ECOLOGICAL ATLAS OF SOUTHEAST ALASKA

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Ecological Atlas of Southeast Alaska

Melanie A. Smith,
editor
2016

Cover photo by Dave Shaw, this page by Nick Jans

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COMMONLY USED ACRONYMS

ABC – Admiralty, Baranof, Chichagof
ADFG – Alaska Department of Fish and Game
ANCSA – Alaska Native Claims Settlement Act
ANILCA – Alaska National Interest Lands Conservation Act
GMU – Game Management Unit
IBA – Important Bird Area
LUD – Land Use Designation
NWI – National Wetlands Inventory
POG – Productive old growth
POW – Prince of Wales
SNAP – Scenarios Network for Alaska and Arctic Planning
TLMP – Tongass Land Management Plan
TNC – The Nature Conservancy
TU – Trout Unlimited
USFS – United States Forest Service
USFWS – United States Fish and Wildlife Service
VCU – Value Comparison Unit

A list of atlas maps and page numbers is included in Table 1-1 on page 4.

MAP ON PAGE 5

INTRODUCTION

Welcome to Southeast Alaska. This Ecological Atlas will take you on a scientific journey along the rugged coastline, through the towering temperate rainforests, up the steep mountainsides, and onto the icefields of Alaska's panhandle. Along the way you'll learn about regional climate, old-growth ecosystems, fishes, endemic mammals and birds, economic development, and more. Like Audubon Alaska itself, the atlas is rooted in science and communicated through maps and writing. Blended in are bits of natural and human history, and perspectives on conservation issues to consider as we learn from the past and look to the future. From your office desk or with a cup of tea in a big comfortable chair, we hope you'll immerse yourself in the maps, photos, and descriptions, and learn something new about this place whether you aspire to visit or have been rooted here for generations.

Audubon Alaska has worked on conservation issues in Southeast Alaska for most of our 40-year history. Our mission is to conserve the spectacular natural ecosystems of Alaska, focusing on birds, other wildlife, and their habitats, for the benefit and enjoyment of current and future generations. Even though Audubon is known for our focus on conservation of birds, in Southeast Alaska our work has taken a whole-ecosystem approach, which is reflected in this Ecological Atlas. We use science to identify conservation priorities and support conservation actions and policies, with an emphasis on public lands and waters. This "data to design" approach gives us a solid foundation in ecological principles and spatial patterns that allow us to identify priority species, places, and threats. We work with science researchers, land managers, local stakeholders, and decision-makers to envision a healthy future for this incredible place better known as the Tongass National Forest. This all begins with an understanding of the ecology, the human history, and current human use aspects of this special landscape—which is why we developed this atlas. It is a multi-purpose information resource that we anticipate will both answer and inspire many types of questions and conversations about Southeast Alaska.

PREVIOUS RELATED EFFORTS

A decade ago, Audubon and The Nature Conservancy (TNC) partnered on *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest* (Conservation Assessment; Schoen and Dovichin 2007). That multi-year project collected, analyzed, and synthesized extensive biological data, resulting in a comprehensive Conservation Area Design for Southeast Alaska. Edited by John Schoen (now retired from Audubon Alaska) and Erin Dovichin (then of TNC), the Conservation Assessment was a major contribution to science and conservation planning in Southeast Alaska. John Schoen and David Albert (TNC) led the effort, designing and carrying out the project. David Albert collected the GIS data needed for the effort, conducted analyses, and mapped the information. Data were mapped across jurisdictions, providing a holistic look at Southeast Alaska. Together with a team of invited experts, they developed spatial models for species and ecosystem components that are key to the functioning of the Tongass. Many experts were involved in the development of the document and writing of the chapters, including university researchers, agency scientists, and local ecologists. The Conservation Assessment addressed various aspects of the Southeast Alaska coastal rainforest ecosystem in depth and continues to be an excellent interdisciplinary resource for the region. It is available online at http://bit.ly/2aNbva2.

The Conservation Assessment resulted in a greater acknowledgment of the globally rare opportunity to preserve a coastal temperate rainforest ecosystem such as the Tongass. Together with the old-growth coastal forests in British Columbia, the region makes up the largest such ecosystem remaining in the world. After publication of the Conservation Assessment, Audubon led an effort to expand scientific awareness of the North Pacific temperate rainforest ecosystem. In 2008, John Schoen and David Albert organized a cruise with eight leading science and policy experts to conduct a field-based peer review of the Conservation Area Design. The cruise led to an endorsement by the group of the approach taken and principles developed around watershed-scale conservation.

Next, that same group of scientists organized a science conference in Juneau, held in 2009, sponsored by Audubon Alaska and TNC. The focus was "to discuss opportunities for incorporating fundamental concepts of conservation biology into management strategies for conserving the biodiversity and ecological integrity of the Tongass National Forest" (Orians and Schoen 2013). The invited speakers each wrote a paper relating their area of expertise to this charge. The conference included papers on forestry, wildlife biology, national forest policy, endemism, natural disturbance, indigenous and commercial use of natural resources, road ecology, watershed-scale conservation, timber harvest methods, riparian ecology, and climate change. During the conference the group laid plans to develop a book based on the work presented there. In 2013, the University of Washington Press published *North Pacific Temperate Rainforests: Ecology and Conservation*, edited by Gordon Orians and John Schoen.

John Schoen

Upper Tenakee Inlet.

John Schoen

Yakutat Bay.

MAP ON PAGE 5

Nick Jans

Totem pole in Kasaan, Prince of Wales Island.

THE 2016 *ECOLOGICAL ATLAS OF SOUTHEAST ALASKA*

Around the time of publication of *North Pacific Temperate Rainforests*, Audubon Alaska began the project of developing the *Ecological Atlas of Southeast Alaska*. At Audubon, maps are a central part of our conservation work. They are the way that we bring together data and ecological concepts to understand a landscape more deeply, to see patterns, to anticipate threats, and to make science-based recommendations. In creating this atlas we are sharing that information with you.

Publishing an atlas most immediately requires spatial data to represent the various ecosystem components on maps. We began by updating and revising many of the great maps and ecological summaries that were published in the 2007 Conservation Assessment. While many datasets were created by Audubon Alaska and our collaborators at TNC, many other primary datasets were provided by outside organizations. We talked with researchers working across Southeast Alaska to locate the latest and best datasets; gathered scientific papers and reports; synthesized data; and conducted spatial analyses. Foremost data contributors include the Scenarios Network for Alaska and Arctic Planning (SNAP), the AdaptWest Project, the US Forest Service, Alaska Department of Fish and Game, and the US Fish and Wildlife Service.

The 56 maps in the atlas bring together many types of spatial data into a common format and geographic extent. Each written summary describes the ecology and natural history of the topic, followed by a Conservation Issues summary. Next, the Mapping Methods section describes the sources of data, how the data were processed, analysis methods, and/or information that is helpful for interpreting the map. A Map Data Sources section provides short-form citations for the data used, which are referenced at the end of each chapter. Each map includes an abstract that relays interesting facts and the relevance of the topic or species to the ecology of Southeast Alaska. Maps also cite the sources of the data presented.

In the *Ecological Atlas of Southeast Alaska*, we present new maps on topics such as climate change, marine bird colonies, mammal species richness, transportation and energy infrastructure, fishing, and mining. These are in addition to the many maps depicting physical geography, hydrology, vegetation, bird and mammal distribution, land ownership, timber, and so on, making this an inclusive resource for Southeast Alaska.

ACKNOWLEDGMENTS

The Ecological Atlas was made possible by the efforts of many. Contributions came in the form of data, analysis, cartography, scientific expertise, writing, editing, expert review, graphic design, and photography. The Conservation Assessment was a foundation for this work. Many datasets developed a decade ago for that effort continue to be the best available. Many of the ecological summaries written for the Conservation Assessment reappear under this cover; the original authors agreed to let us revise and update their written species accounts and ecological summaries. Importantly, we also reduced the length of those summaries, or rearranged them into new ones. The 2007 Conservation Assessment addresses issues in greater length than the Ecological Atlas; for a more in-depth description of species and habitats, refer to that previous work.

Information in the Ecological Atlas is presented in eight chapters. Table 1-1 is an overview of the chapters, maps, and written summaries included. In addition, to clarify the relationship of the 2007 Conservation Assessment to this work, the table notes the origin of the spatial data and writing. In all cases the data and writing were revised for this volume.

There are many moving parts to produce a publication such as this. Many Audubon Alaska staff and board members, partner organizations, and science colleagues have contributed. Below is a summary of the lead contributors in several important categories.

- Concepting: Nils Warnock, Melanie Smith, Nathan Walker, Beth Peluso
- Cartography: Melanie Smith, Nathan Walker, Lauren Tierney
- Data compilation and analysis: Nathan Walker, Melanie Smith, David Albert, Lauren Tierney, Benjamin Sullender
- Writing: Melanie Smith, John Schoen, Bob Armstrong, David Albert, Marge Osborn, Beth Peluso, Lauren Tierney, Matt Kirchhoff, Susan Culliney, Nils Warnock, Nathan Walker, Gordon Orians, and many others (see individual summaries)
- Science Advising: John Schoen, Matt Kirchhoff, Nils Warnock, and Gordon Orians
- Review and Content Editing: Melanie Smith, John Schoen, Susan Culliney, Nathan Walker, Beth Peluso, Nils Warnock, Matt Kirchhoff, Mark Kaelke, Mark Hieronymus, Francis Biles, Gwen Baluss, Buck Lindekugel, Bob Armstrong, Gordon Orians, Guy Archibald, Andrew Thoms, Winston Smith, Sarah Venator, Iain Stenhouse, Ed Jones, Roger Harding
- Copyediting and References: Melanie Smith, Susan Culliney, Jill Dery, Beth Peluso
- Images and Graphics: John Schoen, Bob Armstrong, Nick Jans, Milo Burcham, Melanie Smith, Erika Knight, Beth Peluso, and others
- Print Layout and Design: Eric Cline
- Funding: True North Foundation, Moore Foundation, Turner Foundation, individual donors to Audubon Alaska, and the efforts of development staff of Audubon Alaska including Nils Warnock and Michelle LeBeau. Esri generously donated ArcGIS software.

From birds and wildlife to climate and resource use, this atlas maps out the intricacies of the exceptional landscape of Southeast Alaska. We hope this compilation of a wide array of information will prove to be an invaluable resource for many uses, and that you'll enjoy your journey through the *Ecological Atlas of Southeast Alaska*.

Melanie Smith
Director of Conservation Science

MAP ON PAGE 5

TABLE 1-1 Maps and summaries included in the Ecological Atlas, with information on the foundation of the spatial data and scientific writing.

