys sabrinus griseifrons*), the only known populations of some rare plant species such as the yellow lady's slipper orchid (*Cypripedium parviflora var. pubescens*), and important habitat for Queen Charlotte Goshawk (*Accipiter gentilis laingi*) and Alexander Archipelago wolf (*Canis lupus ligoni*) populations. An additional ecological aspect is the number of symbiotic ecological relationships among endemics. On Prince of Wales Island, the vulnerability of the ecological communities is greater where endemics are facultatively or obligately dependent upon one another. For example, Queen Charlotte goshawks depend on Prince of Wales spruce grouse and flying squirrels as prey and all are dependent on old-growth forest habitat.

The **North Prince of Wales Province** ranks highest for ecological values for any province in the region, and contains more productive forest land and more rare large-tree forests than any other province. This province also ranks highest for winter habitat capability for deer, summer habitat for black bear, and more miles of salmon streams. Even with this high ecological value, North Prince of Wales has experienced substantially more timber harvest: over four times more acres of logging than any other province in Southeast Alaska, with 94% of landscape-scale high-volume forest removed (Albert and Schoen 2013). The province once had the highest nesting habitat values for marbled murrelets (*Brachyramphus marmoratus*), but is currently estimated to be 60% of its original value. Only 7% of the province is congressionally protected.

The **South Prince of Wales Province**, along with North Prince of Wales, makes up the largest island in the Alexander Archipelago, and is home to several endemic subspecies, including the Prince of Wales flying squirrel and an ermine (*Mustela erminea celenda*). This province has the highest remaining percentage of large-tree forest of anywhere else in Southeast Alaska—above both North Prince of Wales and Admiralty. Twenty-nine percent is congressionally protected as the South Prince of Wales Wilderness and Nutkwa LUD II; 34% is administratively protected by the TLMP; 38% is open for development.

The **Outer Islands Province** consists of island regions that were low-elevation coastal refugia during the Wisconsin Glaciation, and served as a source for the recolonization of plant and animal species once ice began to retreat. There are only 11 mammal species present in the province, including three endemic subspecies: a dusky shrew (*Sorex monticolus malitiosus*), the Coronation Island vole *(Microtus longicaudia coronarius*), and an ermine subspecies (*Mustela erminea seclusa*).

The **Dall/Long Island Province** is the smallest biogeographic province, and is also thought to be a source for recolonization of plants and animals after the Wisconsin Glaciation since it remained ice-free during that period. Forrester, Petrel, and Lowrie Islands are part of the Alaska

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Maritime National Wildlife Refuge, and are identified as a globally significant Important Bird Area supporting the largest known colonies of nesting seabirds in Southeast Alaska. Over a million birds of 15 species nest there, and Forrester Island is also the largest sea lion rookery in the world. There is extensive karst in this province, and Long Island has the most productive sites (and had the largest trees) of any place in Southeast Alaska.

CONSERVATION ISSUES

A geographic stratification based on biogeographic provinces (The Nature Conservancy and Audubon Alaska 2007, USFS Tongass National Forest 2007) is important for identifying conservation areas that are sufficiently distributed to maintain viable populations throughout Southeast.

Each of Southeast's 22 biogeographic provinces should include a representative set of intact watershed reserves of high ecological value. With this in mind, Audubon and TNC developed the 2007 Conservation Assessment using biogeographic provinces as a framework for prioritization of conservation areas. Watersheds were ranked from most to least important within each province for a set of focal species and resources, including old-growth forest types, estuaries, bears, deer, and murrelets. This prioritization was used to develop a set of conservation and restoration priority watersheds distributed across the region.

Protecting and restoring the identified lands is a top priority for ensuring long-term ecological sustainability in Southeast Alaska. Some provinces (e.g., North Prince of Wales, Kupreanof / Mitkof) have undergone substantial resource development activities and are at risk of losing their ecological integrity. Developed watersheds which still maintain relatively high ecological values (e.g., Integrated Management Watersheds mapped during the Audubon-TNC Conservation Assessment) should be given first priority for restoration activities. The Conservation Area Design and Tongass 77 maps identify the priority conservation lands.

MAPPING METHODS

Categorization of the biogeographic provinces of Southeast Alaska focused primarily on wildlife species distributions, including similarities in terrestrial wildlife species composition, similarities in distributional patterns, geologic and water barriers from past events such as glaciation, and similar climatic conditions (USFS Tongass National Forest 2008b).

The biogeographic provinces were initially labeled as part of the Tongass Land Management Plan. The original Tongass National Forest (TNF) layer was then modified by The Nature Conservancy (TNC) to include non-TNF lands in Southeast Alaska following similar methods. Provinces added to the original TNF layer included Glacier Bay, Fairweather, and the Chilkat River Complex.

MAP DATA SOURCES

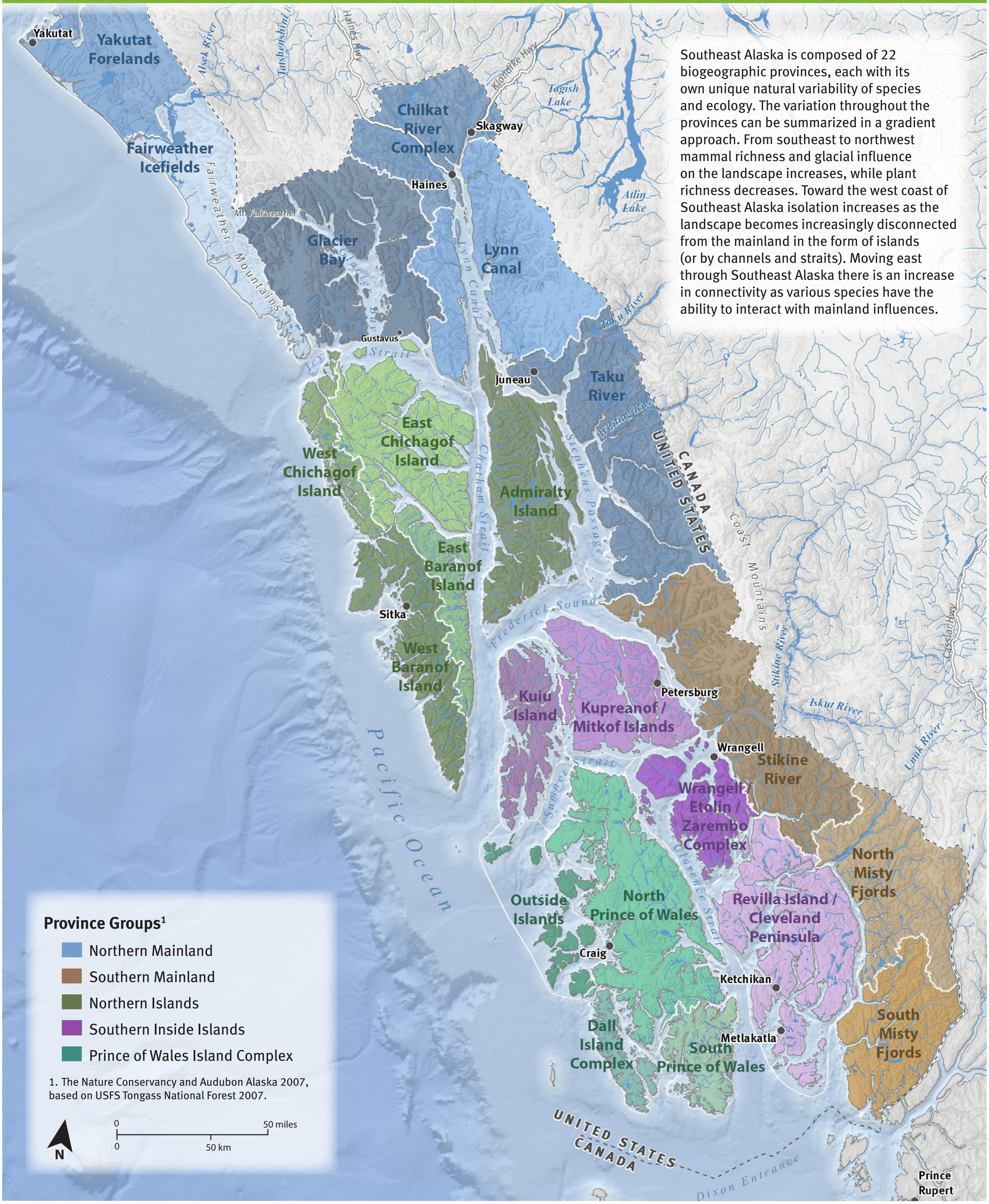
- Biogeographic Provinces: The Nature Conservancy and Audubon Alaska (2007), based on USFS Tongass National Forest (2007).

Prince of Wales Island Complex.

John Schoen

Biogeographic Provinces

Southeast Alaska is composed of 22 biogeographic provinces, each with its own unique natural variability of species and ecology. The variation throughout the provinces can be summarized in a gradient approach. From southeast to northwest mammal richness and glacial influence on the landscape increases, while plant richness decreases. Toward the west coast of Southeast Alaska isolation increases as the landscape becomes increasingly disconnected from the mainland in the form of islands (or by channels and straits). Moving east through Southeast Alaska there is an increase in connectivity as various species have the ability to interact with mainland influences.



Map 3.1: Biogeographic Provinces

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WETLANDS

Melanie Smith

The rugged, wet terrain of Southeast Alaska has more than 10,000 small, steep streams (Edwards et al. 2013), as well as multiple larger, transboundary rivers that include the Alsek, Chilkat, Taku, Whiting, Stikine, and Unuk. The annual freshwater discharge of Southeast Alaska, approximately 90 cubic mi (370 cubic km), is comparable to the annual discharge of the Mississippi River (Edwards et al. 2013).

In this very wet rainforest ecosystem, wetlands are abundant and widely distributed. According to an analysis of data from the National Wetlands Inventory (NWI), 23% of Southeast Alaska is classified as wetland (US Fish and Wildlife Service 2016). Wetlands are present from intertidal areas to moist tundra areas in high alpine, and can occur anywhere from flat regions to surfaces with a 20% gradient (Hall et al. 1994, Edwards et al. 2013). Hillside wetlands are common where there is abundant precipitation and shallow depth to bedrock (Hall et al. 1994). Table 3-1 summarizes acres of wetlands by biogeographic province, which ranges from 58% wetland in the Kupreanof/Mitkof Islands to 6% wetland in the Chilkat River Complex.

The NWI defines five different categories of wetlands: marine, estuarine, lacustrine, palustrine, and riverine. The estuarine intertidal lands are those that are semi-enclosed by land where ocean is at least occasionally diluted by freshwater. This class is subdivided into nonvegetated (e.g., mudflats, sand beaches), aquatic beds (e.g., seagrasses), and vegetated (e.g., emergent herbaceous plants, salt marsh). Lacustrine generally refers to deepwater habitats (lakes) occupying topographic depressions, with area >20 ac (8 ha) or depth >8.2 ft (2.5 m) (Federal Geographic Data Committee 2013). Riverine includes all wetlands and deepwater habitats contained within a channel (streams and rivers), except where dominated by vegetation or brackish waters (Cowardin et al. 1979). Palustrine, the largest class of wetlands in Southeast, includes all non-tidal wetlands not included in the previous three systems or the marine system. They can be unconsolidated shore, open water (e.g., ponds), aquatic beds (e.g., pond lillies), emergent herbaceous (grasses and forbs), scrub/shrub, or forested. Palustrine wetlands are further subdived into saturated (e.g., bogs, muskegs) or flooded (e.g., marshes, swamps) (Hall et al. 1994). The fifth NWI category, marine, represents habitats exposed to the ocean with no, or very little, freshwater influence. Marine includes intertidal and subtidal areas. The marine and estuarine subtidal classes are not included here or on the accompanying map.

CONSERVATION ISSUES

Wetlands and deepwater habitats are essential breeding, rearing, and feeding grounds for many species of fish and wildlife (Federal Geographic Data Committee 2013). Wetlands provide necessary ecosystem services and are internationally recognized for their irreplaceable benefits. Some of those benefits include:

- habitat for fish, birds, other wildlife, and associated vegetation
- subsistence, hunting, fishing, and gathering opportunities
- recreation, wildlife viewing, and open space
- shoreline erosion and sediment control, and flood protection.
- filtering nutrients, sediments, and pollutants (Hall et al. 1994, Federal Geographic Data Committee 2013).

MAPPING METHODS

The US Fish and Wildlife Service developed the NWI to represent the location, extent, and type of wetlands in the US, including Southeast Alaska. The wetland categories on this map include the following NWI classes and codes: M2 (marine: including intertidal but not subtidal); E2 (estuarine: including intertidal but not subtidal); L1–2 (lacustrine: limnetic and littoral); R1–4 (riverine: tidal, lower perennial, upper perennial, and intermittent); PEM, PSS, PFO (palustrine: emergent, shrub-scrub, and forested) (US Fish and Wildlife Service: National Wetlands Inventory 2006). The marine intertidal areas are from the SEAK Hydro database (Plivelich 2014).

TABLE 3-1 Coverage of wetlands in Southeast Alaska by biogeographic province (based on US Fish and Wildlife Service 2016).

Rank	Province Name	Acres	Percent
1	Kupreanof / Mitkof Islands	521,639	58%
2	Revilla Island / Cleveland Pen	613,191	45%
3	Etolin Zarembo Island Complex	221,146	43%
4	North Prince of Wales Complex	653,478	42%
5	West Chichagof Island	118,026	40%
6	South Prince of Wales Island	154,617	40%
7	Kuiu Island	185,737	38%
8	Outside Islands	76,322	33%
9	Admiralty Island	329,635	30%
10	South Misty Fjords	270,483	30%
11	East Chichagof Island	339,191	30%
12	West Baranof Island	228,489	28%
13	Dall Island Complex	45,252	22%
14	Yakutat Forelands	232,876	19%
15	East Baranof Island	72,946	18%
16	Stikine River / Mainland	210,686	12%
17	Fairweather Icefields	113,481	11%
18	Taku River / Mainland	170,585	10%
19	North Misty Fjords	120,688	9%
20	Lynn Canal / Mainland	112,063	7%
21	Glacier Bay	104,889	6%
22	Chilkat River Complex	54,887	6%
	All of Southeast Alaska	4,950,307	23%

*Includes all classes except marine subtidal and estuarine subtidal


Nick Jans

Wetland on Prince of Wales Island.