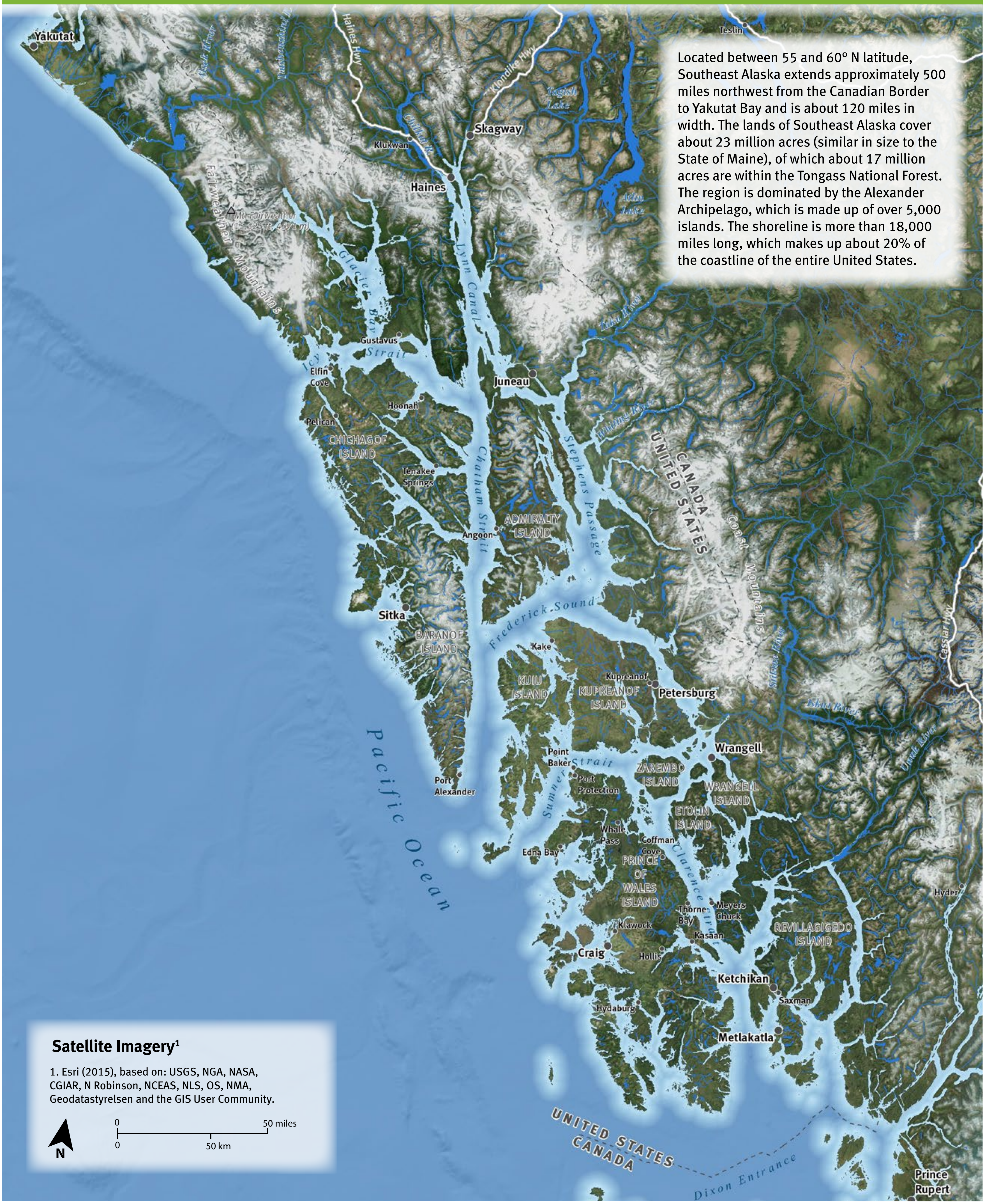
Map #	Page #	Map Name	Written Summary	Data [1]	Writing [1]
Chapter 1: Introduction					
1.1	5	Regional Overview	Introduction	EA	EA
Chapter 2: Physical Setting					
2.1	9	Topography	Topography	EA	EA
2.2	10	Landform	Topography	CFM	EA
2.3	13	Geologic Setting: Glaciers & Karst	Geologic Setting: Glaciers & Karst	EA	EA
2.4	16	Air Temperature: Recent, 1980–2009	Air Temperature	EA	EA
2.5	17	Air Temperature: Projected Change, 2010–2049	Air Temperature	EA	EA
2.6	20	Precipitation: Recent, 1980–2009	Precipitation	EA	EA
2.7	21	Precipitation: Projected Change, 2010–2049	Precipitation	EA	EA
2.8	25	Snow Depth: Recent, 1981–2010	Snow	EA	EA
2.9	26	Snow-Day Fraction: Projected Change, 2010–2049	Snow	EA	EA
2.10	29	Watersheds & Value Comparison Units (VCUs)	Watersheds & Value Comparison Units (VCUs)	CFM, EA	CFM
Chapter 3: Biological Setting					
3.1	38	Biogeographic Provinces	Biogeographic Provinces	CFM	EA, CFM
3.2	40	Wetlands	Wetlands	EA	EA
3.3	43	Salt Marsh Estuaries	Estuaries	EA, CFM	CFM, EA
3.4	49	Land Cover	Land Cover & Forest Vegetation	EA	EA
3.5	50	Forest Vegetation	Land Cover & Forest Vegetation	EA	EA
3.6	55	Productive Old-growth Forest	Old-growth & Second-growth Forest	CFM, EA	CFM, EA
3.7	56	Second-growth Forest	Old-growth & Second-growth Forest	CFM, EA	CFM, EA
3.8	58	Core Areas of High Biological Value: Watershed Scale	Core Areas of High Biological Value	CFM	CFM
3.9	59	Core Areas of High Biological Value: Sub-Watershed Scale	Core Areas of High Biological Value	CFM	CFM
3.10	63	Index of Cumulative Ecological Risk	Index of Cumulative Ecological Risk	CFM	CFM
Chapter 4: Anadromous Fish					
4.1	71	Anadromous Fish Species Richness	Anadromous Fish Habitat	EA, CFM	CFM, EA
4.2	72	Pacific Salmon Hydroclimatic Sensitivity Index	Anadromous Fish Habitat	EA	CFM, EA
4.3	75	King (Chinook) Salmon	King (Chinook) Salmon	EA, CFM	CFM
4.4	78	Red (Sockeye) Salmon	Red (Sockeye) Salmon	EA, CFM	CFM
4.5	81	Silver (Coho) Salmon	Silver (Coho) Salmon	EA, CFM	CFM
4.6	84	Pink (Humpy) Salmon	Pink (Humpy) Salmon	EA, CFM	CFM
4.7	87	Chum (Dog) Salmon	Chum (Dog) Salmon	EA, CFM	CFM
4.8	90	Steelhead Trout	Steelhead Trout	EA, CFM	EA
4.9	94	Dolly Varden	Dolly Varden	EA	CFM
4.10	98	Coastal Cutthroat Trout	Coastal Cutthroat Trout	EA	CFM
4.11	102	Eulachon (Hooligan)	Eulachon (Hooligan)	EA	CFM
Chapter 5: Birds					
5.1	113	Breeding Bird Species Richness	Bird Species Richness	EA	EA, CFM
5.2	116	Important Bird Areas (IBAs)	Important Bird Areas (IBAs)	EA	EA
5.3	119	Marine Bird Colonies	Marine Bird Colonies	EA	EA
5.4	122	Marbled Murrelet	Marbled Murrelet	CFM, EA	EA
5.5	125	Kittlitz's Murrelet	Kittlitz's Murrelet	EA	EA
5.6	128	Shorebirds	Shorebirds	EA	EA
5.7	131	Prince of Wales Spruce Grouse	Prince of Wales Spruce Grouse	EA	EA
5.8	134	Queen Charlotte Goshawk	Queen Charlotte Goshawk	EA	CFM, EA
5.9	137	Bald Eagle	Bald Eagle	EA	CFM
Chapter 6: Mammals					
6.1	146	Mammal Species Richness	Mammal Species Richness	EA, CFM	EA
6.2	149	Northern Flying Squirrel	Northern Flying Squirrel	EA	CFM
6.3	154	Sitka Black-tailed Deer	Sitka Black-tailed Deer	CFM	CFM
6.4	159	Alexander Archipelago Wolf	Alexander Archipelago Wolf	EA	EA, CFM
6.5	167	Brown and Black Bear	Brown Bear, Black Bear	CFM, EA	CFM
Chapter 7: Human Uses					
7.1	179	Land Ownership	Land Ownership	EA	EA
7.2	186	Transportation and Energy Infrastructure	Transportation and Energy Infrastructure	EA	EA
7.3	190	Community Subsistence Use	Community Subsistence Use	CFM, EA	CFM
7.4	194	Timber	Timber	EA	EA
7.5	200	Metals Mining	Metals Mining	EA	EA, CFM
7.6	205	Commercial Fishing	Sport and Commercial Fishing	EA	EA
7.7	209	Land Use Designations	Land Use Designations	EA	EA
7.8	210	Legislatively Protected Areas	Land Use Designations	EA	EA
7.9	213	A Conservation Area Design for Southeast Alaska	A Conservation Area Design for Southeast Alaska	CFM	CFM
7.10	216	Tongass 77 Watersheds	Tongass 77 Watersheds	EA	EA
Chapter 8: Conservation Summary					

[1]EA = *Ecological Atlas of Southeast Alaska*, CFM = *A Conservation Assessment for the Coastal Forests and Mountains Ecoregion.*

Audubon ALASKA

Regional Overview

Located between 55 and 60° N latitude, Southeast Alaska extends approximately 500 miles northwest from the Canadian Border to Yakutat Bay and is about 120 miles in width. The lands of Southeast Alaska cover about 23 million acres (similar in size to the State of Maine), of which about 17 million acres are within the Tongass National Forest. The region is dominated by the Alexander Archipelago, which is made up of over 5,000 islands. The shoreline is more than 18,000 miles long, which makes up about 20% of the coastline of the entire United States.



Map 1.1: Regional Overview

PHYSICAL SETTING

Southeast Alaska is a physically diverse region of amazing complexity. The region has more than 1,000 islands and more than 18,000 mi (29,000 km) of coastline, about 20% of the coastline of the entire United States. The adjacent coast of British Columbia, Canada, has hundreds of additional islands and another 15,000 mi (25,000 km) of shoreline. The narrow island archipelago is bordered to the east by rugged mountains. Southeast Alaska boasts the highest coastal mountain range in the world, rising from sea level to over 15,000 ft (4,600 m) in only 12 mi (19 km). These and other high peaks of the Coast Range support some of the largest glaciers and extensive ice fields in North America. Although the region's glaciers are retreating farther inland, some tidewater glaciers still calve ice directly into the ocean. The rivers that drain these glaciated slopes plunge rapidly to tidewater carrying great loads of silt that fertilizes bays and estuaries. In marked contrast, the islands that border the coast lack glaciers; their rivers carry little silt and carry few nutrients to the sea. The region's "transboundary" rivers play an important role in nutrient transport and dispersal. Major rivers whose watersheds lie primarily in the interior of British Columbia slice through the rugged mountains, forming the most important deltas of the region such as the Taku and Stikine.

Most coastal streams are short and, owing to the region's high precipitation, their watersheds contain large expanses of wetlands and riparian zones. Therefore, interactions between land and water are more intense here than elsewhere on Earth. Southeast Alaskan rivers discharge about 90 cubic mi (370 cubic km) of freshwater annually, similar to the discharge of the Mississippi River. Glaciers constantly release fresh phosphorus as they grind bedrock into glacial flour. Many streams in the area also have high concentrations of iron. Coastal waters that carry freshwater runoff and nutrients from the land are entrained within marine currents that drift northward. These marine eddies, which contain unusually high concentrations of nutrients, are hotspots of primary productivity that are primary feeding areas for fish, marine mammals, and birds. Some of this rich marine productivity is returned to the terrestrial environment by the thousands of salmon that migrate upriver to spawn. Some of those nutrients in their bodies are transported into riparian forests by scavenging birds and mammals.

~ Gordon Orians

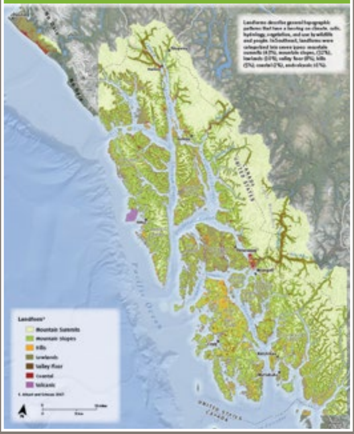
Melanie Smith

PHYSICAL SETTING MAPS INDEX

Topography

MAP 2.1 / PAGE 9

Landform

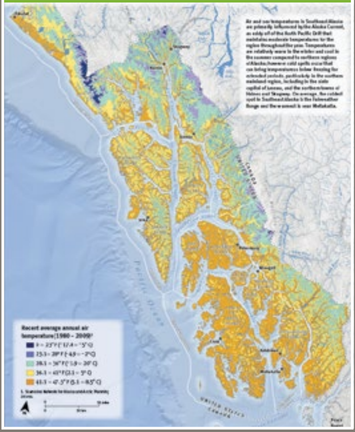


MAP 2.2 / PAGE 10

Geologic Setting: Glaciers & Karst

MAP 2.3 / PAGE 13

Air Temperature: Recent, 1980-2009

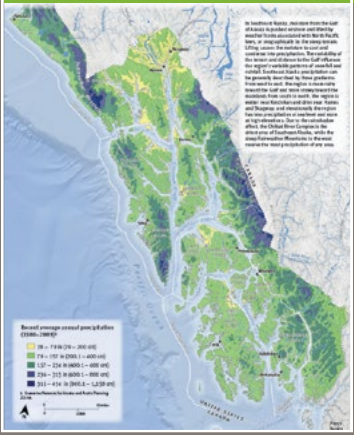


MAP 2.4 / PAGE 16

Air Temperature: Projected Change, 2010-2049

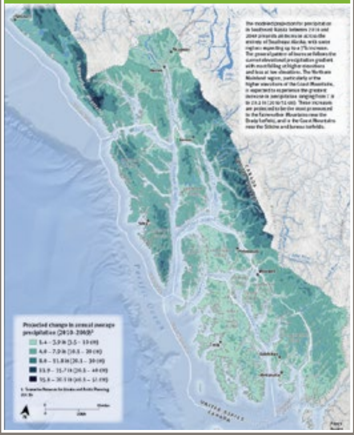
MAP 2.5 / PAGE 17

Precipitation: Recent, 1980-2009



MAP 2.6 / PAGE 20

Precipitation: Projected Change, 2010-2049

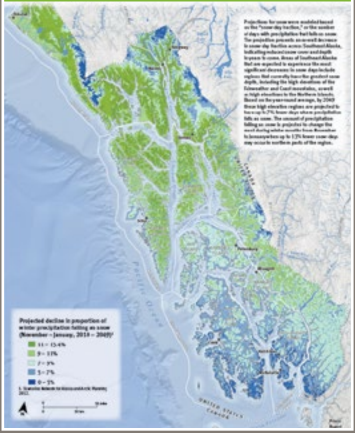


MAP 2.7 / PAGE 21

Snow Depth: Recent, 1981-2010

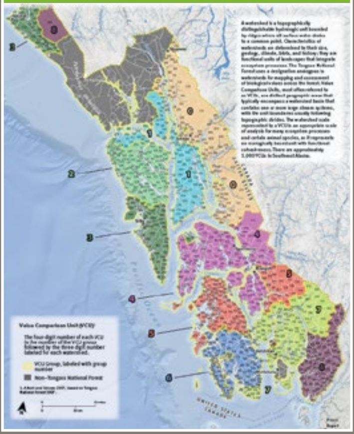
MAP 2.8 / PAGE 25

Snow-Day Fraction: Projected Change, 2010-2049



MAP 2.9 / PAGE 26

Watersheds (VCUs)



MAP 2.10 / PAGE 29

MAPS ON PAGES 9, 10

TOPOGRAPHY

Lauren Tierney and Melanie Smith

Southeast Alaska ("Southeast"), also known as the Inside Passage, is a coastal ecosystem of enormous biological richness and spectacular beauty distinguished by rainforests, glacial fjords, myriad rivers and streams, estuaries and wetlands, mountains, and glaciers. Located between 55 and 60 degrees latitude, Southeast Alaska extends approximately 500 mi (800 km) northwest from the Canadian border to Yakutat Bay and is about 120 mi (193 km) in width. The region is dominated by the Alexander Archipelago, consisting of over 5,000 islands, over 1,000 of which are named. The marine shoreline is more than 18,000 mi (30,000 km), which makes up about 20% of the coastline of the entire United States.

Ecosystems here are naturally fragmented by islands and the steep glacial terrain. Southeast's complex, high-relief topography is a product of intense mountain building energies generated at the suture zone of the North American and Pacific crustal plates. The mountains in this region rise to over 15,000 ft (5,400 m) in elevation, and form a substantial barrier (Cook and MacDonald 2013). Glacial fjords and major river systems cut through the mountainous mainland region of Southeast Alaska, bordered to the east by the Coast Mountains and in the northwest by the Wrangell-St. Elias Range.

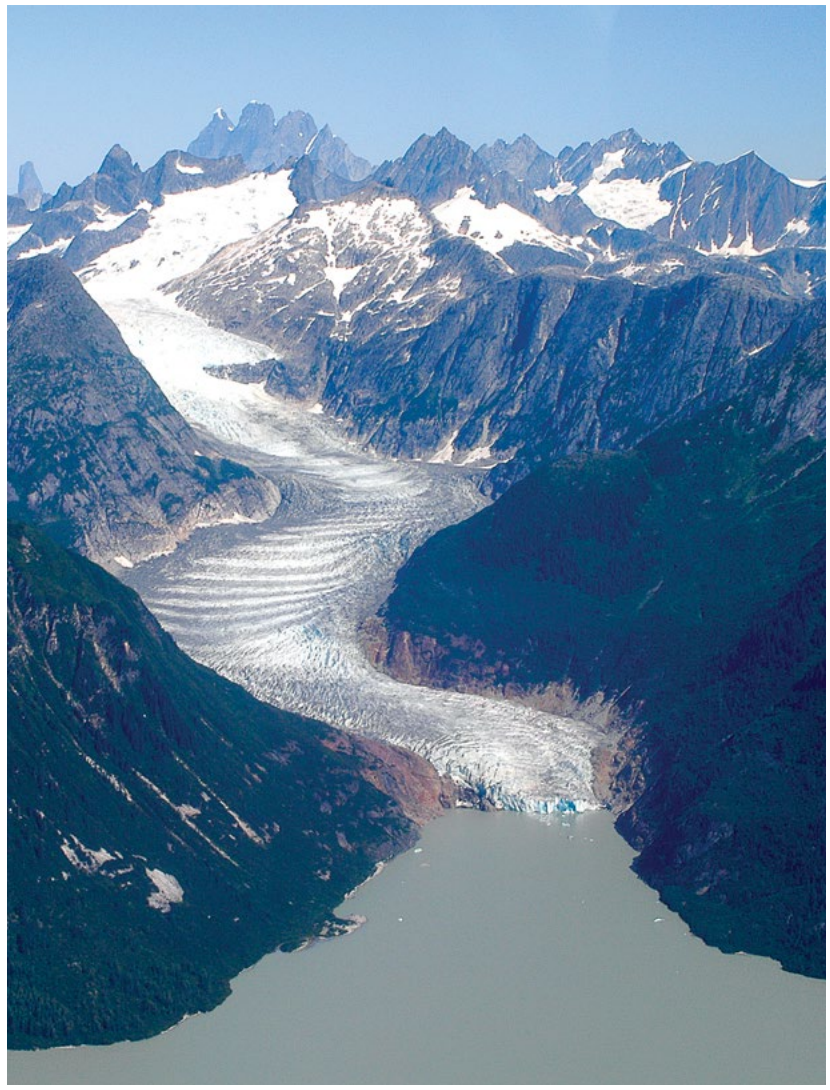
Landforms describe general topographic patterns that have a bearing on disturbance regime, climate, soils, hydrology, and vegetation. In Southeast, landforms were categorized into seven types: mountain summits (43%), mountain slopes, (32%), lowlands (10%), valley floor (8%), hills (5%), coastal (2%), and volcanic (<1%) (Albert and Schoen 2007).

CONSERVATION ISSUES

A comprehensive understanding of the diversity, distribution, abundance, and management of terrestrial and aquatic ecosystems in Southeast is a critically important first step toward maintaining ecological integrity and biodiversity (Albert and Schoen 2007). An effective conservation strategy includes geographically distributed conservation areas; as well as ensuring that population- and ecosystem-level variability are represented in the areas selected for protection (Poiani et al. 2000). A well-balanced geographic distribution is particularly important in Southeast where ecosystems are naturally fragmented by islands and steep glacial terrain, and isolated from the continent of North America by mountains and icefields along the coastal mountain range (MacDonald and Cook 1996, Cook and MacDonald 2001).

MAPPING METHODS

Data on landform were analyzed and provided by The Nature Conservancy (TNC) from their work on the 2007 Audubon-TNC Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest (conservation assessment) (Schoen and Dovichin 2007). They began with data from the Tongass National Forest soils database. This information was interpreted by US Forest Service scientists from aerial photography to describe landscape patterns of soils, vegetation, and landform, and was completed for all non-wilderness areas of the Tongass. For this information to be useful in a regional analysis, development of a comparable system for lands excluded from the original mapping was needed. Because landforms are defined as physical topographic features, a digital elevation model was used to extend the mapping of landform associations (see Albert and Schoen 2007). The Tongass National Forest soils database was used to guide a maximum likelihood classification. This method is more accurate than setting arbitrary thresholds, because it statistically accounts for the natural variation in physical geography that was observed in aerial photography and in the field. Components of the landform model included elevation, slope, and topographic position index (TPI). In general, TPI values indicate whether a point is higher or lower than its average surroundings (Fels and Zobel 1995). The size of the surrounding neighborhood determines the scale of the features identified. A maximum neighborhood radius of 9,840 ft (3,000 m) was chosen to favor capturing the major landforms on the landscape.



John Schoen

Complex, high-relief topography near East Twin Glacier.

Categories of landform derived included Coastal, Lowlands, Valley Floor, Hills, Mountain Slopes, and Mountain Summits.

This map also displays streams and lakes. These come from three different sources. On the Alaska side, this includes named lakes from the SEAK Hydro database (Plivelich 2014). This database consolidates data from various sources across Southeast Alaska with the USGS National Hydrography Dataset. Rivers and streams are from the Alaska Department of Natural Resources inventory (2007). In Canada, the data are made up of named lakes and watercourses from the Atlas of Canada. This is a standardized national dataset compiled at a 1:1,000,000 scale (Geomatics Yukon: Natural Resources Canada: Canada Centre for Remote Sensing 2003).

MAP DATA SOURCES

- Digital Elevation Model and Terrain Hillshade: Esri (2015), based on: USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen and the GIS User Community
- Landform Associations: Albert and Schoen (2007)
- Rivers, Streams and Lakes: Alaska Department of Natural Resources - Land Records Information Section (2007); Geomatics Yukon: Natural Resources Canada: Canada Centre for Remote Sensing (2003); Plivelich (2014).

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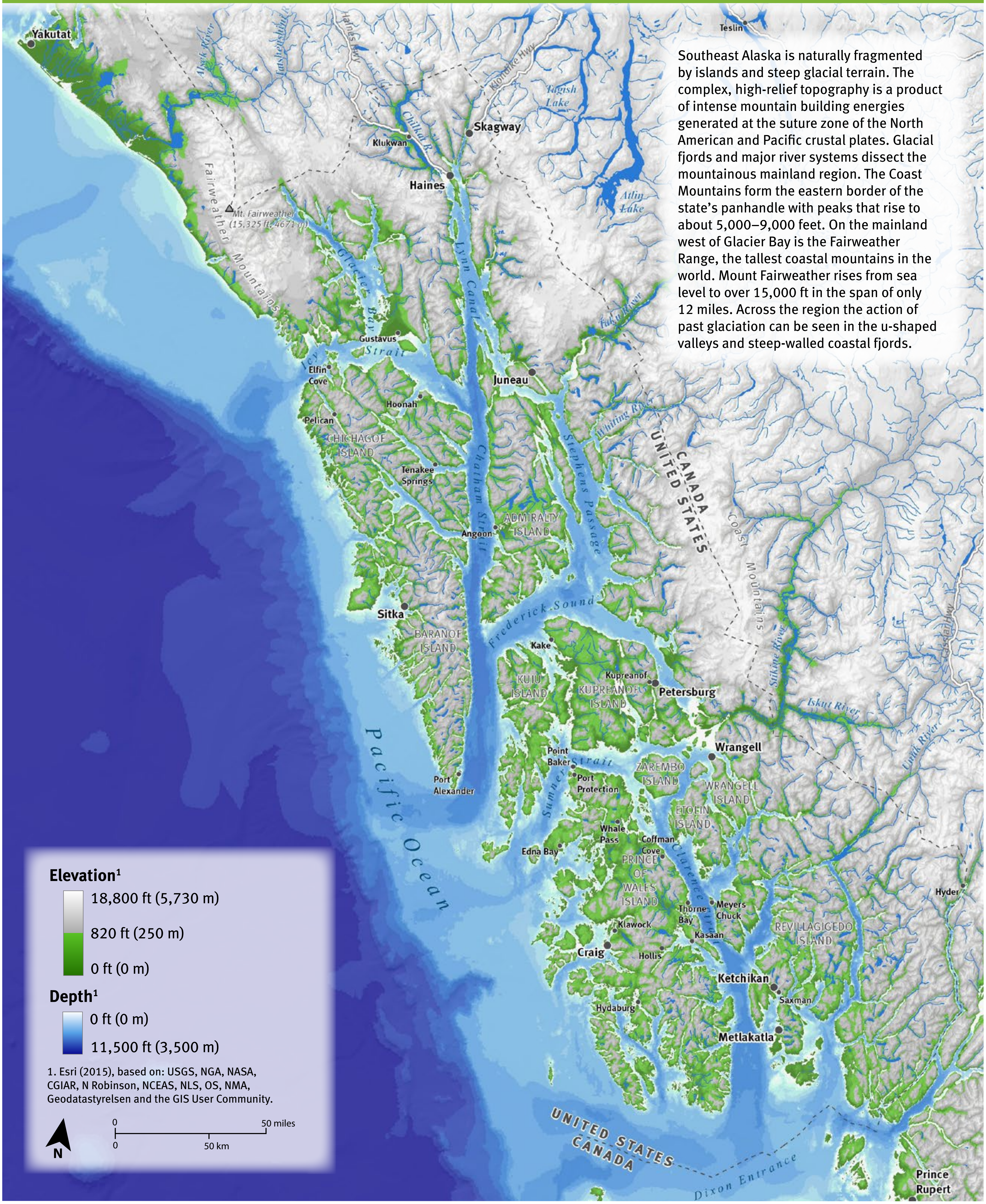
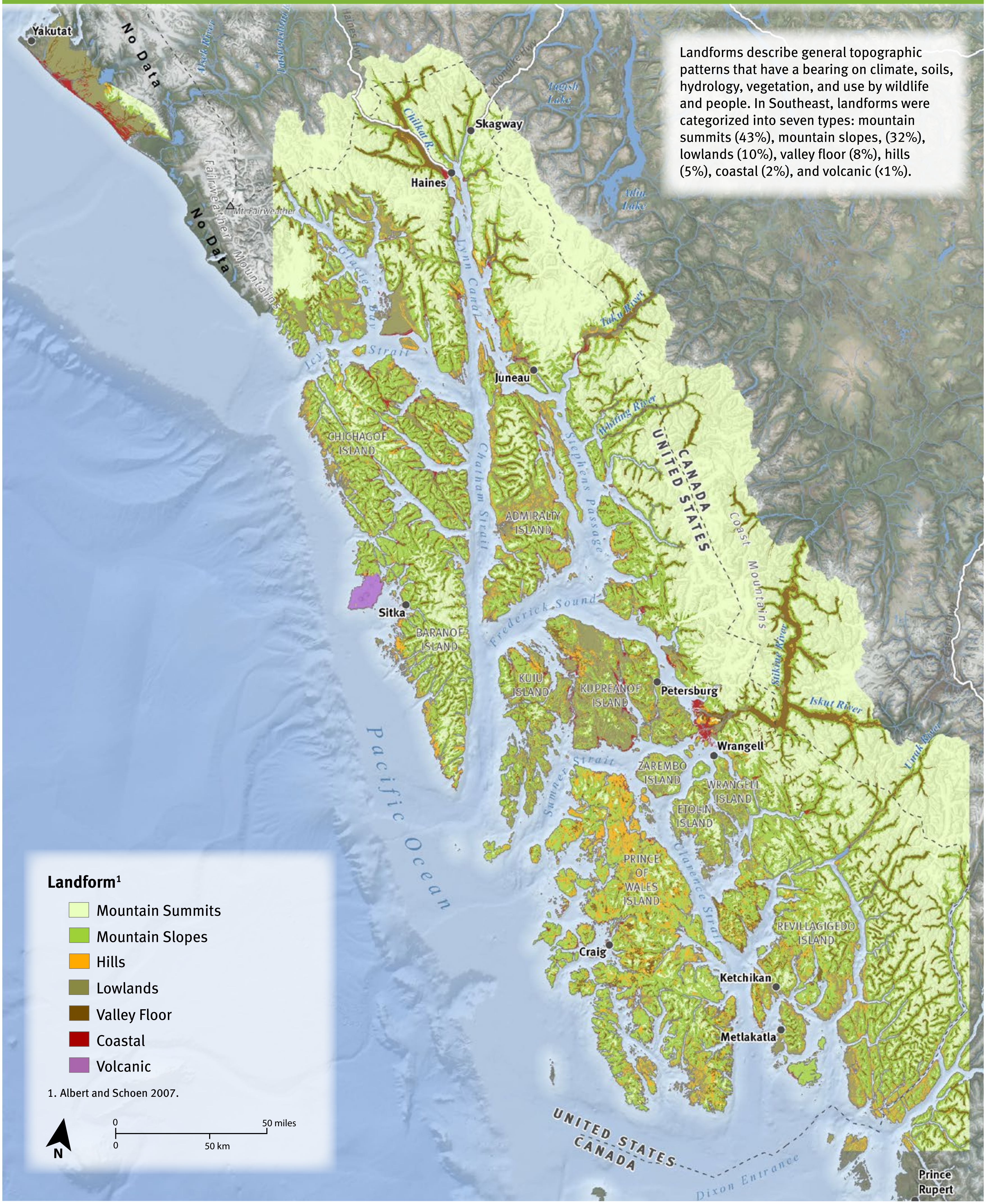
Topography