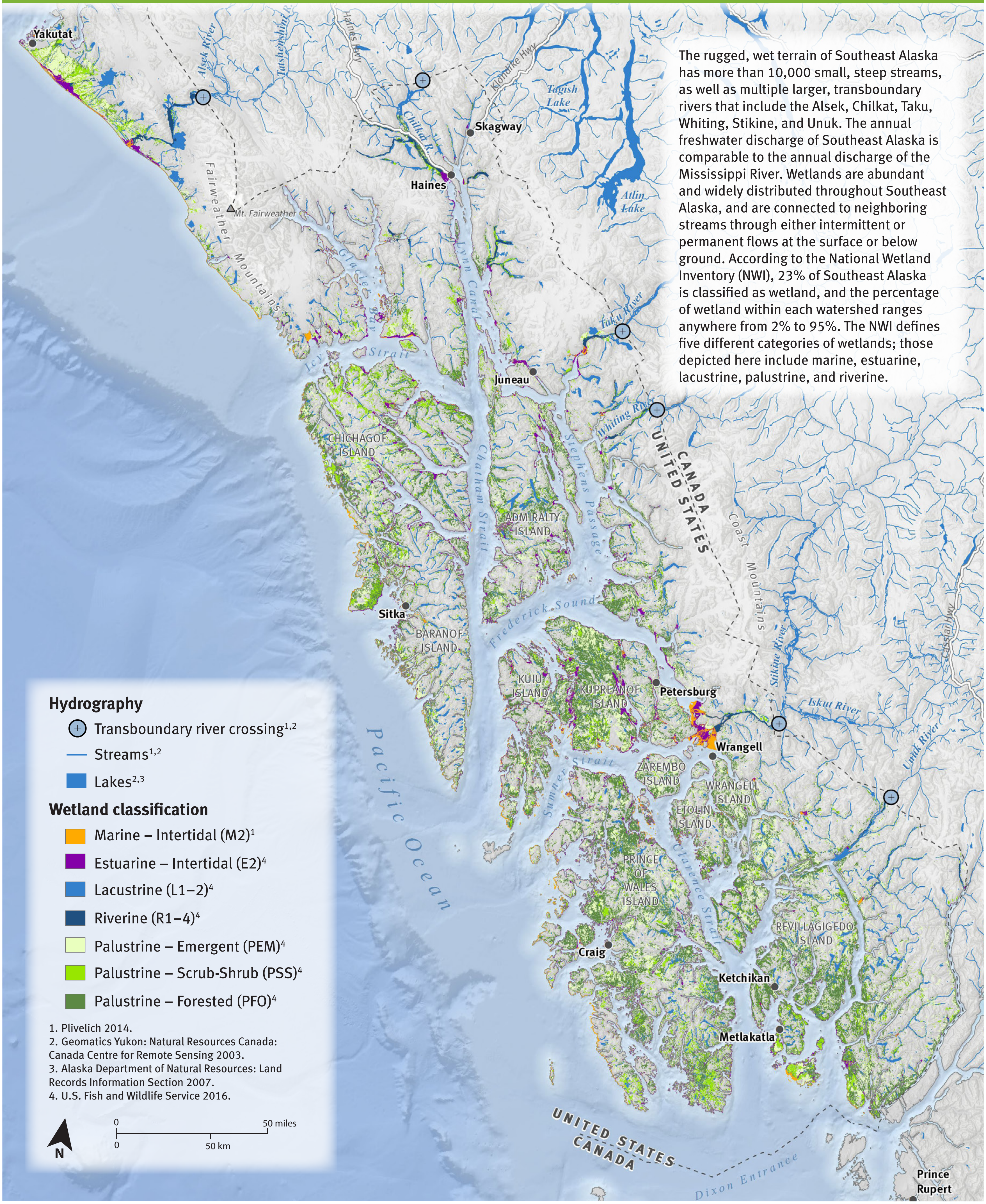
MAP DATA SOURCES

- Wetlands: US Fish and Wildlife Service (2016); Plivelich (2014)
- Transboundary rivers: Plivelich (2014); Geomatics Yukon: Natural Resources Canada: Canada Centre for Remote Sensing (2003).

Wetlands

Audubon ALASKA

The rugged, wet terrain of Southeast Alaska has more than 10,000 small, steep streams, as well as multiple larger, transboundary rivers that include the Alsek, Chilkat, Taku, Whiting, Stikine, and Unuk. The annual freshwater discharge of Southeast Alaska is comparable to the annual discharge of the Mississippi River. Wetlands are abundant and widely distributed throughout Southeast Alaska, and are connected to neighboring streams through either intermittent or permanent flows at the surface or below ground. According to the National Wetland Inventory (NWI), 23% of Southeast Alaska is classified as wetland, and the percentage of wetland within each watershed ranges anywhere from 2% to 95%. The NWI defines five different categories of wetlands; those depicted here include marine, estuarine, lacustrine, palustrine, and riverine.



Map 3.2: Wetlands

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ESTUARIES

David Albert, John Schoen, and Melanie Smith

In the steep rainforest watersheds of Southeast Alaska, water and nutrients are rapidly transferred to estuaries (Edwards et al. 2013). There are approximately 357,000 ac (144,500 ha) of tidal estuaries within Southeast Alaska, which accounts for approximately 2% of the land area. Coastal waters of Southeast Alaska carry freshwater runoff and accompanying nutrients into the Gulf of Alaska. The Haida, Sitka, and Yakutat marine eddies contain unusually high concentrations of nutrients (Edwards et al. 2013) derived from the unique hydrological system of Southeast Alaska.

Estuaries are among the most important coastal features, from the perspective of both resource conservation and resource development. An estuary is an ecological system at the mouth of a stream where fresh-water and saltwater mix, and where salt marshes and intertidal mud flats are present. This creates a nutrient-rich environment that supports large assemblages of marine and anadromous fish, invertebrates, migratory and resident birds, plants, and both terrestrial and marine mammals. In the Audubon-TNC Conservation Assessment (Albert and Schoen 2007b), salt marsh estuaries were selected as a focal resource because they are biologically rich areas that serve many species and species groups by connecting the uplands, forests, and rivers with the ocean.

Estuaries are landscape features of substantial functional and structural complexity. The list of terrestrial and marine species that make seasonal use of estuaries, or at least benefit indirectly from energy exchange taking place there, is basically the complete flora and fauna of the Southeast bioregion. And because estuaries are such highly productive habitats that support a diversity of fish and wildlife, watersheds associated with significant estuaries have higher overall ecological values than do similar watersheds that lack substantial estuarine habitat.

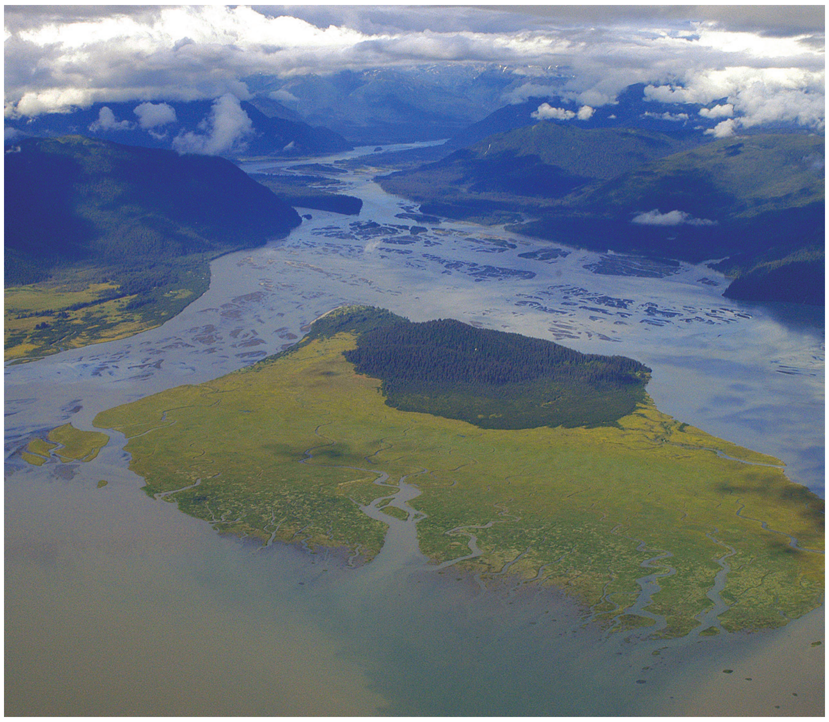
In many watersheds, estuaries and floodplains are small, because most watersheds are small and primarily rain-fed. In Southeast Alaska, estuaries fed by rivers, rain, glaciers, and snowpack are common, and can be very large, such as the mouths of the Taku, Chilkat, and Stikine rivers. The Alexander Archipelago as a whole ranks among the largest and most complex estuarine systems on Earth. The entire archipelago represents a single estuarine complex, being semi-enclosed by land and influenced by freshwater. Indeed, a large number of estuaries occur at intermediate scales such as the complex fjord systems of Glacier Bay, as well as a very large number of individual estuarine streams that flow into salt water (Paustian et al. 1992). TNC developed a preliminary estuarine database in which each unit represented the point of intersection between a stream system and the saltwater. Based on that definition, approximately 12,000 estuaries exist in Southeast Alaska. By imposing a minimum basin size of 247 ac (100 ha), this number is reduced to 2,944 (Albert and Schoen 2007b).

Tidal estuaries are made up of bare tideflats, vegetated salt marsh, and algal beds of rockweed, barnacles, and mussels. Relative proportions of the three types differ considerably (Table 3-2). The Stikine River Delta (North and South Arms) do not have aquatic bed habitat, but have the largest area of emergent salt marsh habitat in Southeast Alaska. The Gustavus Forelands Value Comparison Unit (VCU; i.e. watershed) is in the top 20 for overall estuary size, but NWI indicates no aquatic bed or emergent habitat—only mud flats and shoreline.

Aquatic bed communities are abundant in some estuaries like upper Duncan Canal, but essentially absent at many river mouths. Algae, barnacles, and mussels need to anchor on coarse material like cobbles or at least large gravel mixed in with the low tidal muds. Algal bed communities are especially common in the small estuaries of southern Southeast islands like Prince of Wales. Algal beds are habitat for intertidal organisms such as fish, shrimp, and other crustaceans, as well as foraging areas for birds such as oystercatchers (*Haematopus bachmani*) and mammals such as bears.

TABLE 3-2 Top 20 estuaries, by total acreage within Value Comparison Units (based on US Fish and Wildlife Service 2016).

Watershed Name	Aquatic Bed	Emergent (Salt Marsh)	Shore and Flats	Total
Stikine Delta—South Arm	0	2,391	4,947	7,338
Rocky Pass	928	605	5,242	6,775
Stikine Delta—North Arm	78	496	6,115	6,689
Alsek Dry Bay / East Alsek	0	101	6,468	6,569
Ahrnklin River Estuary	0	1,881	4,559	6,440
Italio Beach	0	131	6,257	6,388
Lower Castle River	0	390	3,998	4,388
Big John Bay	1,473	560	2,033	4,066
Gambier Bay	544	680	2,651	3,875
Duncan Bay	1,078	98	2,582	3,758
Bartlett River / Beardslee Islands	1,947	98	1,183	3,228
Taku River	0	634	2,538	3,172
Petersburg / Wrangell Narrows	0	233	2,776	3,009
Towers Arm	262	136	2,225	2,623
Pybus Bay	244	449	1,811	2,504
Duncan Canal—North Arm	0	298	2,117	2,415
Gustavus Forelands	0	0	2,352	2,352
Duke Island	577	33	1,736	2,346
Sam Peak	1	23	2,262	2,286
Kah Shees Bay	216	162	1,869	2,247



John Schoen

View northeast over Sergief Island up the Stikine River. This highly significant estuary holds the highest acreage of tidal salt marsh in Southeast. The Stikine flats are a globally significant stopover site for migratory shorebirds and waterfowl. Islands well offshore from the river mouth serve as stepping stones for colonization of mammals and amphibians into the Southeast archipelago.

MAP ON PAGE 43

John Schoen

Upper Tenakee Estuary.

Bare tideflats are home to a high density of marine invertebrates which are very important forage for migrating or resident shorebirds, as well as fish when these areas are submerged.

Estuarine emergent intertidal areas, or salt marsh, is often divided into grass-dominated high marsh and sedge-dominated low marsh, which are important to grazing birds and mammals and regarded as the most important estuarine habitat.

The NWI uses a standard system to map and classify wetland habitats, including estuaries. When examining the NWI data for Southeast Alaska, interesting patterns emerge from analysis of this data layer (from Carstensen 2007):

1. Estuary size is not closely correlated with watershed/VCU size. The fifth and sixth largest watersheds of the Southeast/British Columbia borderlands—the Unuk and Whiting rivers—barely rank in the top 50 for estuary size. And three of the ten largest estuaries—Dangerous River, Duncan Canal, and Rocky Pass—have watersheds that are orders of magnitude smaller than those of the great transboundary rivers.
2. Southern Southeast has few large estuaries.
3. Many of the largest estuaries are fed by glacial streams, but a surprising number of very large glacial systems, although heavily laden with sediment, have neglible estuaries.
4. Topographical complexities such as island clusters, convoluted shorelines, and undulating bathymetry lead to increased sediment deposition. In such locations, even small streams can have large estuaries.

An estimated 42,116 ac (17,044 ha) of Southeast Alaska's estuaries are salt marsh habitat, which is regarded as the most biologically important segment of the estuarine habitats. Six of the top ten estuaries (by size of salt marsh habitat) are mainland estuaries. Measured by VCU, only two estuaries in Southeast have salt marsh habitats exceeding 1,000 ac (405 ha); the Stikine Delta South watershed is by far the largest salt marsh estuary in Southeast at 2,391 ac (968 ha), followed by Ahrnklin River Estuary at 1,881 ac (761 ha). The other mainland estuaries in the top ten include: Dundas Bay, Farragut Bay South Arm, Taku River, and North Fork Bradfield River. The island salt marsh estuary systems ranking in the top ten are Gambier Bay, Neka Bay, Rocky Pass, and Big John Bay (Table 3-3).

The State of Alaska has jurisdiction over 60% of Southeast's salt marsh estuaries while the US Forest Service manages 30%. The National Park Service manages a significant portion of estuaries in three provinces: Glacier Bay, Fairweather Icefields, and Chilkat River Complex. Private ownership accounts for 9% of Southeast's salt marsh estuaries scattered through the region with the largest holdings in Lynn Canal and the Dall Island Complex.

CONSERVATION ISSUES

Most of Southeast's estuaries are still largely intact but local habitat impacts have occurred around major communities (e.g., locating a major airport in the Mendenhall Wetlands in Juneau).

TABLE 3-3 Top 20 salt marsh estuaries, by total acreage within Value Comparison Units (US Fish and Wildlife Service 2016).

Watershed Name	Acres
Stikine Delta—South Arm	2,391
Ahrnklin River Estuary	1,881
Dundas Bay	770
Farugut Bay—South Arm	695
Gambier Bay	680
Taku River	634
Neka Bay	621
North Fork Bradfield River	616
Rocky Pass	605
Big John Bay	560
Akwe Beach	515
Stikine Delta—North Arm	496
Mendenhall Valley	482
Kadashan River	472
Pybus Bay	449
Fern Harbor	414
Aaron Creek	414
Idaho Inlet	413
Juneau / Gastineau Channel	404
Lower Castle River	390

Conservation issues near Southeast towns include airport development, pollution from sewage, landfills or roads, and displacement of wildlife from critical foraging habitat by recreational activities. More remote estuaries are vulnerable to oil spills, invasive plants and invertebrates, proliferation of commercial shellfish operations, swamping of native salmon runs by hatchery strays, and increasingly dispersed tourism.

Logging of riparian forests beginning in the 1950s increased sediment delivery into estuaries, damaging habitat for many subtidal estuarine species. Effects of this deposition will influence the productivity of commercially important species like Dungeness crab (*Cancer magister*) for many decades (T. Shirley, Marine Ecologist, University of Alaska Fairbanks, Juneau, AK, personal communication 2005). Similarly, bark deposits from log transfer facilities in estuaries continue to smother the bottoms of many estuaries, displacing benthic fauna. In addition to human-induced changes, natural changes such as loss of low marsh sedges to glacial rebound also need to be better mapped and understood.

MAPPING METHODS

Salt marsh estuary size was mapped using data from the Audubon-TNC Conservation Assessment (Albert and Schoen 2007b). Estuary occurrence data was derived from the intertidal emergent vegetation class (E2EM, M2EM) from the NWI data (circa 2007) and supplemented by a supervised classification of Landsat ETM imagery for areas where NWI data were unavailable (Albert and Schoen 2007b). Salt marsh shoreline habitat data is from the ShoreZone database (NOAA: National Marine Fisheries Service: Alaska Regional Office 2014).