Southeast Alaska is naturally fragmented by islands and steep glacial terrain. The complex, high-relief topography is a product of intense mountain building energies generated at the suture zone of the North American and Pacific crustal plates. Glacial fjords and major river systems dissect the mountainous mainland region. The Coast Mountains form the eastern border of the state's panhandle with peaks that rise to about 5,000–9,000 feet. On the mainland west of Glacier Bay is the Fairweather Range, the tallest coastal mountains in the world. Mount Fairweather rises from sea level to over 15,000 ft in the span of only 12 miles. Across the region the action of past glaciation can be seen in the u-shaped valleys and steep-walled coastal fjords.



Map 2.1: Topography

Landform



Map 2.2: Landform

MAP ON PAGE 13

GEOLOGIC SETTING: GLACIERS & KARST

Melanie Smith and Lauren Tierney

GLACIERS

During the Pleistocene Epoch the landscape of Southeast Alaska was covered by vast amounts of glacial ice, which shaped deep marine fjords and the islands present today through a number of glacial advances and retreats. The Pleistocene, or Ice Age, began about 1.6 million years ago and lasted until about 12,000 years ago. More recently, the Little Ice Age, from about 1550 to 1850 AD (Mann 2002), was a period of glacial advances and retreats that further shaped Southeast Alaska. When Captain Cook arrived at what is now the mouth of Glacier Bay in 1778, he saw the Grand Pacific Glacier 4,000 ft (1,220 m) thick, jutting out into Icy Strait. Today the Grand Pacific has retreated far north, opening up a 65-mi (105-km) waterway that did not exist 200 years ago.

Yet some parts of Southeast Alaska remained unglaciated, and these refugia retained the plants and animals that later recolonized following the ice ages. This, and the disconnected island archipelago that makes up this region, explain much of the endemism and species range differences found here, such as the distribution of black and brown bears, wolves, squirrels, grouse, and more (MacDonald and Cook 1996).

After the weight of glaciers is removed, the land beneath begins to rebound upward. Isostatic rebound, or glacial uplift, is the rise of land masses that were depressed by the huge weight of ice sheets during the last glacial period. Glacial uplift began in about 1770 AD in Southeast Alaska, with the Glacier Bay and Yakutat regions currently having the highest measured rates in the world of up to 1.3 in (3.2 cm) per year (Larsen et al. 2005).

Glaciers continue to have a dominant physical presence throughout many portions of Southeast. Ice covers 4.5 million ac (1.8 million ha), or about one-fifth of the land. Glaciers are active contributors to the climate, ocean dynamics, and barriers to colonization in Southeast Alaska today. What also makes the glacial landscape of Southeast Alaska so unique is the close proximity of highly productive forest communities to glacial environments.

The largest expanses of glaciers and icefields in Southeast Alaska are primarily located in the Northern Mainland and Southern Mainland biogeographic province groups (see Biogeographic Provinces map and summary in next chapter for more information) at the Brady, Juneau, and Stikine icefields. Over a third of the Yakutat Forelands biogeographic province is covered by glaciers; the Fairweather Icefields province is 46% covered by ice; and the Glacier Bay province is 41% covered by ice.

KARST

Karst is a term for the topography and subsurface drainage systems that result from the dissolution of carbonate rocks (e.g., limestone and marble) through the action of water, which creates caves, drainage, depressions, and sinkholes (USDA Forest Service 2012). The geology of Southeast Alaska is particularly favorable for karst, with about 550,000 ac (222,500 ha) of very pure carbonate rock in the Tongass (USDA Forest Service 2012). Karst in Southeast Alaska is classified as a high- or low-elevation landform, with the majority of karst categorized as high elevation.

Southeast Alaska exhibits highly developed karst landscapes, but many of the known caves of Southeast have only been recently discovered, and it is estimated that thousands of caves are still left to be found. Within Southeast Alaska it is estimated that 27% of watersheds (i.e. Value Comparison Units, or VCUs) have high potential for karst landforms and associated caves. Karst with cave features is common on northern Prince of Wales Island, Kuiu Island, eastern Chichagof Island, and around Glacier Bay. The mostly highly developed karst landscapes occur within the Prince of Wales Island Complex.

Karst is important ecologically because the well-drained topography creates very productive growing conditions. Karst landscapes are usually areas of productive old-growth forest and many of the largest trees currently or historically found in the Tongass are grown in karst. Across Southeast, 44% of productive old-growth forests on low-elevation karst lands have been harvested, and 19% on high-elevation lands. Over two-thirds of central Prince of Wales Island karst productive forest has been harvested, while only one-third of non-karst productive forest has been harvested there (Baichtal and Swanston 1996).

Terminus of the LeConte Glacier.

Melanie Smith

MAP ON PAGE 13

CONSERVATION ISSUES

Glacial landscapes are in decline from climate change. An estimated 98% of the glaciers in Alaska are retreating (Earth Policy Institute 2009), many of them rapidly losing ice, for a total loss of more than 100 cubic km (25 cubic mi) of ice each year (Arendt et al. 2002). Glaciers are an important contributor to marine productivity, and in particular for Kittlitz's Murrelets foraging habitat and harbor seal iceberg haulouts and pupping areas.

Karst landscapes are characterized by mature, well-developed western hemlock/Sitka spruce forests, along valley floors and shallow slopes, well-developed subsurface drainage, and unique cave structures (Baichtal and Swanston 1996). The areas of the highest karst concentration are also the most vulnerable, as they are most often associated with development activities. Some of the most productive old-growth forests occur on karst landscapes where past and planned timber harvest activities focus.

In addition to the high productivity of the land, the caves themselves provide important habitat for wildlife (Baichtal and Swanston 1996), such as:

- critical roosting and hibernating habitat for bats
- natal den sites for river otters
- denning for wolves, black bears, and brown bears
- resting areas for Sitka black-tailed deer
- seabird rookeries, including cormorant and pigeon guillemot
- nesting areas for land birds, including American dipper, thrushes, and swallows.

Karst landscapes also possess significant cultural and paleontological resources. The cave systems preserve remarkable evidence of human, wildlife, and plant life from the Pleistocene epoch (Baichtal and Swanston 1996).

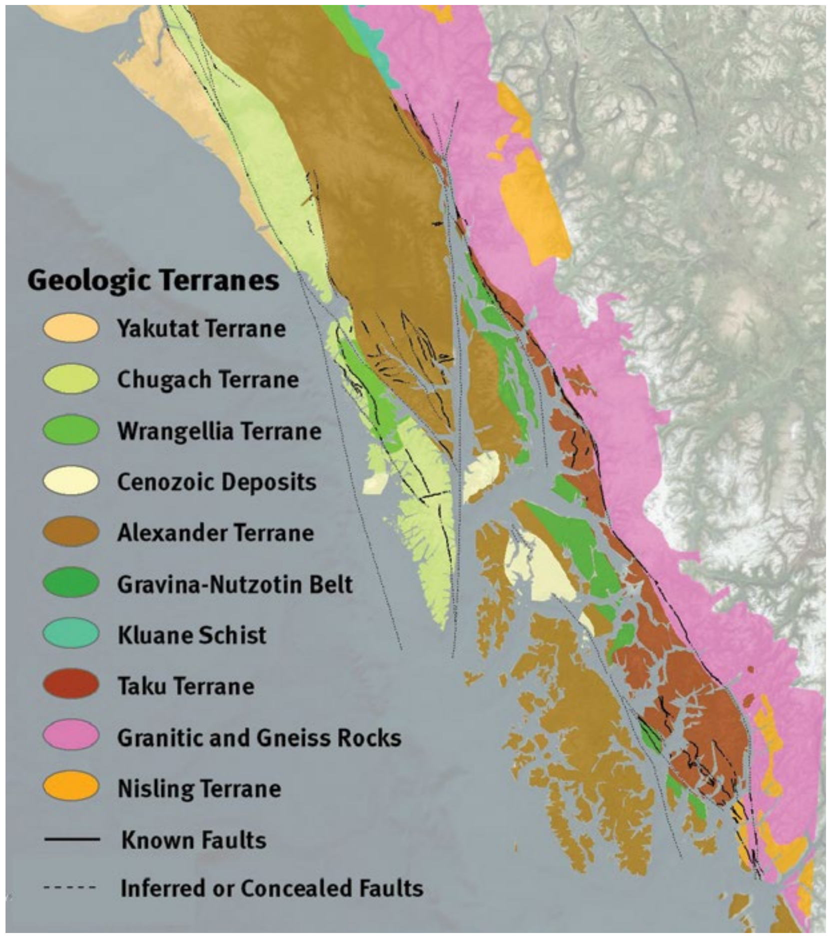
MAPPING METHODS

Glacier data came from the Randolph Glacier Inventory, version 5.0, provided by Global Land and Ice Measurements from Space (GLIMS).

The karst data came from two different sources: in British Columbia, the Reconnaissance Karst-Potential Mapping dataset identifies areas with the potential for karst formations, based on a 1:250,000 scale analysis of topography, bedrock geology, and other sources (BCGOV FOR Forest Analysis and Inventory Branch 2002). On the Alaska side, the comparable dataset was developed for the Tongass Land Management Plan in 1997 (Baichtal and Swanston 1996).

MAP DATA SOURCES

- Glaciers: GLIMS (2016)
- Karst: Baichtal and Swanston (1996); BCGOV FOR Forest Analysis and Inventory Branch (2002).



Major geologic terranes of Southeast Alaska (Silberling et al. 1994). A terrane is a fragment of crustal material formed on, or broken off from, one tectonic plate and accreted or "sutured" to crust lying on another plate. Southeast Alaska is made up of numerous terranes that accreted onto the North American plate during the mid- to late Mesozoic and early Cenozoic eras.

John Schoen

Johns Hopkins Glacier, Glacier Bay.

Audubon ALASKA

Geologic Setting: Glaciers & Karst

The Pleistocene, or Ice Age, began about 1.6 million years ago and lasted until about 11,000 years ago. More recently, the Little Ice Age, from about 1550 to 1850 AD, was a period of glacial advances and retreats that further shaped Southeast Alaska. Today ice covers 4.5 million acres, or one-fifth of the land. The geology of Southeast Alaska is particularly favorable for karst, which is a term for the caves, drainages, depressions, and sinkholes that result from the dissolution of carbonates by water. Karst is important ecologically because the well-drained topography creates very productive growing conditions. Karst landscapes are usually areas of productive old-growth forest and many of the largest trees currently or historically found in the Tongass are grown in karst.

Map 2.3: Geologic Setting: Glaciers & Karst

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AIR TEMPERATURE

Lauren Tierney, Melanie Smith, and Nathan Walker

Air and sea temperatures in Southeast Alaska are primarily influenced by the Alaska Current, a marine eddy off of the North Pacific Drift that maintains moderate temperatures for the region throughout the year. Temperatures are relatively warm in the winter and cool in the summer compared to northern regions of Alaska; however, cold spells occur that can bring temperatures below freezing for extended periods, particularly in the northern mainland region, including in the state capital of Juneau, and the northern towns of Haines and Skagway.

RECENT TEMPERATURES, 1980–2009

In recent years, average annual temperatures across Southeast Alaska ranged from 0°F (-17.8°C) at the top of Mount Fairweather to 47.3°F (8.5°C) just south of Metlakatla.

Summarized by biogeographic province (see Biogeographic Provinces map and summary in next chapter for more information), the mean and standard deviation of annual temperature are presented in Figure 2-1, along with the minimum and maximum average annual temperatures that occurred in each province. The Northern Mainland Complex was the overall coolest group of biogeographic provinces. The high elevation Coast Mountains along the mainland and the Fairweather Mountains near Glacier Bay regularly experienced the coldest average temperatures in Southeast Alaska, with the mountainous area surrounding Mount Fairweather ranging from 0 to 23°F (-17.7 to -5°C) as an annual average. However, the Chilkat River province had the overall coolest annual average at 32.9°F (0.5°C). The Prince of Wales Island Complex made up the warmest region in Southeast Alaska, with Dall Islands being the warmest province at 43.7°F (6.5°C). Overall, average annual temperatures in Southeast Alaska varied by only several degrees Celsius because oceanic air moderates temperature fluctuations, keeping the region cooler in summer and warmer in winter than other regions of Alaska.

PROJECTED CHANGE, 2010–2049

The modeled projection for temperature in Southeast Alaska between 2010 and 2049 presents an overall increase across the entirety of Southeast Alaska, with some regions experiencing a greater increase than others.

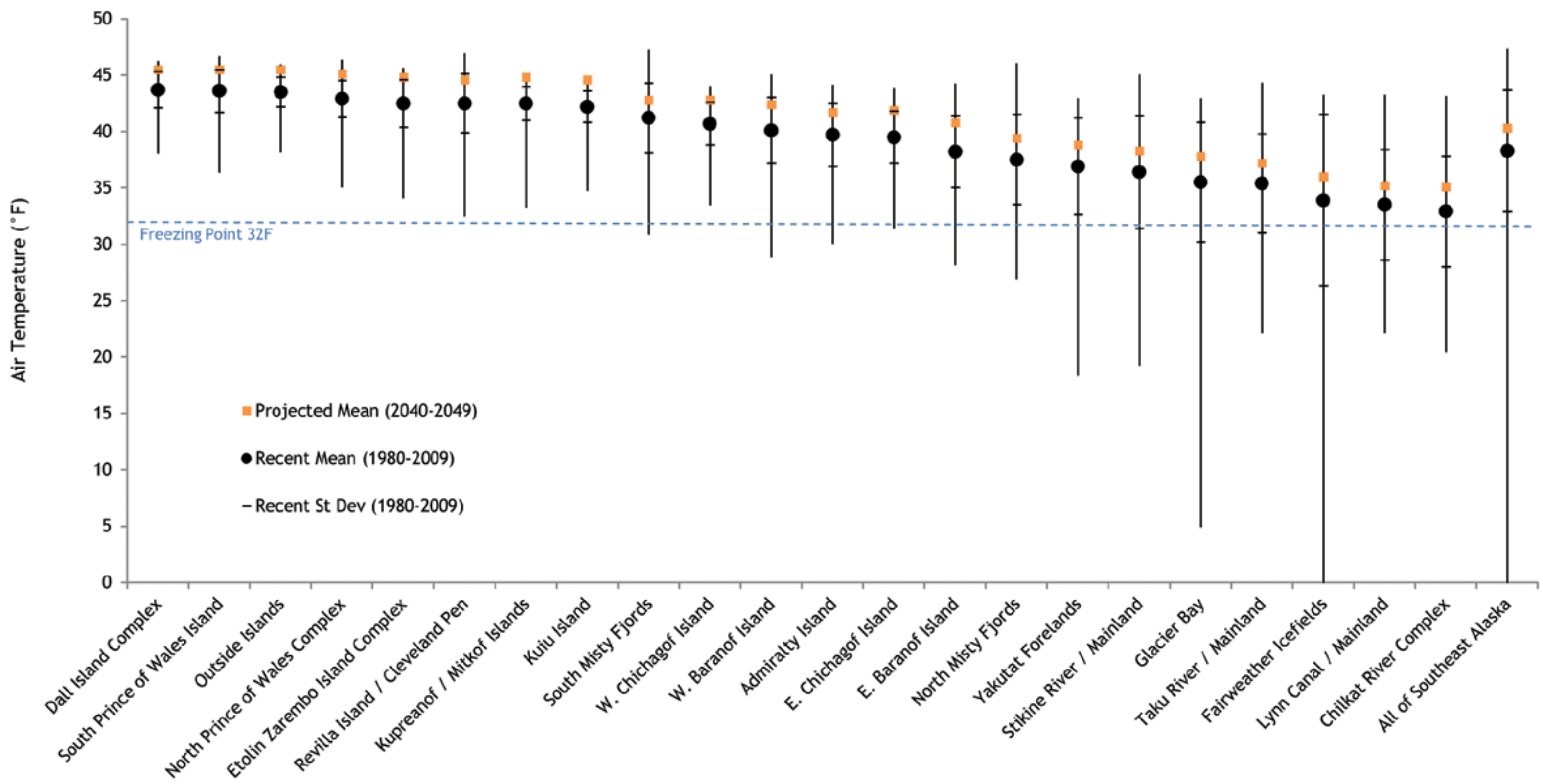
Much of the Northern Mainland region is expected to experience increases ranging from 1.8 to 2.3°F (an increase of 1 to 1.3°C), along with portions of the Northern Islands and the northern segments of the Southern Inside Islands and Southern Mainland regions. These increases in temperature are projected to be the most pronounced in the Coast Mountains along the US-Canada boundary. These regions currently have the lowest annual temperature averages in Southeast Alaska. The Southern Mainland, Southern Inside Islands, and the Prince of Wales Island Complex currently have the warmest annual temperatures in Southeast Alaska, and are predicted to experience a lesser, yet still significant, change in temperature: approximately 1.6 to 1.8°F (a change of 0.9 to 1°C) between 2010 and 2049.

Summarized by biogeographic province, the projected annual mean temperature is presented in Figure 2-1 alongside the recent mean temperature data. The location of the largest projected change for average annual temperature in Southeast Alaska is expected to be in the northern region of the Chilkat River Complex, just north of Skagway, which is the province that currently has the lowest annual average temperatures. More generally, high elevation regions of the mainland Coast Mountains and Yakutat Forelands, Glacier Bay, Lynn Canal, Taku River, and Stikine River provinces are projected to experience the greatest change in average annual temperature, along with high elevation regions of Admiralty, Kupreanof, and Mitkof Islands.

John Schoen

Late-summer fireweed blooming in the Mendenhall Wetlands.

FIGURE 2-1 Mean annual temperatures, by biogeographic province, for the recent time period of 1980–2009, compared to the projected mean for 2040–2049. Also shown are the minimum, maximum, and standard deviation, based on the recent mean annual temperatures across each province.



CONSERVATION ISSUES

A considerable increase in temperature is likely to alter the ecological dynamics of the region—for example through change in mean snowline—precipitating a change in vegetation communities (Edwards et al. 2013). Research suggests that warming at the rate projected will pose significant challenges to the management of natural resources, and that managers have few plans for mitigating the ecological and ecomonic effects of climate change (Mote et al. 2003). The understanding of patterns of future temperature change over the coming decades is important to Alaskan decision-makers and other stakeholders, and should be used to aid in the development of policies and management strategies for Alaska (Scenarios Network for Alaska and Arctic Planning 2014c).

Edwards et al. (2013) have observed that in this salmon-rich forest, “stream temperature alterations alone will have serious biological consequences”. Larval development times of fish and aquatic invertebrates are controlled by the temperatures experienced (Neuheimer and Taggart 2007, Edwards et al. 2013). Aquatic organisms are adapted to specific temperatures, and salmon, for example, effectively lose suitable habitat in warmer streams (Mote et al. 2003, Taylor 2008, Mantua et al. 2010). Additionally, “85% of the northern coastal temperate rainforest will no longer receive precipitation as snow, and spatial redistribution of vegetation will be common” (Edwards et al. 2013).

The following is a summary of some of the ways in which increasing temperature affects the Southeast Alaska rainforest ecosystem:

- faster glacial melt and increased meltwater output
- an elevational shift in the snowline, and a change in precipitation from snow to rain below that line (Edwards et al. 2013)
- reduction in snowpack (Mote et al. 2003)
- hydrologic changes including changes in peak and base flows, seasonal low flows, peak output, timing, and flooding (Mantua et al. 2010)
- increase in stream temperatures (Mantua et al. 2010)
- alteration of riparian soil processes and geomorphic processes in stream channels (Edwards et al. 2013)
- changes in evapotranspiration (Edwards et al. 2013)
- changes in the location, range, and phenology of vegetation communties (Edwards et al. 2013)
- effects on distribution and abundance of wildlife due to underlying changes in habitat.

MAPPING METHODS

Recent Data

This data was provided by the University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning (SNAP) (2014b), and represents the 30-year average annual temperature, based on three decadal datasets for 1980–1989, 1990–1999, and 2000–2009. These data were downscaled by SNAP to 771 m resolution utilizing PRISM climatological datasets from 1971–2000.

Projected Data

SNAP created raster datasets representing projected annual average temperatures in Alaska by decade, spanning between 2001 and 2100, at a resolution of 771 m (Scenarios Network for Alaska and Arctic Planning 2011a). There are five general circulation models that perform best for approximating data in Alaska and the Arctic. Some independent analyses (Radi and Clarke 2011) rate some models higher than others. We decided to use SNAP's average of the five models in order to reduce the risk of error that may arise when using just one model. Using SNAP's raster datasets, we subtracted the 2010–2019 average from the 2040–2049 average, thus creating a dataset representing projected temperature change between the present decade and the 2040s.

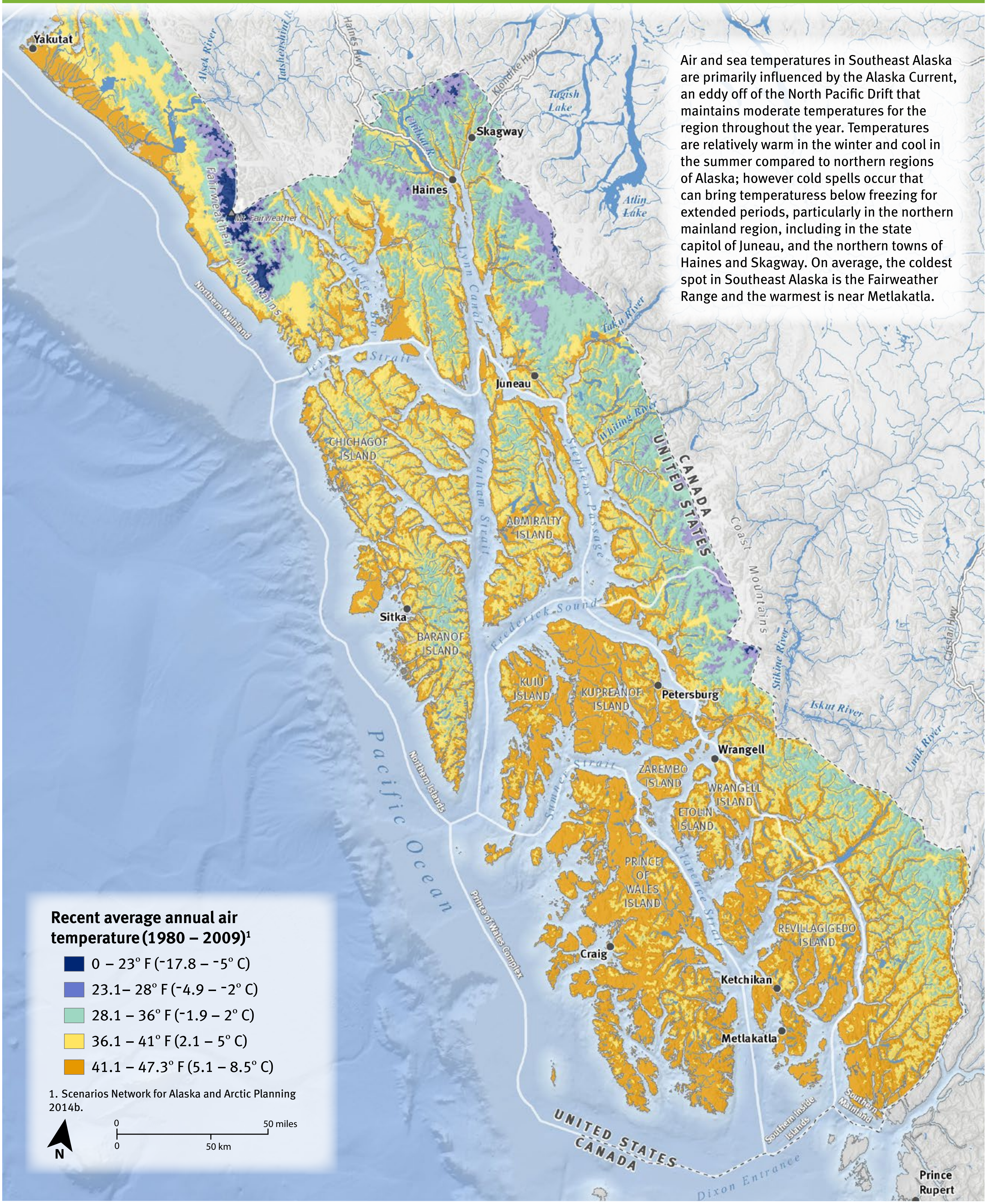
MAP DATA SOURCES

- Recent Temperature, 1980–2009: Scenarios Network for Alaska and Arctic Planning (2014b)
- Projected Temperature, 2010–2049: Scenarios Network for Alaska and Arctic Planning (2011a).