MAP DATA SOURCES

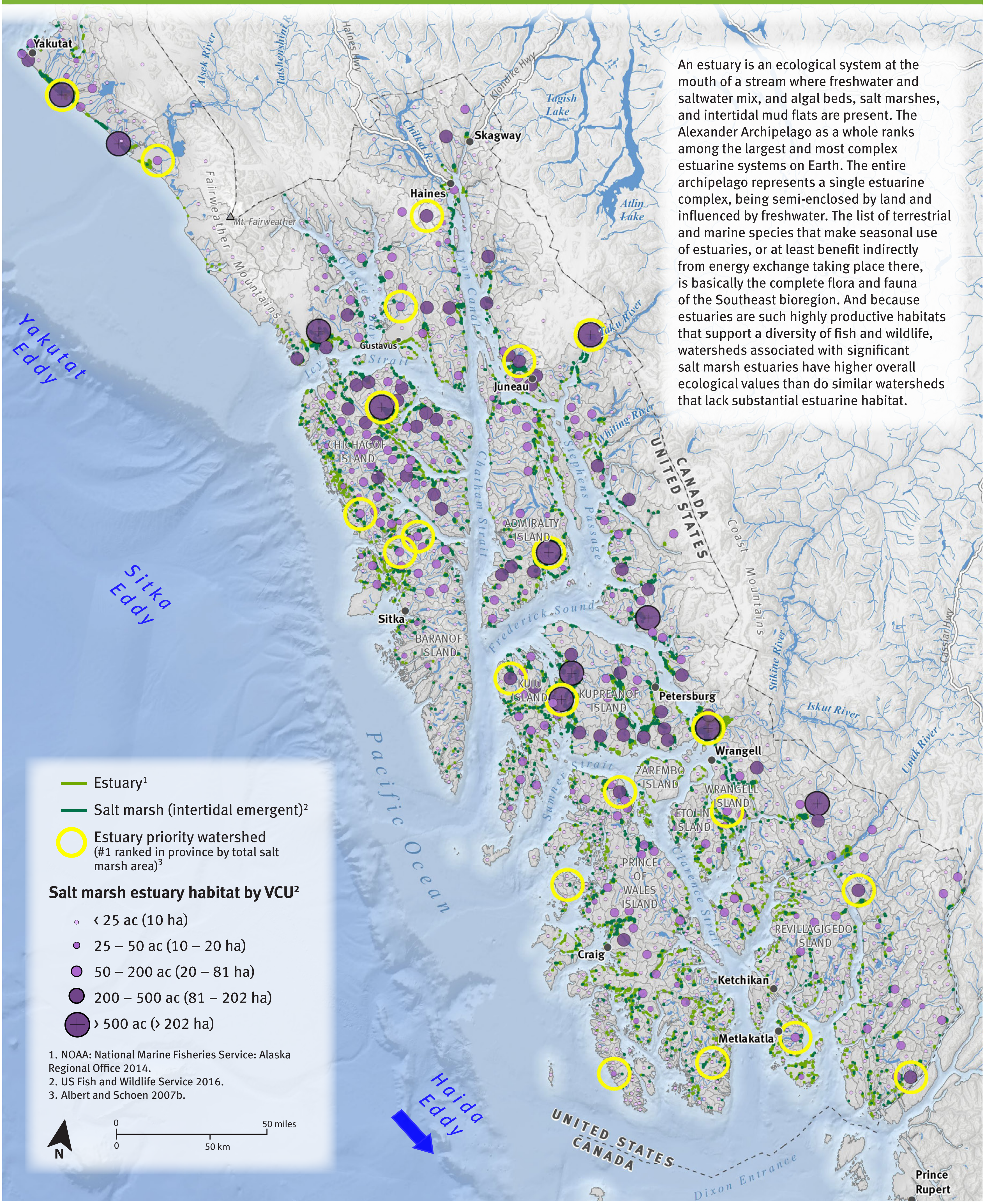
- Salt marsh estuary: NOAA: National Marine Fisheries Service: Alaska Regional Office (2014) ; US Fish and Wildlife Service 2016
- Estuary area and ranking: Albert and Schoen (2007b).

Audubon ALASKA

The Nature Conservancy

Salt Marsh Estuaries

An estuary is an ecological system at the mouth of a stream where freshwater and saltwater mix, and algal beds, salt marshes, and intertidal mud flats are present. The Alexander Archipelago as a whole ranks among the largest and most complex estuarine systems on Earth. The entire archipelago represents a single estuarine complex, being semi-enclosed by land and influenced by freshwater. The list of terrestrial and marine species that make seasonal use of estuaries, or at least benefit indirectly from energy exchange taking place there, is basically the complete flora and fauna of the Southeast bioregion. And because estuaries are such highly productive habitats that support a diversity of fish and wildlife, watersheds associated with significant salt marsh estuaries have higher overall ecological values than do similar watersheds that lack substantial estuarine habitat.



1. NOAA: National Marine Fisheries Service: Alaska Regional Office 2014.
2. US Fish and Wildlife Service 2016.
3. Albert and Schoen 2007b.

Map 3.3: Salt Marsh Estuaries

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LAND COVER & FOREST VEGETATION

Matthew Kirchhoff, Melanie Smith, and Nathan Walker

LAND COVER

Southeast Alaska is widely recognized as the last remaining, largely intact, old-growth rainforest in North America. That simple description belies the complex landcover of the region. Fully one-third of the region is not vegetated at all, but is barren rock, water, and ice. And surprisingly for a rainforest, only about half of the land area supports forest vegetation.

As well-known as it is for its towering forest, Southeast is also known for its majestic mountains, steep rocky fjords, tidewater glaciers, and extensive coastlines. Land cover can be generally described in broad categories of forest, nonforest vegetation, and unvegetated areas primarily of rock and ice.

About two-thirds of Southeast Alaska is vegetated, but not all of that area is forested. Forest vegetation, which covers half of the region (48%) is described in more detail in the following section. About half of the forest, or 27% of Southeast Alaska, is classified as productive old growth (which can include small trees), with 18% of the region classified as timberland. Today, only 3% of all of Southeast Alaska is made up of large-tree timberland, while another 4% of the region (previously in the large-tree or medium-tree timberland category) has been harvested. Forested lands in Southeast Alaska are owned primarily by the US Forest Service (84%) as well as Native Corporations (8%), while smaller amounts are managed by the National Park Service (4%), State of Alaska (2%), Bureau of Land Management (1%), and private landowners (1%).

Nonforest vegetation makes up 17% of the region in the form of shrublands and herbaceous lands such as muskeg areas. Unvegetated areas of bare rock, ice, and fresh water make up about one-third of Southeast Alaska (34%). Icefields and glaciers alone cover 20% of Southeast Alaska. Very little of the region is developed into urban areas (<1%). Collectively, nonforest land types cover 11.9 million ac (4.8 million ha), or 52% of the total land area of the region. Federal agencies manage most of the nonforest lands, including the Forest Service (71%) and the Park Service (21%). Minor amounts are managed by the Bureau of Land Management (3%), the state (4%), and Native and private landowners (1%).

FOREST VEGETATION

Where trees grow in Southeast Alaska, a high percentage of that land (84%) falls within the Tongass National Forest and is managed by the US Forest Service. Relatively minor amounts of forestland are owned and managed by other federal agencies (5.6%), state and local government (3.5%) or private landowners (5.7%). We relied primarily on the nationwide Forest Inventory and Analysis (FIA) (van Hees and Mead 2005) to describe the amount, kind, condition, and ownership of vegetation types across the region. This accounting includes all vegetated lands, including forest and nonforest types.

A major theme of any discussion of forest vegetation types must take note of the extraordinary range of productivity across the forested landscape. This is a reflection of the complex soils, drainage patterns, physiography, and weather from island to island across the region.

Nick Jans

Old-growth forest on Prince of Wales Island.

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Forest growth declines significantly as one moves north through the temperate rainforest of North America (Farr and Harris 1979). In Southeast Alaska, only 37% of the forested land (and 18% of all land) supports what is classified as timberland (van Hees and Mead 2005), or land with at least minimal potential for the commercial harvest of trees. Within timberland, an even smaller percentage supports what can be characterized as valuable timberland, with larger trees and high stand volumes (Hutchison and LaBau 1975, Albert and Schoen 2013). The valuable timberlands are characteristically found at lower elevations, nearer the coast, and along rivers and streams where soils are better drained. Because these sites constitute the most valuable fish and wildlife habitats, and because they have been greatly depleted by past logging (Albert and Schoen 2013), how the Forest Service manages what remains has caused long-standing tension in the region (Nie 2006).

Forest Vegetation Types

Forest vegetation types are those with at least 10% foliar canopy from trees. The main tree species in Southeast Alaska are western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchesis*), western red cedar (*Thuja plicata*), Alaska yellow cedar (*Chamaecyparis nootkatensis*), mountain hemlock (*Tsuga mertensiana*), and lodgepole pine (*Pinus cantorta*).

Western hemlock is the most abundant tree species, comprising 64% of the growing-stock volume on timberlands in the region (Harris and Farr 1974a). It grows widely throughout the region, but shows greatest growth on well-drained, organic soils in valley bottoms and along lower slopes where the largest trees reach 170 ft (52 m) in height and 6 ft (2 m) in diameter (Harris and Farr 1974a). Sitka spruce is the second-most abundant timber species in Southeast Alaska, making up 28% of the growing-stock volume on timberland (Harris and Farr 1974a). The best spruce stands grow on well-drained mineral soils, especially colluvial deposits at the base of hillsides, and alluvial deposits associated with streams. The largest trees can exceed 10 ft (3 m) in diameter and 200 ft (61 m) in height (Harris and Farr 1974a). Western red cedar is found only in the southern half of the Archipelago (south of Frederick Sound). It occurs primarily at lower elevations on poorly drained organic soils and on shallow soils over bedrock or impermeable till. On productive sites, it can reach heights > 150 ft (46 m) and diameters > 9 ft (3 m) (Harris and Farr 1974a). Alaska yellow cedar occurs in scattered stands throughout the region, and is most abundant on Baranof and Chichagof islands. It is more common on poorer growing sites, as is red cedar, and does not compete well with hemlock and spruce on productive sites. The wood is aromatic, strong, and highly resistant to decay, making it a valuable commercial species, particularly in Japan. The largest trees on productive sites can reach 8 ft (2 m) in diameter, 120 ft (37 m) in height, and may exceed 1,000 years in age. Mountain hemlock occurs throughout Southeast Alaska from sea level to timberline. At lower elevations, it is found on poorer sites and organic soils, where it occurs with spruce, hemlock, cedars, and lodgepole pine in mixed conifer stands. On good growing sites, trees may exceed 100 ft (31 m) in height and 3 ft (1 m) in diameter (Harris and Farr 1974a)

The recognized forest vegetation types in this region are: western hemlock (38% of timberland), western hemlock-Sitka spruce (20%), mixed conifer (13%), western red cedar-hemlock (10%), Sitka spruce (8%), mountain hemlock (5%) and Alaska yellow cedar-hemlock (3%) (van Hees and Mead 2005, Albert and Schoen 2013).

Productive old-growth forest may contain trees that exceed 1,000 years of age; dominant trees typically exceed 300 years of age. If we conservatively define old-growth forests as stands over 200 years of age, then 61% of the timberlands in Southeast Alaska are old growth.

John Schoen

South Admiralty Island alpine landscape.

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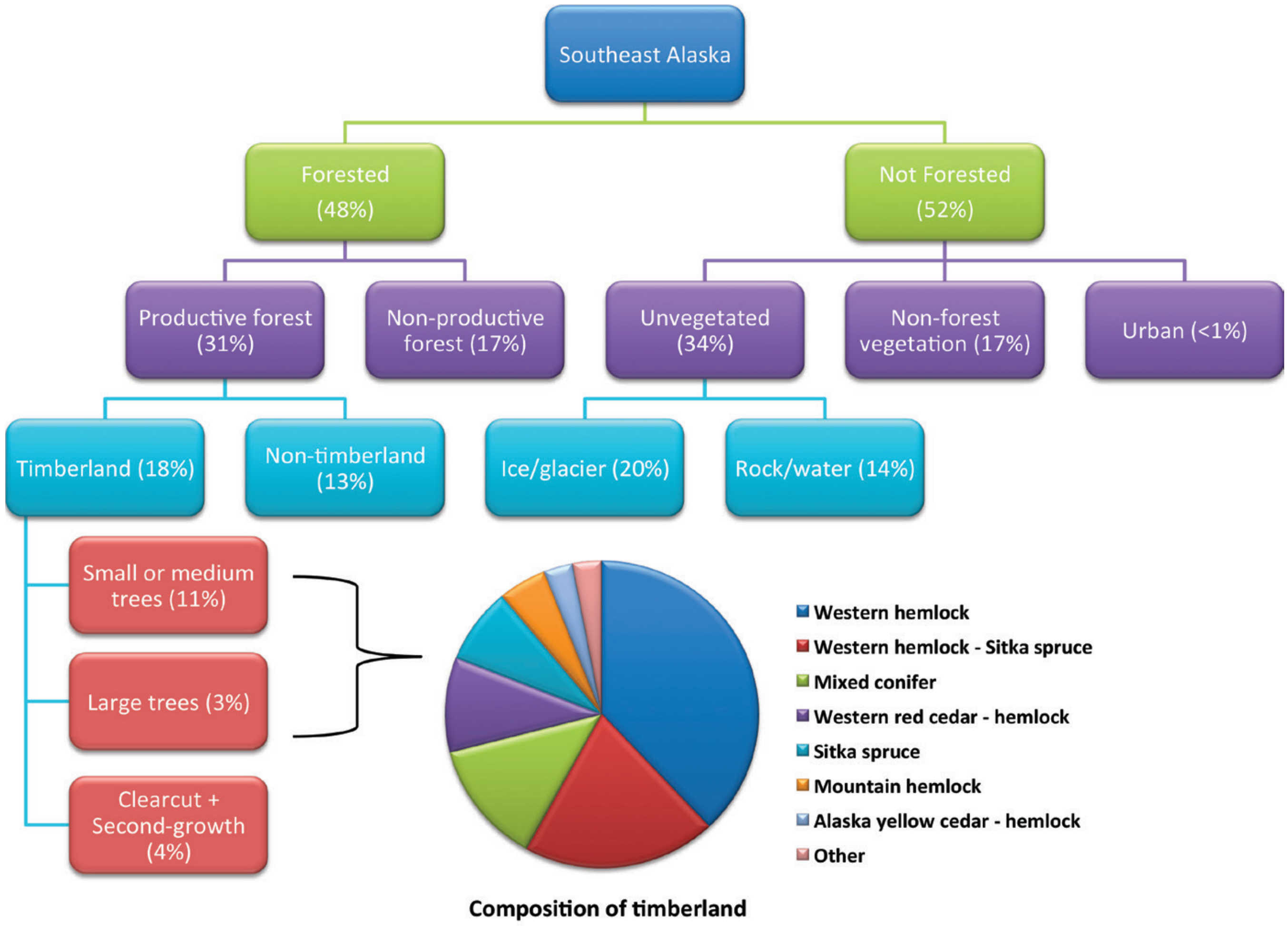

FIGURE 3-1 Land cover classes and timberland composition in Southeast Alaska.

An additional 12% are on the verge of becoming old growth, with a stand age between 150 and 200 years (van Hees and Mead 2005). Old growth dominates every forest type in the region but one: Sitka spruce. In part, because of historic logging pressure on Sitka spruce (Harris and Farr 1974a, Mackovjak 2011), the region now has more hectares in younger age classes (50–150 years) than old growth in this forest type (van Hees and Mead 2005).

Different densities of trees on the land have implications for wildlife habitat management, assessment of carbon sequestration, and viability of timber harvest operations, which depend heavily on wood volume, measured in board ft/ac (cubic m/ha) (van Hees and Mead 2005). Across all timberlands in the region, the forest contains an average net volume of 61,000 board ft/ac (357 m^3/ha). Forest types, ranked by volume per acre, are Sitka spruce (88,000 board ft/ac; 513 m^3/ha), western hemlock-Sitka spruce, western hemlock, western red cedar, mixed conifer, mountain hemlock, Alaska cedar-hemlock and lodgepole pine (15,000 board ft/ac; 88 m^3/ha). High-value timberlands are almost exclusively in spruce, hemlock, and cedar types. Western Hemlock and Sitka spruce together account for 94% of the sawtimber volume in the region (Harris and Farr 1974a).

Alaska cedar-hemlock forest type is the rarest in the region, and it supports the highest plant species diversity (van Hees and Mead 2005). Because of Alaska yellow cedar's strength and natural decay resistance, it is also the region's most valuable commercial species (Hennon et al. 2000). Even dead-standing cedar trees have sufficient value to warrant helicopter-yarding (Donovan 2004). The heavy exploitation of rare cedar types is a significant conservation concern (e.g. Carstensen 2013).

Other vegetation types in the region can be described using the framework of the Alaska Vegetation Classification System (AVCS) developed by Viereck et al. (1992). According to this classification system, needleleaf forest covers the highest proportion of land area (47%), and barren lands account for 31% of the total (van Hees and Mead 2005). Total vegetated land area in Southeast Alaska is estimated at 15.3 million ac (6.2 million ha) compared with 7.7 million ac (3.1 million ha) occurring as barren, ice, or water-covered lands. Figure 3-1 and Table 3-4 summarize land cover and forest vegetation across Southeast Alaska.