Air Temperature: Recent, 1980–2009

Audubon ALASKA

Air and sea temperatures in Southeast Alaska are primarily influenced by the Alaska Current, an eddy off of the North Pacific Drift that maintains moderate temperatures for the region throughout the year. Temperatures are relatively warm in the winter and cool in the summer compared to northern regions of Alaska; however cold spells occur that can bring temperaturess below freezing for extended periods, particularly in the northern mainland region, including in the state capitol of Juneau, and the northern towns of Haines and Skagway. On average, the coldest spot in Southeast Alaska is the Fairweather Range and the warmest is near Metlakatla.

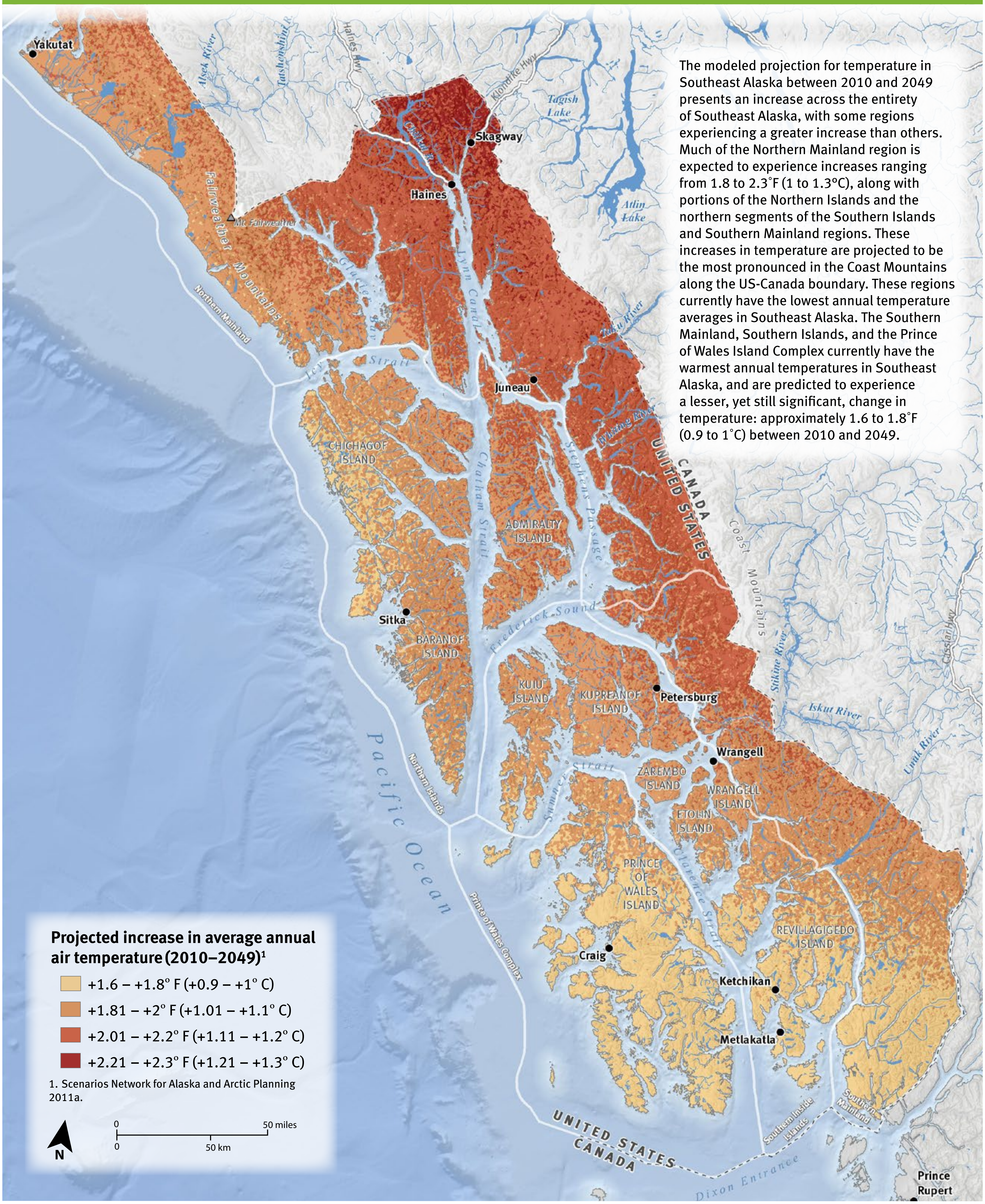


Map 2.4: Air Temperature: Recent, 1980–2009

Audubon ALASKA

Air Temperature: Projected Change, 2010–2049

The modeled projection for temperature in Southeast Alaska between 2010 and 2049 presents an increase across the entirety of Southeast Alaska, with some regions experiencing a greater increase than others. Much of the Northern Mainland region is expected to experience increases ranging from 1.8 to 2.3˚F (1 to 1.3°C), along with portions of the Northern Islands and the northern segments of the Southern Islands and Southern Mainland regions. These increases in temperature are projected to be the most pronounced in the Coast Mountains along the US-Canada boundary. These regions currently have the lowest annual temperature averages in Southeast Alaska. The Southern Mainland, Southern Islands, and the Prince of Wales Island Complex currently have the warmest annual temperatures in Southeast Alaska, and are predicted to experience a lesser, yet still significant, change in temperature: approximately 1.6 to 1.8˚F (0.9 to 1˚C) between 2010 and 2049.



Map 2.5: Air Temperature: Projected Change, 2010–2049

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PRECIPITATION

Lauren Tierney, Melanie Smith, and Nathan Walker

In Southeast Alaska, moisture from the Gulf of Alaska is pushed onshore and lifted by weather fronts associated with North Pacific lows, or orographically by the steep terrain. Lifting causes the moisture to cool and condense into precipitation. The variability of the terrain and distance to the Gulf influence the region's variable patterns of snowfall and rainfall.

Moving from west to east, precipitation along the Gulf coast falls more often as rain compared to the snowier mainland, due to the cooler interior temperature gradient toward the mainland. The same pattern applies orographically, with coastal areas being more rainy and high elevations more snowy. Total precipitation varies greatly across Southeast, with dynamics such as rainshadow and ocean effects that can create microclimates of wet and dry pockets in close proximity.

RECENT PRECIPITATION, 1980–2009

In recent decades, average annual precipitation in Southeast Alaska ranged from a high of 456 in (1,158 cm) near Mount Fairweather, to a low of 28 in (70 cm) near Skagway. Summarized by biogeographic province, the mean and standard deviation of annual precipitation is presented in Figure 2-2, along with the average minimum and maximum annual precipitation for each province (see Biogeographic Provinces map and summary in next chapter for more information). The Fairweather Icefields was the wettest biogeographic province in Southeast Alaska at 200 in (508 cm), with the Chilkat River Complex being the driest at 72 in (183 cm).

PROJECTED CHANGE, 2010–2049

The modeled projection for precipitation in Southeast Alaska between 2010 and 2049 presents an overall increase across the entirety of Southeast Alaska, with some regions expecting up to a 5% increase. The general pattern of increase follows the current elevational precipitation gradient with most falling at higher elevations and less at low elevations.

Summarized by biogeographic province, the projected annual mean precipitation is presented in Figure 2-2 alongside the recent mean precipitation data. Between 2010 and 2049, the mean change in average annual precipitation ranges from 3 in (7.5 cm) across the Dall Island Complex to 9.4 in (23.9 cm) across the Yakutat Forelands.

John Schoen

Southeast Alaska generally receives more precipitation at higher elevations than at sea level. This is due to cooling and condensation of moisture as air masses coming from the Gulf of Alaska are lifted above the steep terrain of Southeast Alaska.

CONSERVATION ISSUES

Models project a 2 to 5% increase in preciptation across Southeast Alaska in the next four decades. Figure 2-3 is a linear regression of temperature versus precipitation, which categorizes provinces into warmer/wetter, warmer/drier, cooler/wetter, or cooler/drier. Warmer temperatures projected across Southeast Alaska will mean that a greater proportion of precipitation will fall as rain, and the elevation of the snow line will be higher. Edwards et al. (2013) stated that "85% of the northern coastal temperate rainforest will no longer receive precipitation as snow, and spatial redistribution of vegetation will be common."

Below are some additional ways in which increasing precipitation affects the Southeast Alaska rainforest ecosystem:

- an increase in rain-on-snow events (Rennert et al. 2009)
- reduction in snowpack (Mote et al. 2003) below the new snow line and a potential increase in snow pack above that line
- hydrologic changes including changes in peak and base flows, seasonal low flows, peak output, timing, and flooding (Mantua et al. 2010)
- possible reduction in salmon productivity due to alteration of flow regimes causing an increase in peak discharge during sensitive periods of spawning and incubation (Shanley and Albert 2014).

Understanding the patterns of precipitation-change over the coming decades is important to Alaskan decision-makers and other stakeholders, and should be used to aid in the development of policies and management strategies for Alaska (Scenarios Network for Alaska and Arctic Planning 2014c).

MAPPING METHODS

Recent Data

This data was provided by SNAP (2014a), and represents the 30-year average annual temperature, based on three decadal datasets for 1980–1989, 1990–1999, and 2000–2009. These data were downscaled by SNAP to 771 m resolution utilizing PRISM climatological datasets from 1971–2000.

Projected Data

SNAP created raster datasets representing projected annual average precipitation in Alaska by decade, spanning between 2001 and 2100, at a resolution of 771m (2011b). There are five general circulation models that perform best for approximating data in Alaska and the Arctic. Some independent analyses (Radi and Clarke 2011) rate some models higher than others. We decided to use SNAP's average of the five models in order to reduce the risk of error that may arise when using just one model. Using SNAP's raster datasets, we subtracted the 2010–2019 average from the 2040–2049 average, thus creating a dataset representing projected precipitation change between the present decade and the 2040s.

MAP DATA SOURCES

- Recent Precipitation, 1980–2009: Scenarios Network for Alaska and Arctic Planning (2014a)
- Projected Precipitation, 2010–2049: Scenarios Network for Alaska and Arctic Planning (2011b).

MAPS ON PAGES 20, 21

FIGURE 2-2 Mean annual precipitation, by biogeographic province, for the recent time period of 1980–2009, compared to the projected mean for 2040–2049. Also shown are the minimum, maximum, and standard deviation, based on the recent mean annual precipitation across each province.