Nonforest Vegetation Types

Nonforest vegetation types are defined as lands with >2% foliar cover (otherwise barren) and <10% canopy cover from trees (otherwise forested). Within nonforest vegetation the major types are labeled (under AVCS) as tall scrub, low scrub, dwarf scrub, and herbaceous vegetation.

"Tall scrub" vegetation types occur on 792,000 ac (32,000 ha), and represent 5.2% of the vegetated land area of Southeast Alaska. Within the tall scrub type are subtypes alder (*Alnus spp.*), alder-salmonberry (*Rubus spectablis*), dwarf birch-willow (*Salix spp.*), blueberry-salmonberry (*Vaccinium spp.*), salmonberry, unclassified tall scrub, and willow. Of these, the alder and alder-salmonberry account for 58% and 20% of the tall scrub vegetation type respectively (van Hees and Mead 2005). On private lands, the most common subtype is blueberry-salmonberry (90%) which is typical of the shrub stage that follows 6–25 years after clearcut logging. The high percentage of this subtype is reflective of the recent logging on private lands.

"Low Scrub" vegetation type occurs on 336,000 ac (136,000 ha) and represents 2.2% of the vegetated land area of Southeast Alaska. Within the low scrub type, the main subtypes include ericaceous plants (i.e., muskeg vegetation) (26%), salmonberry-blueberry (17%), copperbush (*Elliottia pyroliflorus*), and sweetgale (*Myrica gale*) (11%) (van Hees and Mead 2005).

"Dwarf Scrub" vegetation type occurs on 505,000 ac (204,000 ha) and represents 3.3% of the vegetated land area of Southeast Alaska. Within the dwarf scrub type, the main subtypes include moss heather (*Cassiope spp.*) (48%), mountainheath (*Phyllodoce spp.*) (23%), and unclassified (1%) (van Hees and Mead 2005).

"Herbaceous" vegetation type occurs on 905,000 ac (366,000 ha) and represents 6% of the vegetated land area of Southeast Alaska. This primarily encompasses vegetation in alpine, subalpine, and estuarine or wetland meadows. Within the herbaceous type, the main subtypes are unclassified herbaceous (63%), fresh sedge marsh (6%), mixed herb (5%), wet sedge (3.5%) and alpine herb (3%) (van Hees and Mead 2005).

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TABLE 3-4 Generalized classification of vegetation and land cover in Southeast Alaska (Albert and Schoen 2007).

Land Cover	Land Management			Totals	
	Tongass NF (acres)	Glacier Bay NP (acres)	Private / Other (acres)	(acres)	(%)
Productive Old Growth Forest					
POG - Large tree	534,516		54,355	588,871	2.7%
POG – Medium tree	3,679,543		456,679	4,334,410	19.8%
POG - Small tree	772,839		110,359	883,874	4.0%
Other Forests					
Clearcut & 2nd-growth	466,056	200	320,029	786,285	3.6%
Conifer <150yrs	91,333	198,864	6,159	296,356	1.4%
Conifer forest (other)	91,617	134,614	226,373	452,604	2.1%
Deciduous forest	65,170		2,882	68,052	0.3%
Mixed forest	15,256		33	15,289	0.1%
Muskeg forest	1,133,245	0	47,013	1,180,258	5.4%
Muskeg woodland	1,253,607		37,210	1,290,817	5.9%
Sub-alpine forest	1,186,709		8,661	1,195,370	5.5%
Nonforest Vegetation					
Alpine tundra	540,044	2	4,247	544,293	2.5%
Slide zone	792,633	6	15,371	808,010	3.7%
Shrubland	952,257	112	9,608	961,977	4.4%
Herbaceous	18,667		3,613	22,280	0.1%
Nonforest (other)	186,494	632,374	240,479	1,059,347	4.8%
Freshwater wetlands					
Muskeg meadow	252,160		9,418	261,579	1.2%
Emergent wetlands	25,623	4,253	17,753	47,630	0.2%
River bar	20,077	11,797	23,030	54,904	0.3%
Lake	164,683	12,811	27,053	204,547	0.9%
River channel	36,690	60,809	46,678	144,178	0.7%
Coastal wetlands					
Algal bed	1,361	305	80,704	82,370	0.4%
Rocky shore	4,176	206	34,320	38,703	0.2%
Salt marsh	7,073	2,038	24,348	33,458	0.2%
Sand & gravel beach	10	3,031	2,754	5,795	0.0%
Tide flat	17	1,611	10,948	12,577	0.1%
Unconsolidated sediments	8,633	3,386	99,804	111,824	0.5%
Unvegetated lands					
Ice & Snow	2,189,317	1,158,675	248,252	3,596,244	16.4%
Unvegetated	2,299,167	472,273	227,576	2,999,016	13.7%
Urban	749		9,082	9,831	0.0%
Totals	**16,789,724**	**2,697,370**	**2,404,791**	**21,891,885**	**100.0%**

CONSERVATION ISSUES

A benchmark for effective conservation is to maintain species and ecological systems within their natural ranges of variability, including geographic distribution and spatial scales necessary to maintain genetic, population, and ecosystem processes (Noss et al. 1997, Poiani et al. 2000). The vast number of species composing the biological diversity of an ecoregion makes it impractical to assess and plan for each individual element of that diversity. Therefore, the most effective approach is to maintain a high percentage of habitat in its natural state.

Southeast Alaska encompasses one of the most significant areas of old-growth temperate rainforest in the world. Much of this region also comprises a unique assemblage of intact coastal watersheds that support abundant populations of fish and wildlife, including many species that have declined or become threatened in the southern portion of their historical ranges (for example, Pacific salmon [*Oncorhynchus spp.*], brown bear [*Ursus arctos*], and marbled murrelet [*Brachyramphus marmoratus*]).

Management of terrestrial and aquatic ecosystems in Southeast for diversity, distribution, and abundance of species is critically important for maintaining ecological integrity throughout this ecoregion. As an example, flood plain and karst forest communities represent small but important components of the forest ecosystems of Southeast. We estimate that a significant portion of the rare, large-tree flood plain and karst old growth (>50% in some provinces) has been harvested in Southeast during the last century.

To date, forests of Southeast Alaska have been most greatly affected by social pressures to supply timber and logging jobs. Conservation efforts should additionally consider cumulative impacts to the land base from timber, road-building, mining, development of renewable energy, and urban growth.

MAPPING METHODS

The transboundary land cover classification was put together by Audubon Alaska et al. (2012) which involved collaboration between Alaskan and Canadian government agencies (e.g. US Forest Service,

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National Park Service, US Fish and Wildlife Service, and British Columbia Ministry of Forests), non-profit organizations (including The Nature Conservancy), and universities (Including Simon Fraser University and University of Alaska Southeast) to pave the way for future cross-border cooperation, research, and large-scale conservation initiatives. Audubon collected, merged, and "cross-walked" attributes for forest vegetation cover types spanning the Southeast Alaska-northern British Columbia region with input from regional forestry experts.

The Forest Inventory conducted by van Hees and Mead (2005) utilized an extensive grid of nearly 4,000 plots, systematically spaced 3 mi (4.8 km) apart, and individually photo-interpreted; all but those in reserved areas (wilderness which precluded helicopter access) were intensively surveyed on the ground. The result is an accurate and precise assessment of the extent of different vegetation types and attributes (tree age, stand volume, understory composition) that cannot be measured or estimated from aerial photos alone. We used this information to describe forest vegetation. Because this is a point sample, however, it does not yield the 100% coverage that a GIS mapping effort requires. For that, we relied on other data to show spatial patterns.

This map contains tree species data from two sources. For Forest Service lands, we used the Tongass National Forest's cover type database. According to the US Forest Service metadata:

> CoverType is a photo-interpreted delineation of the Tongass National Forest by land type and timber cover type. Classification of lands was done sequentially: 1) land and water identified; 2) forested and nonforested areas were identified; 3) forested areas were classified by forest type and forest productivity; and 4) productive forest lands were further characterized by volume class, tree size, species composition. The original classifications were based on photo-interpretation of 1:15,840 aerial photographs in 1978. The minimum map unit size is approximately 10 acres [4 hectares], though the average area for forested polygons is 60 acres [24 hectares]. Additionally, CoverType is updated for new stands created through natural events or management activity. The data has also been corrected for errors, as found, that occurred during the attributing and digitizing of the original classification data. (USFS Tongass National Forest Timber Management Staff 2013b)

Outside of the Forest Service lands, we used the vegetation map and classification for southern Alaska and the Aleutian Islands developed by the Alaska Natural Heritage Program (AKNHP). They used 13 mosaicked regional satellite-image and aerial photography maps, converted to a 98 x 98 ft (30 x 30 m) pixel resolution, to create 49 coarse-scale and 388 finer scale vegetation classes (Boggs et al. 2014). Audubon Alaska then used the coarse-scale vegetation classes related to forest vegetation combined with the cover classes in the Forest Service lands to create a single simplified classification scheme, described in the tables below.

Where available, the Forest Service data were used; elsewhere, the AKNHP dataset was used. These were then converted to a common format and merged together.

MAP DATA SOURCES

- Forest Cover: Boggs et al. (2014); USFS Tongass National Forest Timber Management Staff (2013b)
- Glaciers: Arendt (2002); BCGOV FLNRO GeoBC (2008)
- Land Cover: US Forest Service (2016); Audubon Alaska et al. (2012), based on:
  - BC Ministry of Forests: Lands and Natural Resource Operations (2011)
  - BCGOV FOR Forest Analysis and Inventory Branch (2011)
  - Glacier Bay National Park and Preserve (2008)
  - The Nature Conservancy of Alaska (2006).

TABLE 3-5 Framework for crosswalking US Forest Service Cover Type vegetation classes.

Forest Type & Productivity	Audubon Alaska Forest Class
Cedar	Cedar
Black Cottonwood (poplar)	Deciduous
Cottonwood with Sitka Spruce understory	Deciduous
Red Alder	Deciduous
Hemlock	Hemlock
Hemlock-Spruce	Hemlock-Spruce
Lodgepole Pine	Other
Black Spruce	Spruce
Spruce	Spruce
White Spruce	Spruce
Low Productivity - Alder	Deciduous
Low Productivity - Willow	Deciduous
All other categories	Other

TABLE 3-6 Framework for crosswalking AKNHP coarse-scale vegetation classes.

Vegetation Class	Audubon Alaska Forest Class
Western Red Cedar (Woodland-Closed)	Cedar
Deciduous Forest (Open) (Peatland) (Southern Alaska)	Deciduous
Deciduous Forest (Open-Closed) (Seasonally Flooded) (Southern Alaska)	Deciduous
Deciduous Forest (Woodland-Closed) (Southern Alaska)	Deciduous
Hemlock (Woodland-Closed)	Hemlock
Hemlock-Sitka Spruce (Woodland-Closed)	Hemlock-Spruce
Needleleaf Forest (Woodland-Closed) (Southern Alaska)	Other
Needleleaf Forest (Woodland-Open) (Peatland) (Southern Alaska)	Other
Needleleaf-Deciduous Forest (Woodland-Closed) (Southern Alaska)	Other
Sitka Spruce (Open-Closed) (Seasonally Flooded)	Spruce
Sitka Spruce (Woodland-Closed)	Spruce
Sitka Spruce-Black Cottonwood (Open-Closed) (Seasonally Flooded)	Spruce
Sitka Spruce-Black Cottonwood (Woodland-Closed)	Spruce
White Spruce or Black Spruce (Open-Closed)	Spruce
White Spruce or Black Spruce (Woodland)	Spruce
White Spruce or Black Spruce/Lichen (Woodland-Open)	Spruce
White Spruce or Black Spruce-Deciduous (Open-Closed)	Spruce

Audubon ALASKA

The Nature Conservancy

Land Cover

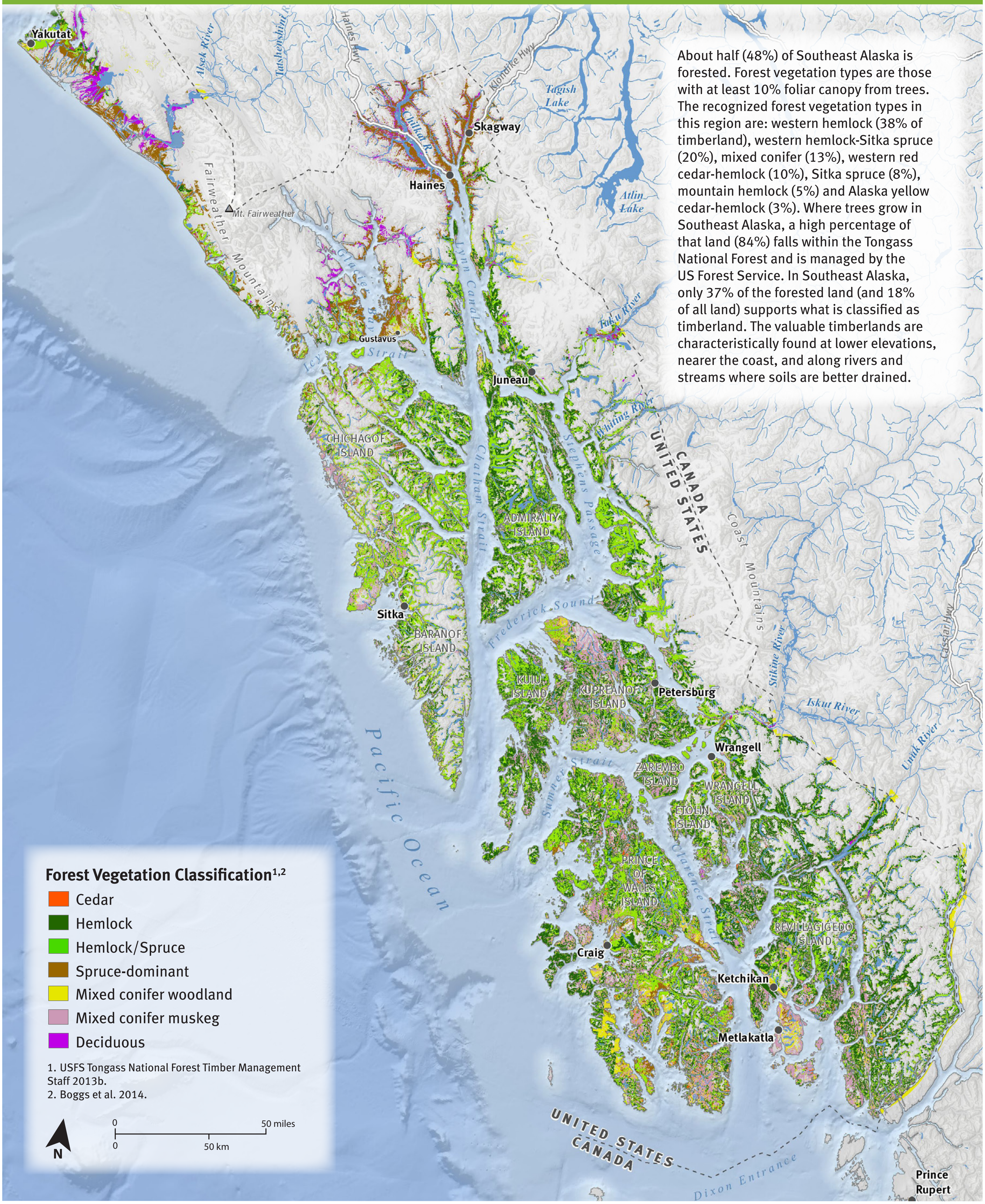
Southeast Alaska is widely recognized as the last remaining, largely intact, old-growth rainforest in North America. That simple description belies the complex landcover of the region. One-third of the region is not vegetated at all, but is barren rock, water, and ice. And surprisingly for a rainforest, only about half of the land area supports forest vegetation. As well-known as it is for its towering forest, Southeast is also known for its majestic mountains, steep rocky fjords, tidewater glaciers, and extensive coastlines. Land cover can be generally described in broad categories of forest (48%), nonforest vegetation (17%), and unvegetated areas (34%) primarily of rock and ice. About half of the forest, or 27% of Southeast Alaska, is classified as productive old growth (POG), which can include small trees. Today, about 3% of all of Southeast Alaska is made up of large-tree POG, while another 4% of the region (previously in the large-tree or medium-tree POG category) has been harvested.