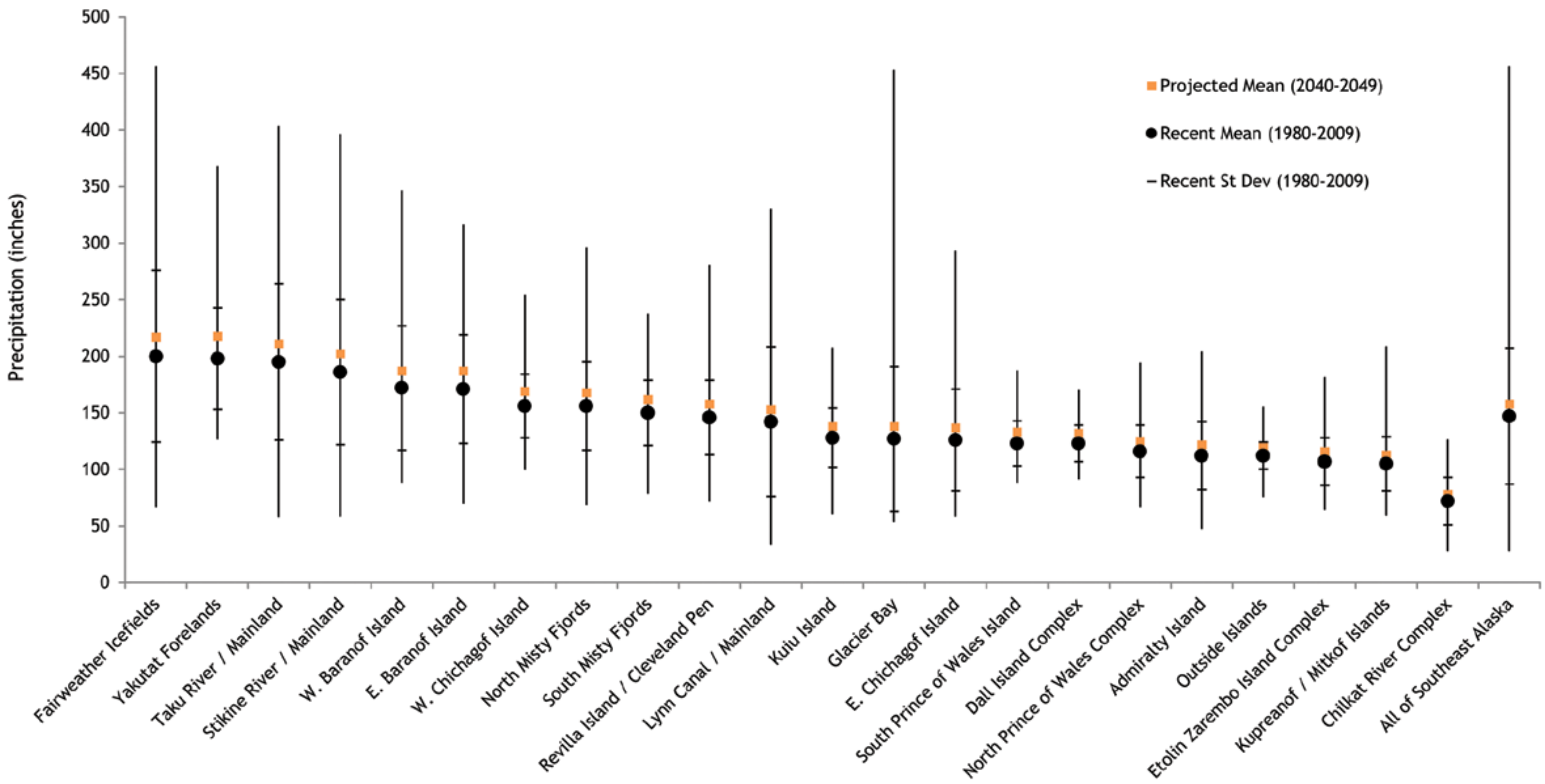
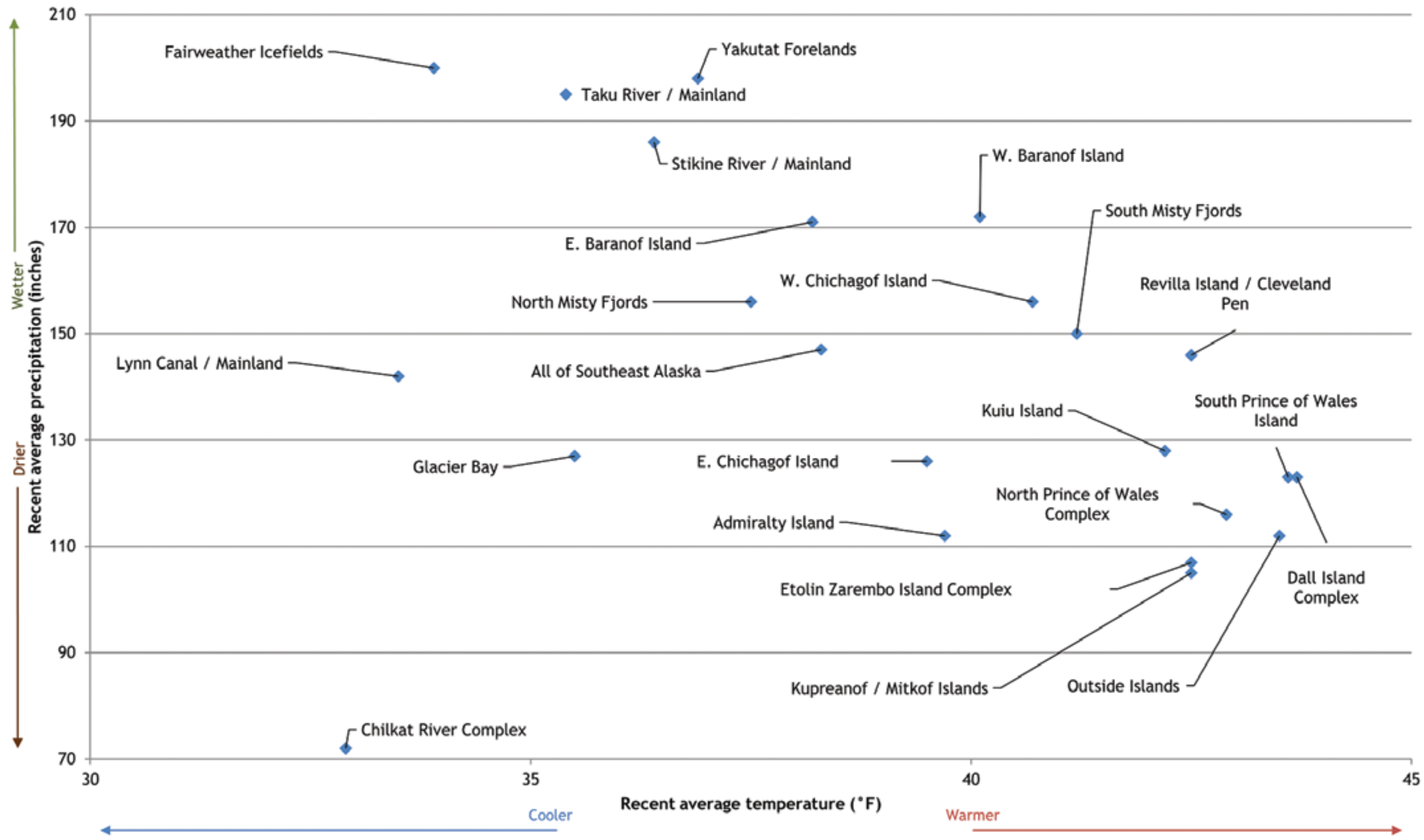


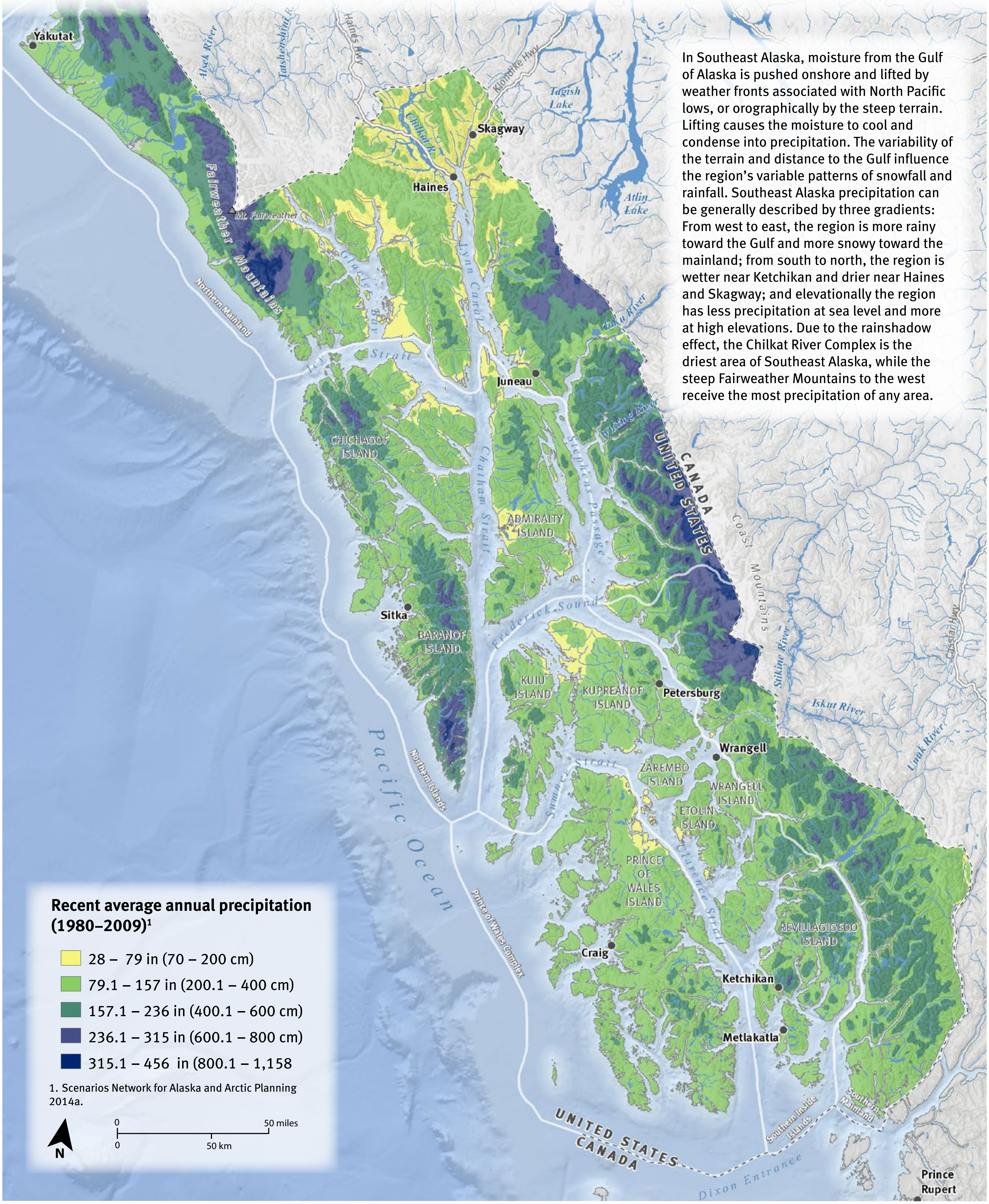
FIGURE 2-3 Linear regression comparing recent mean annual temperatures to recent mean annual precipitation, by biogeographic province.



Precipitation: Recent, 1980–2009

Audubon ALASKA

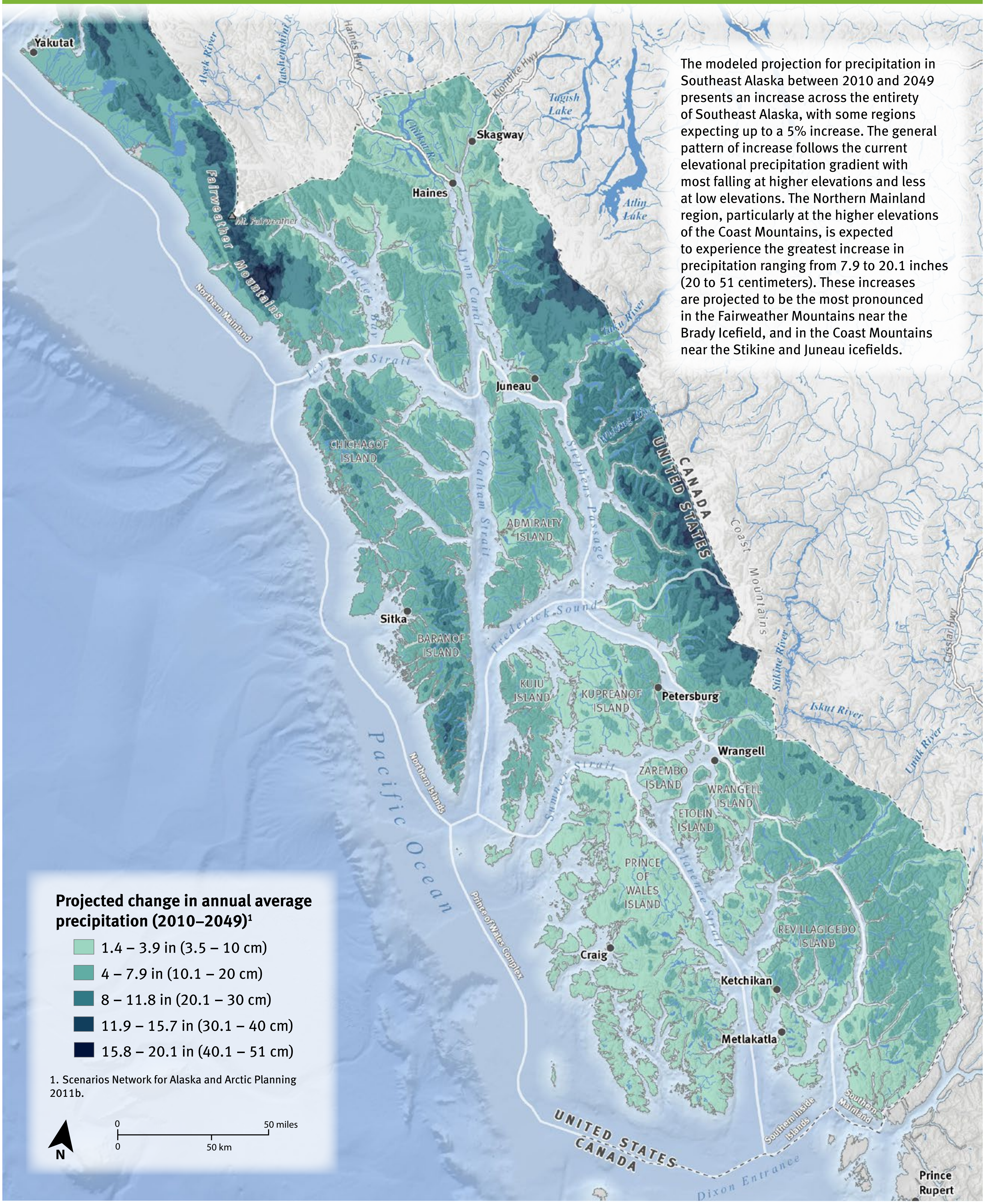
In Southeast Alaska, moisture from the Gulf of Alaska is pushed onshore and lifted by weather fronts associated with North Pacific lows, or orographically by the steep terrain. Lifting causes the moisture to cool and condense into precipitation. The variability of the terrain and distance to the Gulf influence the region's variable patterns of snowfall and rainfall. Southeast Alaska precipitation can be generally described by three gradients: From west to east, the region is more rainy toward the Gulf and more snowy toward the mainland; from south to north, the region is wetter near Ketchikan and drier near Haines and Skagway; and elevationally the region has less precipitation at sea level and more at high elevations. Due to the rainshadow effect, the Chilkat River Complex is the driest area of Southeast Alaska, while the steep Fairweather Mountains to the west receive the most precipitation of any area.