Map 3.4: Land Cover

Forest Vegetation

Audubon ALASKA

About half (48%) of Southeast Alaska is forested. Forest vegetation types are those with at least 10% foliar canopy from trees. The recognized forest vegetation types in this region are: western hemlock (38% of timberland), western hemlock-Sitka spruce (20%), mixed conifer (13%), western red cedar-hemlock (10%), Sitka spruce (8%), mountain hemlock (5%) and Alaska yellow cedar-hemlock (3%). Where trees grow in Southeast Alaska, a high percentage of that land (84%) falls within the Tongass National Forest and is managed by the US Forest Service. In Southeast Alaska, only 37% of the forested land (and 18% of all land) supports what is classified as timberland. The valuable timberlands are characteristically found at lower elevations, nearer the coast, and along rivers and streams where soils are better drained.



Map 3.5: Forest Vegetation

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OLD-GROWTH & SECOND-GROWTH FOREST

David Albert, John Schoen, Melanie Smith, and Nathan Walker

PRODUCTIVE OLD GROWTH

According to the 2008 Tongass Land Management Plan, productive old-growth (POG) forest is defined as old-growth forest lands capable of producing at least 20 cubic ft/ac (1.4 cubic m/ha) of wood fiber per year, or having greater than 8,000 board ft/ac (47 cubic m/ha) (USFS Tongass National Forest 2008c), with some stands having as much as 200,000 board ft/ac (1166 cubic m/ha).

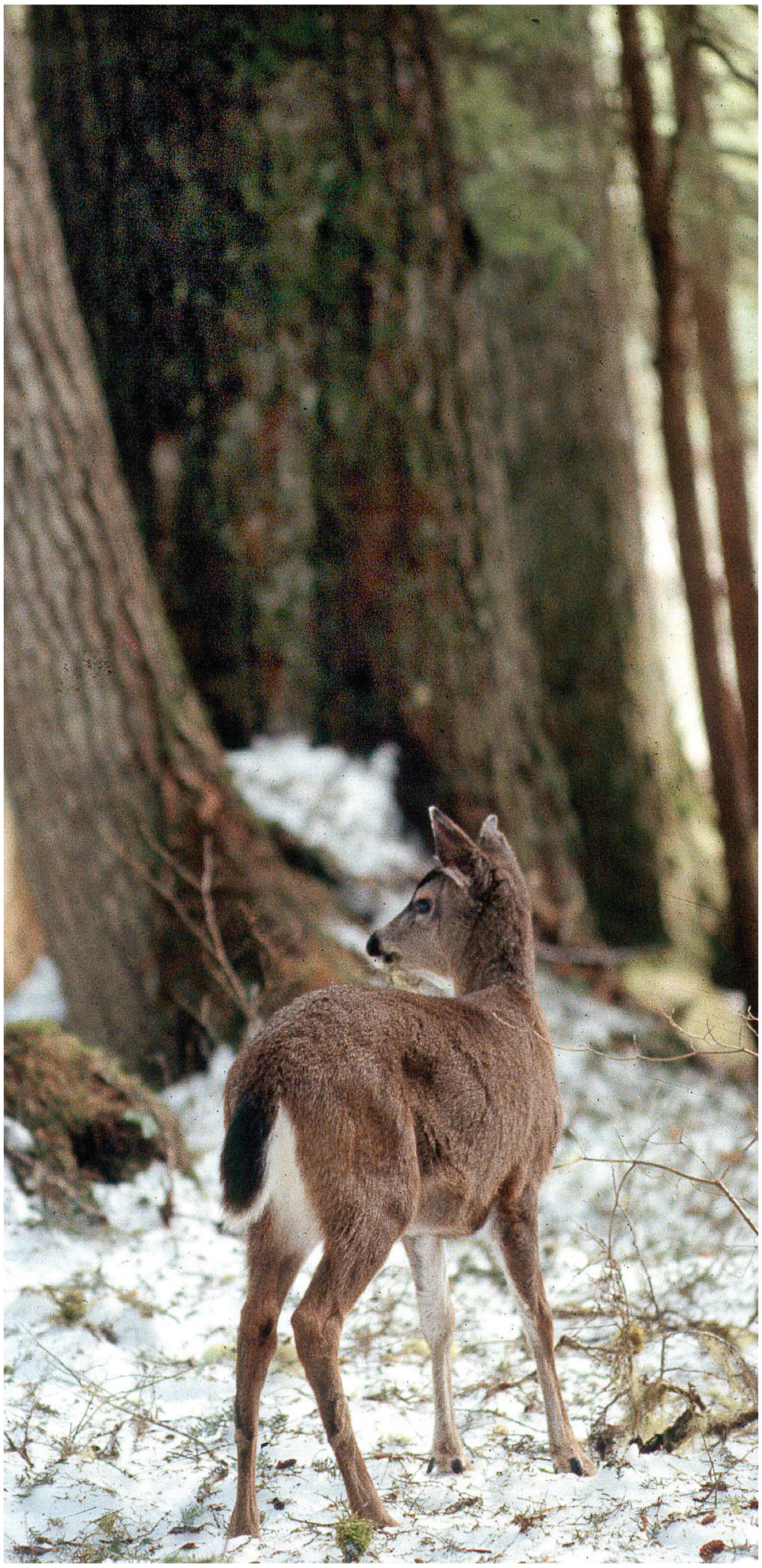
This is a good technical definition, but what is lacking is a sense of the size of the trees in these forest stands, their natural history, and their importance to the ecology of Southeast Alaska. Productive old-growth forest may contain trees that exceed 1,000 years of age; dominant trees typically exceed 300 years of age. The largest trees may reach heights of 130–175 ft (40–50 m) with diameters ranging from 5–11 ft (1.5–3.4 m). Tree species found in these stands typically include western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), and sometimes red or yellow cedar (*Thuja plicata* and *Cupressus nootkatensis*, respectively). Western hemlock tends to dominate in the oldest stands, as it is the more shade-tolerant species.

One key characteristic of old-growth stands is that they include trees of multiple ("uneven") ages and sizes, from seedlings and saplings to pole-sized trees (30–80 years) to trees many centuries old. This forest structure is the cumulative result of many single tree or small tree-group mortality events caused by disease or wind opening gaps in the canopy and creating the space for a rich understory of herbs, ferns, and shrubs, as well as the next generation of trees vying for dominance. Even without the creation of a new forest gap, the multi-aged canopy typical of an old-growth forest lets in adequate sunlight, supporting an understory of blueberries and huckleberries of the genus *Vaccinium*, along with rusty menziesia (*Menziesia ferruginea*), salmonberry (*Rubus spectabilis*), devil's club (*Oplopanax horridum*), and red elderberry (*Sambucus racemosa*).

Productive old-growth forest can include a range of forest types and size classes. Differences in soil drainage result in widely divergent forest structure and stand dynamics. For example, forests growing at lower elevations on well-drained alluvial and floodplain soils are relatively rare, yet are very diverse and productive. Likewise, forests at low elevations on karst formations also produce stands of very large trees. Karst formations in limestone and marble bedrock allow water to drain and trees to grow very large by preventing water-logged soils that can reduce growth rates. Upland forests tend to be dominated by stands of western hemlock and mixed western hemlock-Sitka spruce. Conversely, old-growth forest can be made up of small trees that grow on poorly-drained wet (hydric) soils for centuries without ever reaching a size class that would merit the label productive old growth.

This variation in productive old-growth forests has been described by Caouette and DeGayner (2005), who devised a system to categorize POG stands based on tree size, stand density, and geomorphic stratification grouped into floodplain and upland types as well as forests associated with karst landscapes. Productive old-growth stands were categorized based on a measure of quadratic mean diameter into "large-tree" (>21 in [53 cm]), "medium-tree" (17–21 in [43–53 cm]), and "small-tree" (<17 in [43 cm]).

Productive old-growth forest currently comprises 27% of the land cover in Southeast Alaska, with 3% in large-tree, 20% in medium-tree, and 4% in small-tree size classes. Large-tree old-growth forests are very important habitat for fish and wildlife populations. For example, during periods of deep snow, Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) move into large-tree stands (Schoen and Kirchhoff 1990) where the massive canopy structure intercepts and holds large amounts of snow, providing for winter foraging opportunities below the canopy (Kirchhoff and Schoen 1987). Trees that grow along streams, particularly larger trees, provide an important source of long-lasting woody debris that provides stream structure and enhances habitat for salmon (Murphy and Koski 1989). Productive old growth provides dens for black bears (*Ursus americanus*) and wolves (*Canis lupus*), and nesting trees for Northern Goshawks (*Accipiter gentilis*) (Erickson et al. 1982, Iverson et al. 1996, Person and Russell 2009), as well as habitat for countless other species.



John Schoen

Old-growth forests are considered critical winter deer habitat in Southeast because they provide deer with the combination of abundant forage and shelter from deep snow.

MAPS ON PAGES 55, 56

SECOND GROWTH

The temperate rainforests of Southeast Alaska are in the perhumid (continuously wet) rainforest zone with high annual precipitation distributed throughout the year. Disturbance events impacting large swathes of forest, such as wildland fires, are not common in Southeast. In this zone, wind is the dominant natural disturbance regime while fire is comparatively rare (Alaback et al. 2013). Wind disturbance events tend to occur most frequently on higher elevation south-facing slopes (Doerr et al. 2005), affecting small patches (2–3 ac [.8–1.2 ha]) at a time (Alaback et al. 2013). Thus the kind of large-scale impacts created by industrial logging are in stark contrast to natural windthrow events (Brady and Hanley 1984) and represent a precarious experiment in ecosystem ecology with unknown long-term impacts.

It is estimated that 12% of all productive old-growth forest in Southeast Alaska has been harvested (>800,000 ac [>323,749 ha]). Areas that were harvested after 1986 consisted of approximately 29% large-tree, 65% medium-tree, and 6% small-tree productive old-growth forest types. These figures are likely lower than what was the historic harvest rate (pre-1986) for the large-tree forest type, because regulations in the 1979 Tongass Land Management Plan and 1990 Tongass Timber Reform Act placed new restrictions on logging in the most productive floodplain forests. Accounting for data deficiencies, the Audubon-TNC Conservation Assessment estimated that roughly 50% of the original large-tree old-growth forests have been logged.

Importantly, this logging was not evenly distributed across Southeast, with rates as high as 32% of all POG and 40% of all large-tree POG being harvested on North Prince of Wales Island. Nearly all of the previously harvested areas shown on the accompanying map were once productive old-growth forests. In total, large trees in Southeast Alaska have been the target of industrial logging operations for 60 years. During this time large trees were logged disproportionately, known as "highgrading" (Albert and Schoen 2013). To that end, extremely large trees, those 3 ft (1 m) or more in diameter, have been almost completely removed from the landscape. Remnant patches of productive large-tree old growth are very important for maintaining wildlife populations and biodiversity (Houde et al. 2007) within the matrix of logged lands.

The highgrading within the Prince of Wales Island Complex has resulted in a dramatic shift in forest structure from historic old-growth conditions (see Figure 3c in Albert and Schoen 2013). North Prince of Wales Island was logged at a rate 2.7 times higher than the forest-wide average, and 1.6 times higher than the next most intensively logged province (Dall Island Complex). In total, 120,000 ha (296,000 ac) have been logged in this single province, which is 38% of what has been logged forest-wide. At the landscape scale, 31% of contiguous high-volume forest in Southeast Alaska historically occurred on Northern Prince of Wales Island, and these forests were reduced by 94% between 1954 and 2004 (191,596 ac [77,536 ha] down to 11,864 ac [4,801 ha]) (Albert and Schoen 2013).

Second-growth stands are ecologically much different from old-growth stands. Unlike uneven-age, multi-story old growth generated through small patch disturbances, clearcut logging removes many tens of hectares (hundreds of acres) of contiguous timber at one time. Following clearcutting in Southeast, a forest's succession follows in multiple stages (Harris 1974, Harris and Farr 1974b, Harris and Farr 1979, Wallmo and Schoen 1980, Alaback 1982). Initially young seedlings and saplings generate an abundance of new forage (i.e. herbs, ferns, and shrubs) for some species, including deer, during snow-free months. Conifer seedlings grow abundantly and peak at approximately 15 to 20 years. At about 20 to 30 years, young conifers begin to overtop shrubs and dominate the second-growth stand. After 35 years, stands move into the "stem-exclusion" phase where pole-sized trees grow so tightly packed that light does not reach the forest floor. In this stage, conifers completely dominate second growth, the forest floor is continually shaded, and the understory (including forbs, shrubs, and lichens) largely disappears from the even-aged, second-growth stand. This results in an excess of lands being converted from high forage to essentially no forage. Therefore, an excess of logging causes an ecological "debt" that eventually must be accounted for. This stage typically lasts >100 years (Wallmo and Schoen 1980, Dellasala et al. 1996), while climax uneven-aged old-growth characteristics can take several centuries to redevelop (Alaback 1982, DellaSala 2011).

CONSERVATION ISSUES

The Tongass National Forest has identified a suite of Management Indicator Species that are monitored in order to assess the effects of management activities on their populations and on the populations of other species that share similar habitat requirements (USFS Tongass National Forest 2008c). Some of the species identified in the 2008 Tongass Land Management plan as Management Indicator Species that depend upon productive old-growth forest include: Sitka black-tailed deer, American marten (*Martes americana*), coho salmon (*Oncorhynchus kisutch*), and pink salmon (*Oncorhynchus gorbuscha*). Other species of interest identified by the US Forest Service that need productive old-growth forest habitat include the northern flying squirrel (*Glaucomys sabrinus*), marbled murrelet (*Brachyramphus marmoratus*), and Queen Charlotte Goshawk (*Accipiter gentilis laingi*) (USFS Tongass National Forest 2008a). The relationship between productive old-growth forest and these species is described below:

- The herbaceous understory, along with the ability of the canopy to intercept heavy winter snows, makes productive old-growth forests particularly good deer habitat during hard winters (Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990). Hard winters with lasting deep snow are an important stochastic influence on the Sitka black-tailed deer, reducing total population size (Olson 1979); thus the amount of productive old-growth forest that remains plays an important role in the abundance of this species.
- The American marten (*Martes americana*) is a small- to medium-sized carnivore of the weasel family whose fate is bound with that of productive old-growth forest. Studies have shown the marten's strong preference for large-tree old-growth and unfragmented forests (Flynn et al. 2004).
- Productive old-growth forest plays a large role in the maintenance of healthy salmon populations, and the nutrients that salmon provide in turn create a healthy and productive ecosystem. When bears and other animals carry salmon away from streams, the carcasses serve as fertlizer for the near-stream vegetation and trees (Gende et al. 2002).
- Research has shown that over 20% of the foliar nitrogen of trees and shrubs growing near streams is derived from spawning salmon (Helfield and Naiman 2001). Coho and pink salmon are two of the widely distributed salmon species in Southeast Alaska. Maintaining productive old-growth forests and forested buffers along salmon streams is vitally important to these species for several reasons.
- Without buffers, sedimentation caused by logging can cover the clean gravel needed for spawning (Scrivener and Brownlee 1989). The lack of forested stream buffers can also contribute to high levels of pre-spawning mortality in small drainages at low elevations due to higher stream temperatures and resulting low oxygen levels (Murphy 1985, Halupka et al. 2000). The mature trees that surround salmon streams also often either fall or drop branches, creating large woody debris in the stream. This creates pools that help salmon (especially coho salmon) to remain in the stream despite high water levels in the fall and to overwinter successfully (Tschaplinski and Hartman 1983, Heifetz et al. 1986, Murphy et al. 1986).
- The northern flying squirrel has been shown to be closely associated with old-growth forest (Carey 1995). Gliding, not flying, in Tongass forests, this species plays an important ecological role by feeding on the fruiting bodies of mycorrhizal fungi and dispersing the spores throughout the forest (Maser and Maser 1988). These fungi form a beneficial symbiotic relationship with the roots of many woody plants, including conifer trees. The mycorrhizal fungi are able to enhance nutrient acquisition for the trees, while extracting some sugars from the roots.

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- The Marbled Murrelet nests in the abundant moss present on the large branches of mature trees. The best habitat for the Marbled Murrelet is considered to be large contiguous blocks of high volume, low elevation old-growth forest (USFS Tongass National Forest 2008a).
- The Queen Charlotte Goshawk, a subspecies of the Northern Goshawk, is listed as a sensitive species and is known to select nesting sites in mature, high volume stands of western hemlock. Individual nest trees typically average 27 in (68.7 cm) diameter at breast height (Flatten et al. 2001).

According to Albert and Schoen (2013), results of a review of habitat thresholds literature (to inform forest planning in coastal British Columbia) indicated that maintaining loss of habitat below 40% of historical abundance poses a low risk to most species, whereas declines above that level result in less confidence that risks of extirpation will remain low (Price et al. 2009). On the basis of this criterion, rare forest types that have been reduced by >40% of historical abundance such as landscape-scale blocks of high-volume old growth, and particularly those on Prince of Wales Island, may warrant special consideration (Cook et al. 2006).

The loss of old-growth forest to industrial-scale clearcut logging has been central to petitions to list the Queen Charlotte Goshawk, Prince of Wales flying squirrel (*Glaucomys sabrinus griseifrons*), and Alexander Archipelago wolf (*Canis lupus ligoni*) under the US Endangered Species Act.

MAPPING METHODS

Productive Old Growth

The productive old-growth data layer was created by Albert and Schoen for the Audubon-TNC Conservation Assessment. Methods are as follows. The Tongass Forest timber inventory provided the foundation for mapping of vegetation, and was augmented with timber inventory data from Haines State Forest and with classified Landsat Multi-spectral Scanner (MSS) imagery from the Interim Landcover Mapping Program of the US Geological Survey. This imagery, in combination with 1997 US Forest Service (USFS) aerial photography, allowed development of a reasonably current database of forest condition on USFS, state, and private lands across Southeast. Although land cover categories were limited by the resolution of information from management agencies, it was mostly possible to maintain consistency among general types throughout the region. To represent the diversity of ecological values associated with forest ecosystems, a general classification developed by Caouette and DeGayner (2005) was used based on tree size and stand density and a geomorphic stratification grouped into flood plain and upland types as well as forests associated with karst landscapes. Stands of productive old growth were categorized based on a measure of quadratic mean diameter into “large-tree” (>21 in [53 cm]) , “medium-tree” (17–21 in [43–53 cm]), and “small-tree” stands (<17 in [43 cm]) using the USFS database on existing vegetation, historical information on forest structure contained in the 1986 Timtype (Timber Type) database, and data on hydric (wet) soils contained in the National Wetlands Inventory. Forest condition on private lands was estimated by using Landsat ETM (1999–2000) and USFS orthophotographs (1996). For lands within the Tongass National Forest, floodplain forests were identified based on the Tongass National Forest soils database. For lands outside the Tongass, a multivariate modeling approach was used.

Using the total acreage of habitat, Audubon and TNC ranked watersheds in Southeast Alaska, stratified by biogeographic province (Albert and Schoen 2007). Watersheds were ranked for riparian and upland forest habitat separately. The top (#1 ranked) riparian and/or upland forest watersheds in each province are shown on the map.

Second Growth

The second-growth dataset that is included here brings together multiple data sources to create a seamless data layer for all of Southeast Alaska. The 2013 Land Cover dataset produced by the Tongass National Forest was used to identify young-growth areas on Tongass National Forest (both natural and resulting from harvest activity). The Forest Type dataset produced by Albert and Schoen 2007 Conservation Assessment and Resource Synthesis for Southeast Alaska was used to locate post-harvest second-growth areas on non-Tongass National Forest lands (Albert and Schoen 2006, USFS Tongass National Forest Timber Management Staff 2013b). Additionally, locations on non-Tongass National Forest Lands where post-harvest young growth identified in the 2013 Size Density layer agreed with the 2013 Activity Polygon from Tongass National Forest (showing timber harvest or other management) were classified as second growth. This captured recent logging activity that has taken place since 2007 as well as historical harvests not detected via the remote-sensing approach used for development of the Forest Types dataset (USFS Tongass National Forest Timber Management Staff 2013a). Finally, the 2016 USFS Harvest Activity nationwide layer was used to add in harvested stands not portrayed by the other layers.

Landscape-scale Forest Change

The inset maps represent the 1954 and 2004 forest conditions, showing change in the amount of historic landscape-scale forest in m^3/km^2. Albert and Schoen developed this metric using a moving-window analysis of volume with a 0.6 mi (0.9 km) radius, in order to integrate “information on forest structure and the degree to which productive old growth-forests are contiguous across the landscape” (Albert and Schoen 2013).

MAP DATA SOURCES

- Landscape-scale Forest Change: Albert and Schoen (2013)
- Productive Old-growth Forest: Albert and Schoen (2007b)
- Second-growth Forest: Audubon Alaska (2014), based on: Albert and Schoen (2007b), USFS Tongass National Forest Timber Management Staff (2013a), USFS Tongass National Forest Timber Management Staff (2013b); US Forest Service (2016).

MAPS ON PAGES 55, 56


John Schoen


John Schoen

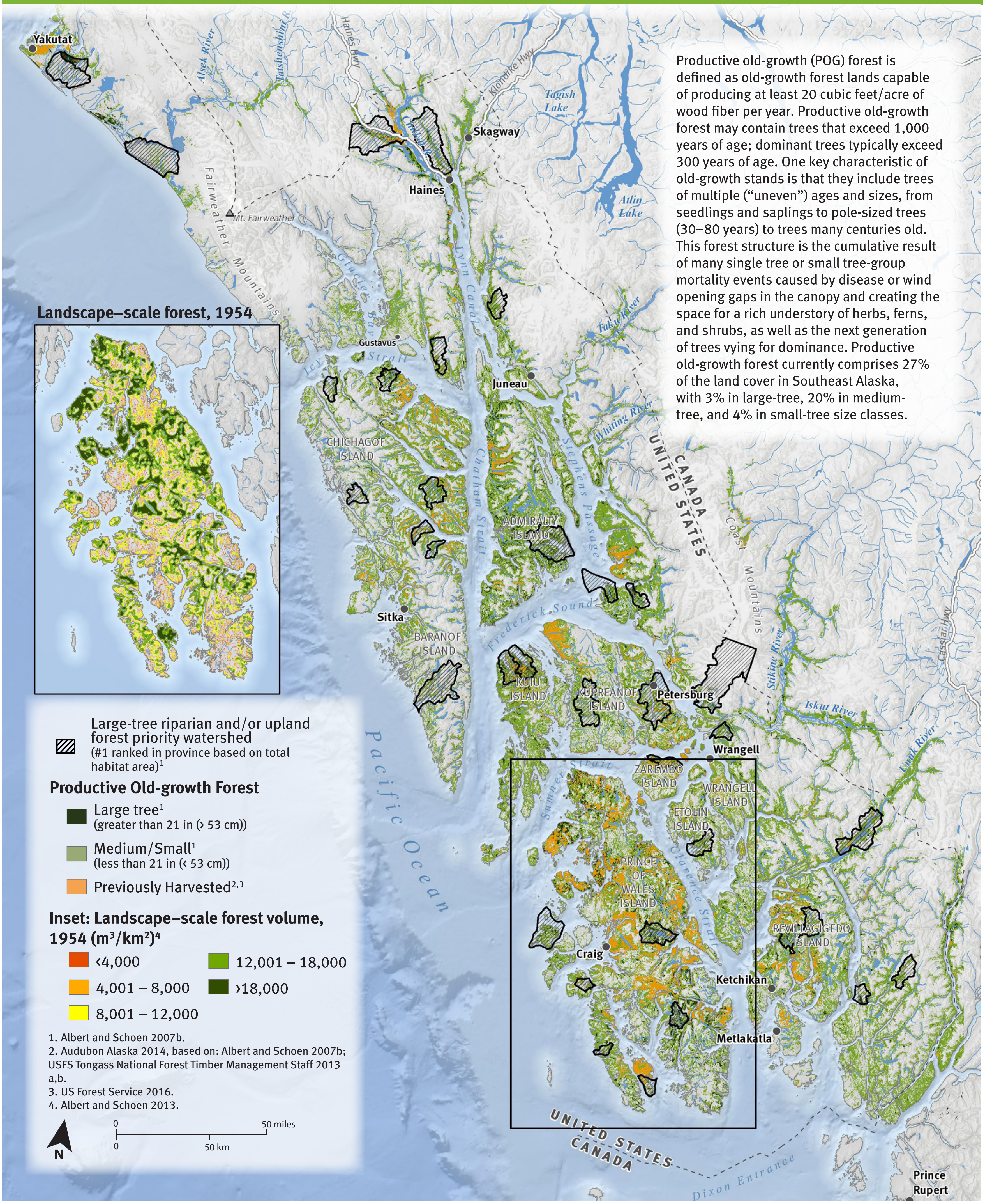
Above: Old-growth forest is characterized by large snags, trees of diverse size and age, multiple canopy layers with frequent gaps, and luxuriant understory of forbs, shrubs, and hemlock saplings. Old growth has high habitat value for many species of fish and wildlife. **Below:** A post-logging forest stand, approximately 60 years old. The stand is even-aged, has a closed canopy with little understory, and habitat value for most wildlife is low.

Audubon Alaska

The Nature Conservancy

Productive Old-growth Forest

Productive old-growth (POG) forest is defined as old-growth forest lands capable of producing at least 20 cubic feet/acre of wood fiber per year. Productive old-growth forest may contain trees that exceed 1,000 years of age; dominant trees typically exceed 300 years of age. One key characteristic of old-growth stands is that they include trees of multiple ("uneven") ages and sizes, from seedlings and saplings to pole-sized trees (30–80 years) to trees many centuries old. This forest structure is the cumulative result of many single tree or small tree-group mortality events caused by disease or wind opening gaps in the canopy and creating the space for a rich understory of herbs, ferns, and shrubs, as well as the next generation of trees vying for dominance. Productive old-growth forest currently comprises 27% of the land cover in Southeast Alaska, with 3% in large-tree, 20% in medium-tree, and 4% in small-tree size classes.

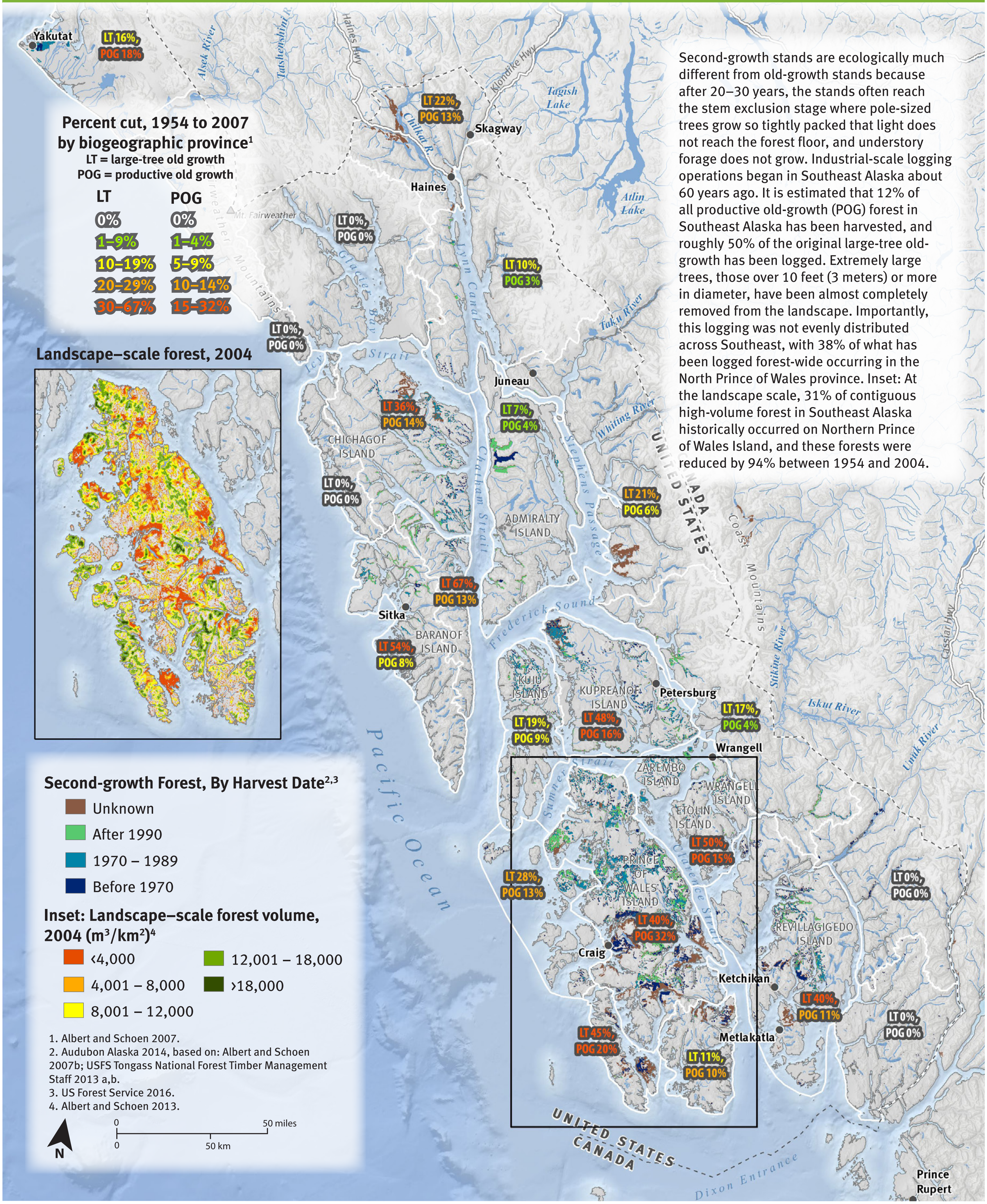


Map 3.6: Productive Old-growth Forest

Second-growth Forest

Audubon ALASKA
The Nature Conservancy

Second-growth stands are ecologically much different from old-growth stands because after 20–30 years, the stands often reach the stem exclusion stage where pole-sized trees grow so tightly packed that light does not reach the forest floor, and understory forage does not grow. Industrial-scale logging operations began in Southeast Alaska about 60 years ago. It is estimated that 12% of all productive old-growth (POG) forest in Southeast Alaska has been harvested, and roughly 50% of the original large-tree old-growth has been logged. Extremely large trees, those over 10 feet (3 meters) or more in diameter, have been almost completely removed from the landscape. Importantly, this logging was not evenly distributed across Southeast, with 38% of what has been logged forest-wide occurring in the North Prince of Wales province. Inset: At the landscape scale, 31% of contiguous high-volume forest in Southeast Alaska historically occurred on Northern Prince of Wales Island, and these forests were reduced by 94% between 1954 and 2004.



Map 3.7: Second-growth Forest

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CORE AREAS OF HIGH BIOLOGICAL VALUE

David Albert and John Schoen
Revised by Melanie Smith

The analysis of core areas of biological value is based on an analytical model that identifies the highest ecological value for a combined suite of species, using the smallest footprint possible. The resulting core areas are spread across biogeographic provinces to ensure adequately viable and well-distributed populations. This analysis was first completed using salmonid habitat (five species of Pacific salmon [*Oncorhynchus spp.*] plus steelhead trout [*O. mykiss*] combined) as a single focal target, as well as old-growth forest (big-tree riparian and upland stands), estuaries, brown (*Ursus arctos*) and black bear (*Ursus americanus*) summer habitat, Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) winter habitat, and Marbled Murrelet (*Brachyramphus marmoratus*) nesting habitat. The Marxan model was utilized to optimize a conservation area design for the combination of these values. The complete description of models and methods used to identify core areas, as well as the justification for this approach can be found in the 2007 Audubon-TNC Conservation Assessment.

Two types of planning units were selected for these analyses. Watersheds represent an ecologically based unit with functional cohesiveness (at least for some systems) and are relatively easily mapped. Secondly, watersheds correlate well with an existing inventory system called Value Comparison Units (VCU) used by the Tongass National Forest. VCUs are watershed-based units that have the additional advantage of encompassing estuaries and adjacent marine habitats associated with terrestrial drainage systems. In most cases, the VCU contains a cluster of coastal drainages for a single bay or small island. In rare cases, watersheds had been divided among several VCUs along management or ownership boundaries. In addition, we used consistent criteria to delineate VCUs for the rest of Southeast, including Glacier Bay National Park and lands near Haines and Skagway.

Although watersheds are useful for landscape-scale comparisons of some ecological systems (e.g., salmon), they are less suitable for description of others (e.g., winter habitat for deer). Moreover, direct comparison among watersheds is confounded by differences in basin size. Thus, we developed a secondary planning unit based on hexagons of 100 ha (247 acres) in size. These units are of consistent size and shape and are a better representation of ecological processes at a sub-watershed scale.

In this conservation assessment, we programmed Marxan to perform 10 million iterative attempts to find the most efficient solution and perform 10 such runs for each alternative conservation scenario we explored. The score for each planning unit is the sum of runs in which it was selected as part of the most efficient solution. An area consistently identified as part of the optimal solution under a range of scenarios is a robust solution that may be considered to have high biological value for the combined set of focal species and ecological systems, and is a useful element for the design of a regional conservation network (Pressey et al. 1994, Leslie et al. 2003). When specifically applied to achieving goals for the range of focal species selected in this analysis (i.e., salmon, deer, bear, murrelet, estuary, large-tree forest) these areas were considered as "core areas" of biological value.

CONSERVATION ISSUES

The term "ecological integrity" is defined by Poiani et al. (2000) as the ability to maintain component species and processes over long time frames. Protection of these core areas is necessary for Southeast and the Tongass National Forest before conservation options are foreclosed by substantial new development in roadless areas, forest fragmentation, and loss of rare, at risk habitats.

The ranking of core areas of biological value within watersheds represents a spectrum of conservation opportunities based on ecological value and habitat condition. The watershed context provides the

Nils Warnock

Brown bear habitat was one of several factors taken into account in the analysis of core areas of biological value.

primary, landscape-scale characterization, while core areas represent the highest concentrations of intact ecological values within watersheds. Protection of the core areas would ensure the conservation of well-distributed focal targets and ecological systems.

To protect these core areas, foremost, the US Forest Service should transition out of old-growth clearcut logging across the Tongass, but especially in the areas mapped in the top two tiers (Marxan 50–100th percentile) of biological value. Additionally, road building should be minimized. Modified landscapes (e.g. second-growth forest) that rank high should be considered for stewardship treatments such as road closures, improvement of fish passage structures, and forest restoration.

MAPPING METHODS

The Marxan tool (Possingham et al. 2000) was used to identify and rank areas of ecological value throughout Southeast. Marxan is a spatial optimization tool for developing and evaluating reserve networks based on explicit conservation goals. The utility of Marxan is to identify a set of areas that most efficiently meet specified goals for representation of conservation targets. Ecological rankings were based on the areas of highest concentration of habitat values for the suite of focal species and ecological systems selected with the minimum total area and maximum connectivity.

The Marxan software utilizes an algorithm called "simulated annealing with iterative improvement" as a method for efficiently selecting regionally representative sets of areas for conservation of biological diversity (Pressey et al. 1994, Csuti et al. 1997, Possingham et al. 2000). Simulated annealing is basically a complex computer search for an optimal solution. In order to identify these areas, Marxan examines each individual planning unit for the values it contains. It then iteratively selects collections of units to meet the conservation goals that have been assigned. The algorithm attempts to minimize portfolio "cost" (efficiency of the solution) while maximizing attainment of conservation goals. As the program progresses and the solution improves, smaller and smaller cost increases are accepted until finally only changes in the portfolio that actually reduce cost are accepted. If enough runs are undertaken, a subset of superior solutions can be created.

MAP DATA SOURCES

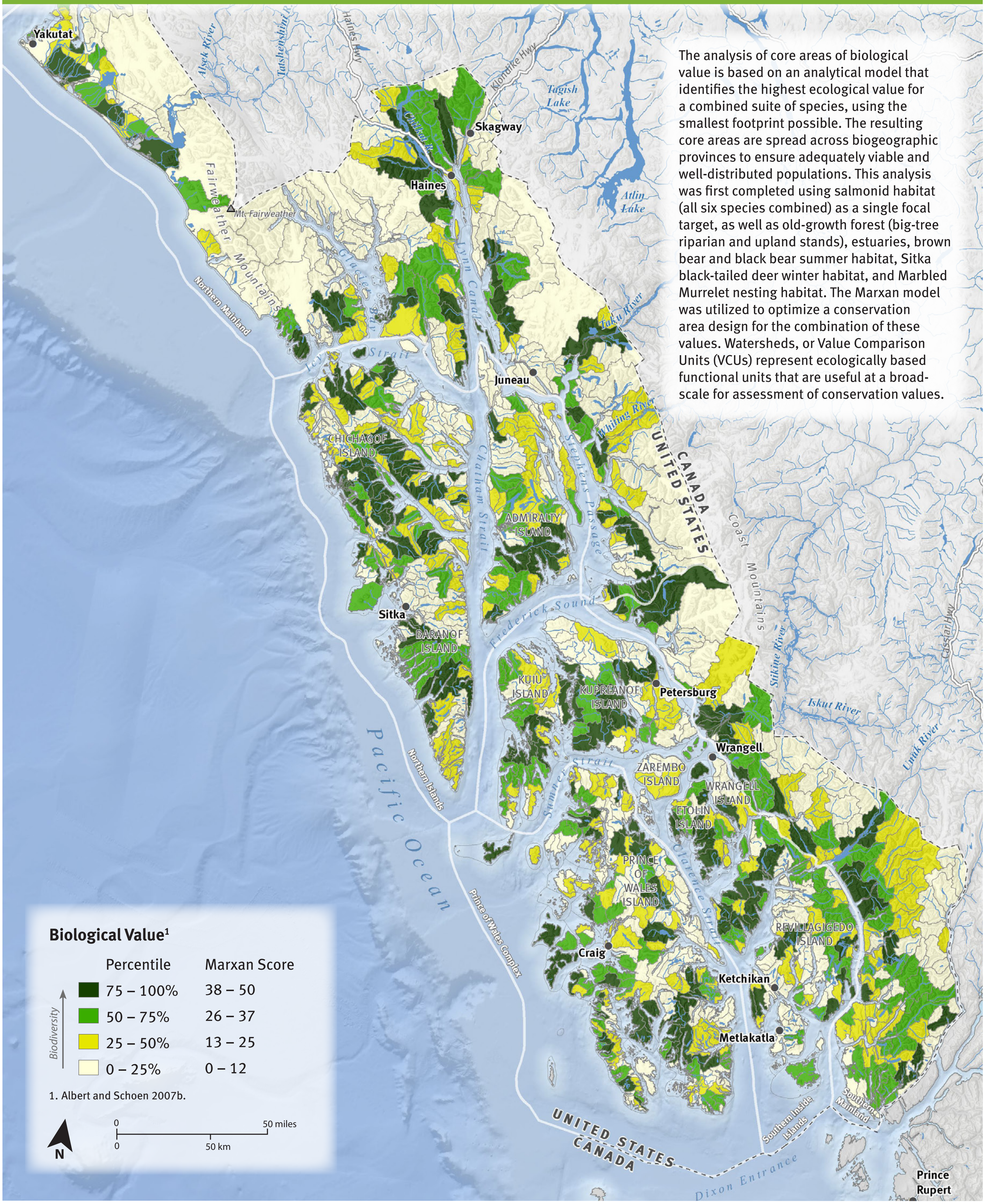
- Core Areas of Biological Value: Albert and Schoen (2007b).

Core Areas of High Biological Value
Watershed Scale

Audubon ALASKA

The Nature Conservancy

The analysis of core areas of biological value is based on an analytical model that identifies the highest ecological value for a combined suite of species, using the smallest footprint possible. The resulting core areas are spread across biogeographic provinces to ensure adequately viable and well-distributed populations. This analysis was first completed using salmonid habitat (all six species combined) as a single focal target, as well as old-growth forest (big-tree riparian and upland stands), estuaries, brown bear and black bear summer habitat, Sitka black-tailed deer winter habitat, and Marbled Murrelet nesting habitat. The Marxan model was utilized to optimize a conservation area design for the combination of these values. Watersheds, or Value Comparison Units (VCUs) represent ecologically based functional units that are useful at a broad-scale for assessment of conservation values.



Map 3.8: Core Areas of High Biological Value: Watershed Scale

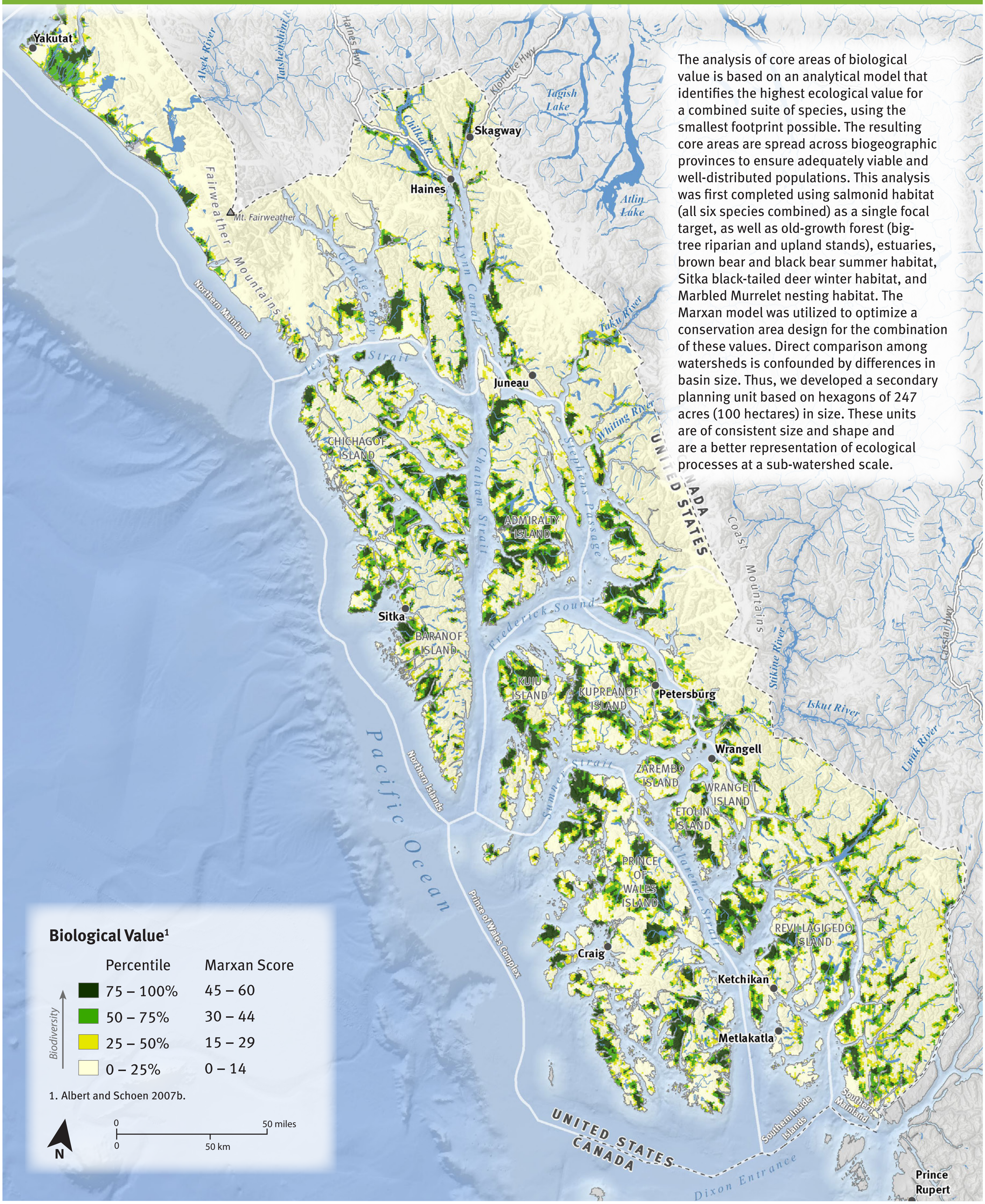
Audubon ALASKA

The Nature Conservancy

Core Areas of High Biological Value

Sub-Watershed Scale

The analysis of core areas of biological value is based on an analytical model that identifies the highest ecological value for a combined suite of species, using the smallest footprint possible. The resulting core areas are spread across biogeographic provinces to ensure adequately viable and well-distributed populations. This analysis was first completed using salmonid habitat (all six species combined) as a single focal target, as well as old-growth forest (big-tree riparian and upland stands), estuaries, brown bear and black bear summer habitat, Sitka black-tailed deer winter habitat, and Marbled Murrelet nesting habitat. The Marxan model was utilized to optimize a conservation area design for the combination of these values. Direct comparison among watersheds is confounded by differences in basin size. Thus, we developed a secondary planning unit based on hexagons of 247 acres (100 hectares) in size. These units are of consistent size and shape and are a better representation of ecological processes at a sub-watershed scale.



Map 3.9: Core Areas of High Biological Value: Sub-Watershed Scale

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INDEX OF CUMULATIVE ECOLOGICAL RISK

David Albert and John Schoen
Revised by Melanie Smith

INDEX OF RELATIVE BIOLOGICAL VALUE

Central to the long-term conservation of species and management of ecological risk throughout the region is an understanding of the relative distribution of habitat values as well as the current condition and conservation status of those lands. Species, populations, and ecological processes occur at a range of spatial scales. Therefore, it is essential to incorporate a multi-scale approach into an assessment of ecological condition and conservation measures (Poiani et al. 2000).

For the 2007 Audubon-TNC Conservation Assessment, Schoen and Albert selected a suite of focal species and ecological systems that provide the best indicators of large-scale changes that have occurred in this region, primarily associated with industrial logging and road construction, as well as more localized urbanization. For the analysis, focal species included salmon (*Oncorhynchus spp.*), brown (*Ursus arctos*) and black (*Ursus americanus*) bear, Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), and Marbled Murrelet (*Brachyramphus marmoratus*), while ecological systems included large-tree forests and estuaries.

Habitat values for deer, bear, and murrelet were estimated using habitat models that reflect key aspects of each species' life history. The estimate of habitat values for salmon was based on the distribution of freshwater habitat used for spawning or rearing by each of five species of Pacific salmon and steelhead (*O. mykiss*), while the distribution of forest types and estuaries was based on an integrated regional database of vegetation and land cover. These data were extensively reviewed by interagency biologists and local experts and were judged to adequately describe the large-scale patterns of distribution and abundance of habitat values in the region. Albert and Schoen evaluated the current and original distribution of habitat values for each focal species or ecological system across biogeographic provinces.

These indices can be useful for single-species comparison as well as for all focal resources combined. Given that this suite of focal targets represents a range of terrestrial, freshwater, and nearshore marine ecosystems, it also provides a reasonably robust ranking of biological values associated with coastal forest ecosystems.

Based on combined resource values, North Prince of Wales Island ranked highest in biological value with particularly high contribution to the regional distribution of large-tree forests, salmon, and deer habitat. Admiralty Island ranked second in biological value with high large-tree forests, brown bear, and deer habitat. East Chichagof Island and the Stikine River Mainland have high values based on the distribution of salt marsh estuarine habitats, while Yakutat ranks second in the region for total freshwater salmon habitat.

INDEX OF ECOLOGICAL CONDITION

A key understanding developed in the Audubon-TNC Conservation Assessment was the estimation of change in the distribution of forest types and associated habitat values since the initiation of industrial-scale logging in Southeast Alaska in 1954. These estimates were used to calculate the original distribution of large-tree forests, and to estimate the original capability of nesting habitat for Marbled Murrelet, winter habitat for deer, and summer habitat for brown and black bear. Albert and Schoen estimated condition of habitat for salmon by measuring the percent of floodplain forests associated with salmon streams that had been logged. While these estimates are not expected to directly predict population size or abundance, they can be used as a conservative index to the degree of change from natural conditions, which in turn provides insight into the robustness of these systems in the face of population and environmental variability (e.g., climate change).

The greatest percentage change in original habitat conditions has occurred on North Prince of Wales, East Baranof, East Chichagof, Etolin / Zarembo / Wrangell, Kupreanof / Mitkof, and West Baranof provinces.

INDEX OF CONSERVATION AND VULNERABILITY

A measure of the effectiveness of a conservation strategy is the degree to which high-value habitats are conserved within a landscape context where ecosystem functions are likely to remain intact. As an indicator of the adequacy of both the design and implementation of the existing conservation strategy in Southeast, Albert and Schoen attempted to estimate the percent of habitat values for focal species and ecological systems that are designated within conservation areas. For the analysis,

Recent clearcut logging on Prince of Wales Island.

John Cannon

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TABLE 3-7 Cumulative ecological risk based on projected possible change in habitat values for focal species and ecological systems within 22 biogeographic provinces in Southeast Alaska.

	Percentage of original habitat values at risk					
Biogeographic Province	Large-tree forest	Murrelet	Salmon	Bear	Deer	All (avg.)
Chilkat River Complex	91.8%	90.7%	37.2%	82.0%	--	73.7%
North Prince of Wales	64.7%	68.0%	63.7%	79.4%	66.3%	68.7%
Kupreanof / Mitkof Island	71.6%	67.6%	67.1%	73.2%	61.7%	67.7%
Etolin / Zarembo / Wrangell	70.0%	58.7%	23.9%	66.2%	50.9%	54.8%
East Chichagof Island	52.2%	55.4%	45.1%	67.7%	53.1%	54.6%
East Baranof Island	74.4%	52.0%	41.1%	53.1%	53.7%	53.6%
Dall / Long Island Complex	51.8%	39.6%	43.7%	55.0%	49.0%	46.8%
Kuiu Island	53.6%	37.9%	47.0%	54.5%	37.2%	46.2%
Revilla / Cleveland Pen.	58.0%	42.0%	24.1%	57.7%	44.1%	45.5%
Taku River / Mainland	51.8%	39.8%	34.6%	43.9%	--	42.6%
Stikine River / Mainland	38.0%	32.7%	55.7%	39.1%	--	41.5%
Yakutat Forelands	46.5%	31.5%	37.8%	38.8%	--	38.4%
West Baranof Island	63.0%	27.7%	33.2%	37.8%	30.1%	38.2%
Outside Islands	48.7%	29.0%	37.1%	37.6%	34.2%	37.4%
Lynn Canal / Mainland	41.0%	30.2%	30.9%	45.3%	--	36.9%
South Prince of Wales	36.3%	39.7%	13.6%	42.4%	35.6%	33.5%
Admiralty Island	11.1%	7.4%	32.8%	15.5%	9.9%	15.5%
North Misty Fjords	4.6%	2.8%	35.8%	6.0%	--	12.1%
Glacier Bay	--	0.9%	18.6%	17.4%	--	10.3%
South Misty Fjords	0.3%	0.2%	34.2%	4.0%	--	9.6%
West Chichagof Island	0.7%	1.3%	19.6%	7.8%	5.1%	6.9%
Fairweather Range	--	0.1%	2.9%	8.9%	--	3.5%
All	49.7%	40.0%	42.6%	48.9%	45.9%	45.4%

[a] Regional data on condition and management of estuaries were not available for this analysis.

they combined congressional protections, all conservation measures under the 1997 Tongass Land Management Plan, and other conservation designations on state and private lands. The inverse of habitats included within conservation areas is the percent of habitats designated for timber production and other extractive uses, and is referred to as an index of vulnerability (Margules and Pressey 2000). The provinces with the least conservation protection include Chilkat River, Kupreanof / Mitkof, North Prince of Wales, Etolin / Zarembo / Wrangell, and East Chichagof.

INDEX OF CUMULATIVE ECOLOGICAL RISK

Cumulative ecological risk is an estimate of the combined effects of change in habitat values resulting from past activities such as timber harvest, road construction and urbanization, as well as the possibility of future change based on current management designations and conservation systems. This is the primary tool for evaluating risks resulting from the cumulative effects of habitat alteration on private, state, and national forest lands, and is particularly important given the fragmented nature of the island provinces. The provinces estimated to face the greatest ecological risks include the Chilkat River Complex, North Prince of Wales, Kupreanof / Mitkof, Etolin / Zarembo / Wrangell, East Chichagof, and East Baranof (see Table 3-7). Those provinces with the least ecological risks include the Fairweather Icefields, West Chichagof, South Misty Fjords, Glacier Bay, North Misty Fjords, and Admiralty Island.

To reiterate, this is simply a measure of the degree to which habitat values for these focal species and ecological systems are expected to remain intact over the current planning horizon (circa 2007 when the analysis was completed). This does not imply that species declines will or will not occur, simply that the risk of instability is related to the cumulative change in habitat values relative to the natural range of variability within coastal forest ecosystems. The analysis does not address special ecological features inherent in specific provinces such as unique salmon stocks (Halupka et al. 2000) or centers of endemism (Cook and MacDonald 2001, Cook et al. 2006).

An effective conservation strategy for Southeast must address each province's special features as well as areas of importance for community or subsistence use. With those caveats in mind, the assessment of cumulative ecological risk provides resource managers and conservationists with an additional tool for prioritizing conservation and restoration actions throughout Southeast.

CONSERVATION ISSUES

Figure 3-2 is a comparison of biological value and vulnerability among biogeographic provinces which reveals a trend that potentially reflects an imbalance in management for conservation in the region. Biological value is distributed along the y-axis, with North Prince of Wales, Admiralty Island, East Chichagof, Revilla Islands / Cleveland Peninsula, Stikine River, and Kupreanof / Mitkof exhibiting the highest value. These

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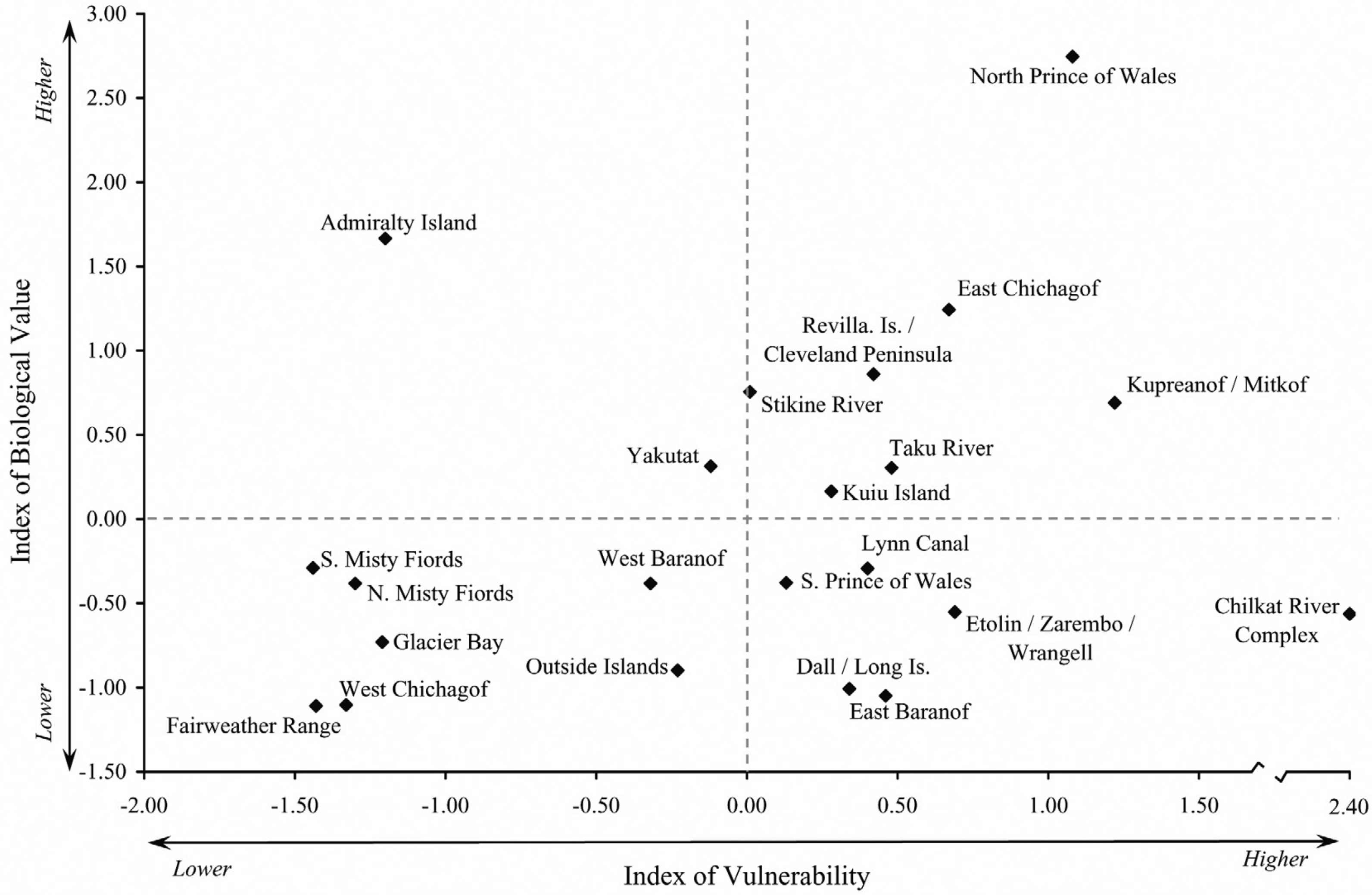
FIGURE 3-2 The index of biological value is a combined index based on relative contribution of each province to the regional distribution of habitat values, and the index of vulnerability reflects the percent of habitat values within each province that are designated within development Land Use Designations (LUDs) or private lands. Values were normalized to facilitate comparison among provinces.



provinces contain extensive areas of large-tree forests, salmon streams, estuaries and high value habitat for deer and bears. Provinces with relatively lower biological value (based on the focal resources used in this analysis) include the mainland provinces of the Fairweather Range and Glacier Bay, as well as the island provinces of West Chichagof and East Baranof.

Relative vulnerability is distributed along the x-axis, with the Chilkat River Complex, Kupreanof / Mitkof, North Prince of Wales, Etolin / Zarembo / Wrangell, and East Chichagof demonstrating the highest proportion of habitats designated for extractive uses on national forest, private, or state lands. Significantly, six of the nine most productive provinces have high vulnerability (upper-right quadrant) while those with the highest levels of conservation (e.g., wilderness areas or parks with low vulnerability) are also among the lowest in terms of biological value (lower-left quadrant). This imbalance reflects a high-risk strategy in terms of long-term protection of biodiversity and ecosystem integrity in the region (Gaston et al. 2002). The notable exception is Admiralty Island, which is the only province that is both highly productive for the full suite of focal resources and also managed primarily for fish and wildlife conservation and ecosystem integrity.

According to this analysis, provinces in the upper-right quadrant, including North Prince of Wales, East Chichagof, Revilla / Cleveland, and Kupreanof / Mitkof rank as the highest priorities for additional conservation and restoration measures (Margules and Pressey 2000).

MAPPING METHODS

In this context, Albert and Schoen defined an index of relative biological value (RBV) as the percent contribution of each biogeographic province to the total distribution of habitat values for each species or ecological system:

$$RBV_p = \frac{\sum_{i=1}^{n} (h_p / h_{total})}{n}$$

where:

- p = biogeographic province
- n = number of target species or systems within province *(p)*
- h_p = habitat value for species *(i)* contained within province *(p)*
- h_{total} = total habitat for species *(i)* in the region

To estimate the distribution of forest types that had been logged, they used available data on logging activity from 1986 to the present as a conservative estimate of the percent change in the rare, large-tree forest types over time. However, because logging practices have changed over time, it is important to recognize this comparison likely represents a significant underestimate of the original distribution of large-tree forest types.

Index of Vulnerability was calculated as:
1 – (% of existing habitat protected)

Cumulative Ecological Risk was calculated as:
1 – [(% of original habitat remaining intact) /
(% of existing habitat protected)]

For mapping methods of individual species and focal targets, refer to those maps' summaries in this and other sections.

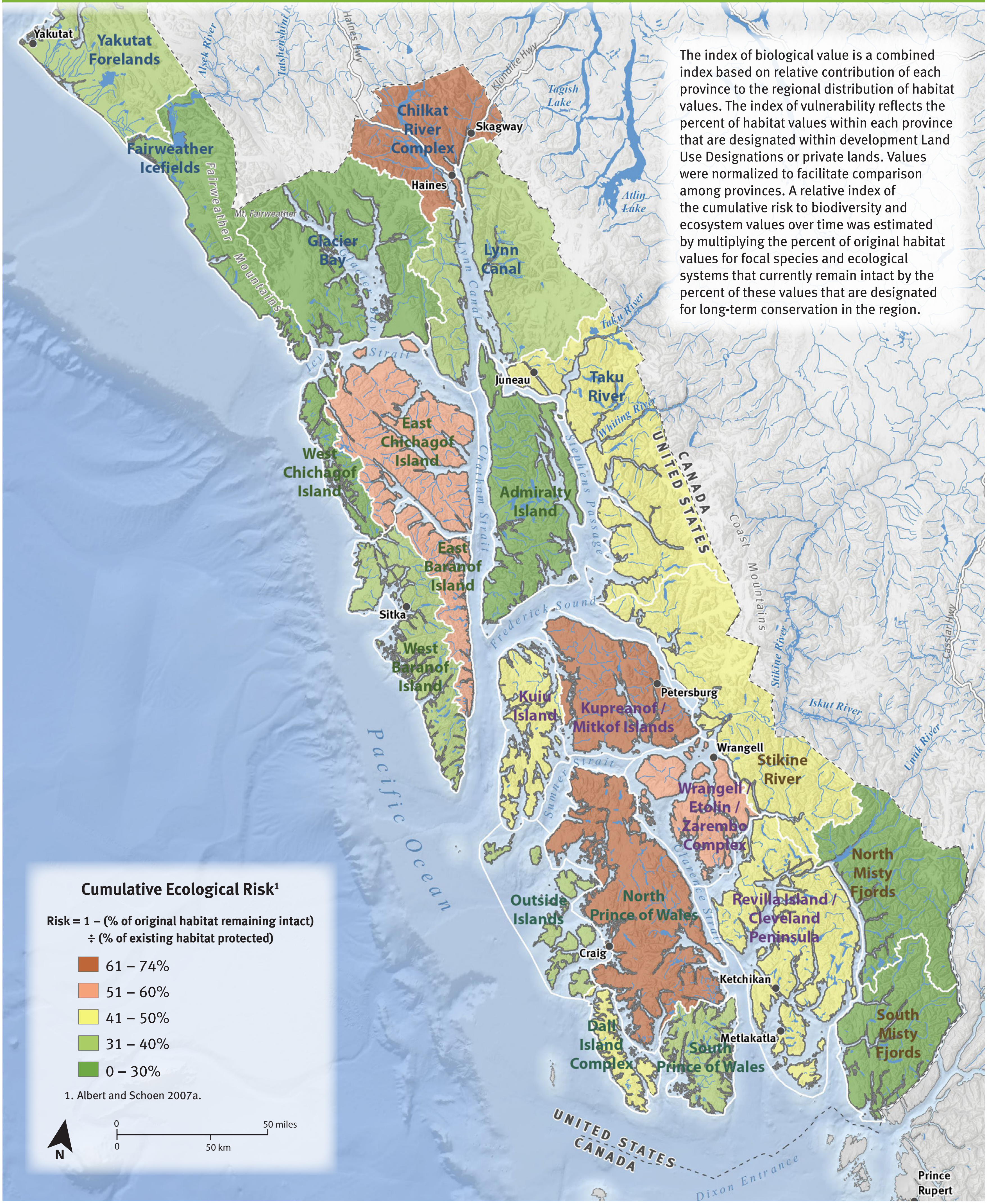
MAP DATA SOURCES

- Cumulative Ecological Risk: Albert and Schoen (2007a).

Audubon Alaska | The Nature Conservancy

Index of Cumulative Ecological Risk

The index of biological value is a combined index based on relative contribution of each province to the regional distribution of habitat values. The index of vulnerability reflects the percent of habitat values within each province that are designated within development Land Use Designations or private lands. Values were normalized to facilitate comparison among provinces. A relative index of the cumulative risk to biodiversity and ecosystem values over time was estimated by multiplying the percent of original habitat values for focal species and ecological systems that currently remain intact by the percent of these values that are designated for long-term conservation in the region.



Map 3.10: Index of Cumulative Ecological Risk

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