Map 2.6: Precipitation: Recent, 1980–2009

Precipitation: Projected Change, 2010–2049

The modeled projection for precipitation in Southeast Alaska between 2010 and 2049 presents an increase across the entirety of Southeast Alaska, with some regions expecting up to a 5% increase. The general pattern of increase follows the current elevational precipitation gradient with most falling at higher elevations and less at low elevations. The Northern Mainland region, particularly at the higher elevations of the Coast Mountains, is expected to experience the greatest increase in precipitation ranging from 7.9 to 20.1 inches (20 to 51 centimeters). These increases are projected to be the most pronounced in the Fairweather Mountains near the Brady Icefield, and in the Coast Mountains near the Stikine and Juneau icefields.



Map 2.7: Precipitation: Projected Change, 2010–2049

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SNOW

Melanie Smith, Lauren Tierney, and Nathan Walker

Snow is a driving force in Southeast Alaska's hydrology and ecology. Current snow patterns maintain vegetation and ecological zones for plant and animal species in the region. Snow presence and accumulation contribute to the length of growing seasons. Snow melt discharges into rivers, streams, and lakes, contributing greatly to the seasonal temperature and flow patterns of the region's short, steep stream systems. The more stable high-elevation snowpack feeds streams throughout the year.

While much of the annual snow accumulation occurs at the highest elevations, the presence of snow at lower elevations plays a vital role in ecosystem processes. For example, Hennon et al. (2012) found that snow cover protects the fine roots of yellow cedar from freezing in the wet soils they are adapted to. Changes in snow depth due to climate factors (Liston and Hiemstra 2011) have recently caused a cascade effect that freezes shallow roots and causes widespread mortality of yellow cedar stands throughout its Southeast Alaska range (Hennon et al. 2012).

RECENT, 1981–2010

Over the past three decades, annual snowfall across all of Southeast Alaska averaged 4.25 ft (1.3 m), but varied considerably between high and low elevations, from a few inches along coastlines bordering Clarence Strait to about 40 ft (12 m) near Mount Fairweather. Depth is greatest in the Fairweather Icefield near Glacier Bay where snow accumulation averaged 9.25 ft (2.8 m) across the province (see Biogeographic Provinces map and summary in next chapter for more information). The high elevation regions of the Coast Mountains along the US/Canada border between the Stikine River and Berner's Bay regularly received more than 8 ft (2.5 m) of snow annually, with some areas receiving 16 ft (5 m). The islands of Southeast Alaska received the least amount of snowfall, ranging from 3 in to 1 ft (7 to 30 cm) along the coastlines, and up to 8 ft (2.5 m) in the highest elevation areas. The Outside Islands province received the least snowfall, at an average of 10 in (25 cm) across the region.

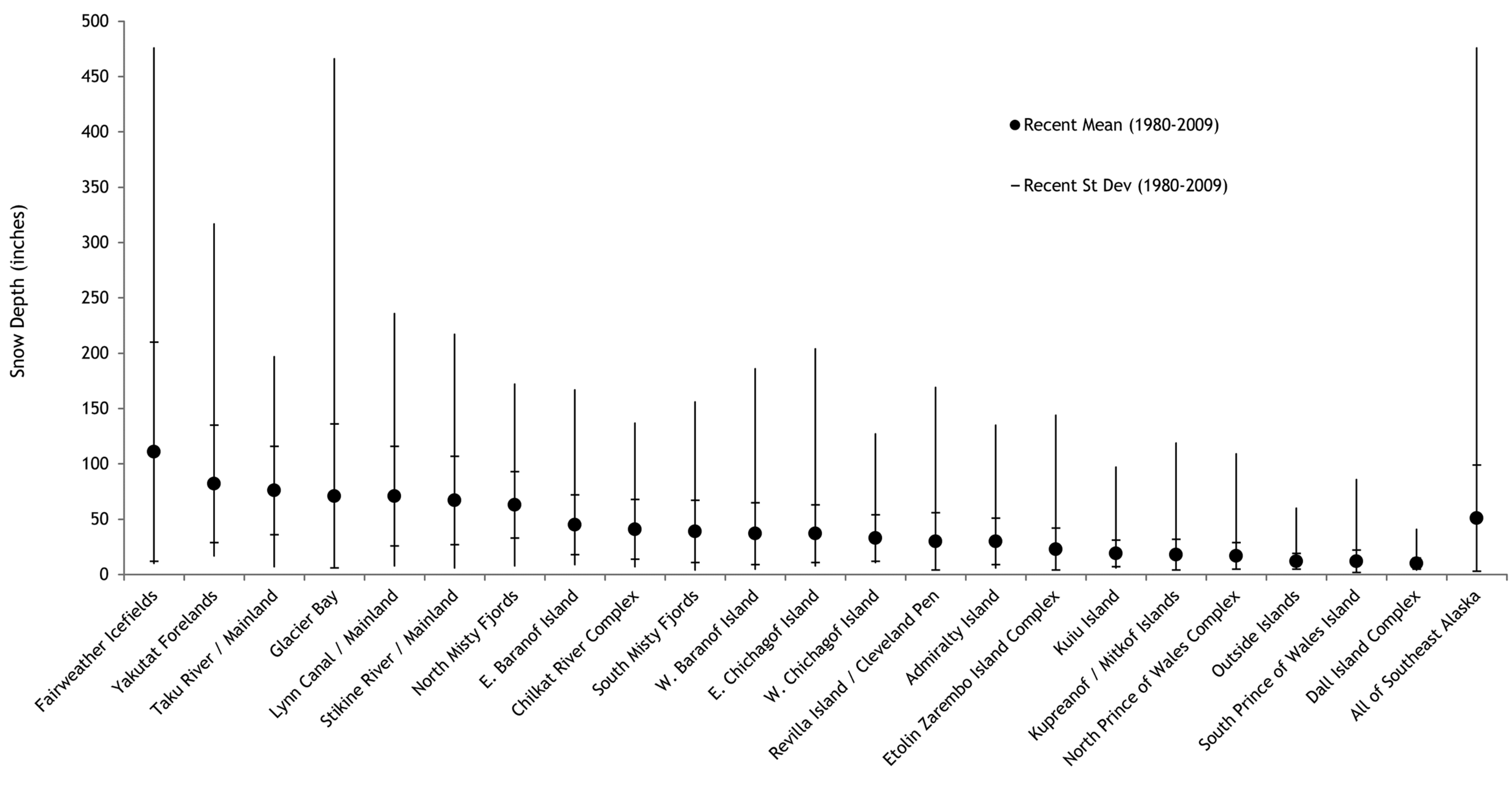
Summarized by biogeographic province, the mean and standard deviation of average annual snow depth for 1981–2010 are presented in Figure 2-4, along with the range of annual snowfall depths across the entire province.

PROJECTED CHANGE, 2010–2049

Projections for snow were modeled based on the "snow-day fraction," or the percent of days with precipitation that falls as snow. The projection presents an overall decrease in snow-day fraction across Southeast Alaska, indicating reduced snow cover and depth in years to come. For example, Juneau's average winter temperatures are expected to rise above freezing or near the freeze/thaw line by the end of the 2040s, potentially leading to little or no snow pack except at higher elevations, which will affect spring runoff in particular (UAF SNAP 2013).

The most significant decrease in the number of snow days will occur in the areas of Southeast that currently have the greatest snow depth (i.e. the high elevations of the Fairweather and Coast mountains, and the high elevations in the Northern Islands). According to the annual averages, these high elevation areas will have up to 7% fewer snowy days by 2049. Table 2-2 compares the change in snow-day fraction for low (0–1,641 ft; 0–500 m), mid (1,641–4,921 ft; 500–1,500 m), and high (>4,921 ft; >1,500 m) elevations.

FIGURE 2-4 Mean annual snow depth, by biogeographic province, for the recent time period of 1981–2010. Also shown are the minimum, maximum, and standard deviation, based on the mean annual snow depth across each province.



MAPS ON PAGES 25, 26

TABLE 2-2 Projected change in monthly snow-day fraction, by elevation class, between the decades of 2010–2019 and 2040–2049 for Southeast Alaska.

Elevation	0–499 m	500–1,499 m	1,500+ m	Overall
Acres	13.0 million	8.7 million	1.5 million	23.2 million
October	-2.9%	-7.5%	-11.9%	-5.2%
November	-11.4%	-14.5%	-9.1%	-12.4%
December	-6.8%	-6.9%	-3.9%	-6.6%
January	-7.6%	-6.7%	-3.8%	-7.0%
February	0.3%	-0.9%	-1.0%	-0.3%
March	-6.0%	-6.5%	-2.0%	-5.9%
April	-2.3%	-5.0%	-4.3%	-3.4%
May	-1.1%	-4.5%	-9.7%	-2.9%
June	-0.4%	-1.6%	-7.2%	-1.3%
July	-0.1%	-0.5%	-2.7%	-0.4%
August	-0.1%	-0.4%	-2.5%	-0.3%
September	-0.5%	-1.8%	-5.3%	-1.3%

Precipitation is projected to generally increase in Southeast (see Precipitation Section above), but the percent of that precipitation that is snow will decrease. Generally, the biggest changes in snowfall are projected to occur between the months of November and January (shown on the accompanying map). The highest levels of change for mid- and low elevations are expected during the winter months between October and March, when winter snow will fall as rain. The highest overall impact is projected to occur for mid-elevation areas during the month of November, when the number of precipitation days that are snow days will decrease by 14%. During the summer months (between April and September), the greatest changes will occur in high elevations, where the typical mountaintop summer snow will more often fall instead as rain. The most dramatic summer changes are expected to occur in May and June in the Fairweather and Coast mountains. Figure 2-6 compares the mean annual precipitation and snow depth for each province based on recent years.

Summarized by biogeographic province, the projected change in snow-day fraction is presented in Figure 2-5. The mean change ranges from 11% fewer precipitation days with snow in the Yakutat Forelands to 5% fewer days for the Dall Island Complex, based on year-round data. In the Fairweather Icefields, where some areas have a snow-day fraction of 100%, a mean change in snow-day fraction of 9% across the province would mean that rain will fall in areas that have historically had only snow.

CONSERVATION ISSUES

Models project a 2 to 5% increase in preciptation across Southeast Alaska in the next 35 years. Warmer temperatures projected across Southeast Alaska will mean that a greater proportion of precipitation will fall as rain, and the elevation of the snow line will be higher. Projected temperature increases suggest that the mean snow line will rise by about 2,953 ft (900 m) by 2100 (Edwards et al. 2013). Additionally, Edwards et al. (2013) stated that "85% of the northern coastal temperate rainforest will no longer receive precipitation as snow, and spatial redistribution of vegetation will be common." Below are some additional ways in which an increase in precipitation as rain, and the resulting reduced snowpack, affects the Southeast Alaska rainforest ecosystem:

- an increase in rain-on-snow events (Rennert et al. 2009)
- reduction in snowpack (Mote et al. 2003)
- hydrologic changes, including changes in peak and base flows, seasonal low flows, peak output, timing, and flooding (Mantua et al. 2010); as well as possible changes to stream temperatures
- possible reduction in salmon productivity due to alteration of flow regimes causing an increase in peak discharge during sensitive periods of spawning and incubation (Shanley and Albert 2014)
- decline in yellow cedar stands (Hennon et al. 2012).

The understanding of patterns of future precipitation change over the coming decades is important to Alaskan decision-makers and other stakeholders, and should be used to aid in the development of policies and management strategies for Alaska (Scenarios Network for Alaska and Arctic Planning 2014c).

MAPPING METHODS

Recent Data

This data represents modeled historical snow depth, at 1 km resolution, averaged over 30 years from 1981 to 2010. Data were provided by the AdaptWest Project (2015) using the ClimatNA software package (Hamann et al. 2013).

Projected Data

SNAP, a research unit of UAF, created raster datasets representing projected decadal averages of monthly snow-day fractions, from 2001 to 2100, at a resolution of 771 m. Separate equations were used to model the relationship between decadal monthly average temperature and the fraction of wet days with snow for seven geographic regions in the state (Scenarios Network for Alaska and Arctic Planning 2012). These were made available for each of the five GCMs that performed best in Alaska and the Arctic; we used the 5-model average to reduce errors introduced through reliance on just one model. We averaged the monthly grids (already summarized across each decadal time period), then we subtracted the 2010–2019 annual average from the 2040–2049 annual average to create a raster dataset representing projected snow-day fraction change by the 2040s, expressed as a percent. It is important to note that because there are few weather stations with long records above 500 meters in Alaska, it is unclear how accurate the snow-day fraction equations are at high elevations.

MAP DATA SOURCES

- Recent Snow Depth, 1981–2009: AdaptWest Project (2015)
- Projected Snow Depth, 2010–2049: Scenarios Network for Alaska and Arctic Planning (2012).

John Schoen

Average annual snowfall in Southeast Alaska varies greatly with elevation, from just a few inches near the coast to close to 40 feet in high mountain ranges.

MAPS ON PAGES 25, 26

FIGURE 2-5 Mean annual snow-day fraction (number of days with precipitation falling as snow), by biogeographic province, for the current projected time period of 2010–2019, compared to the projected mean for 2040–2049. Also shown are the minimum, maximum, and standard deviation, based on the current annual mean snow-day fraction across each province.

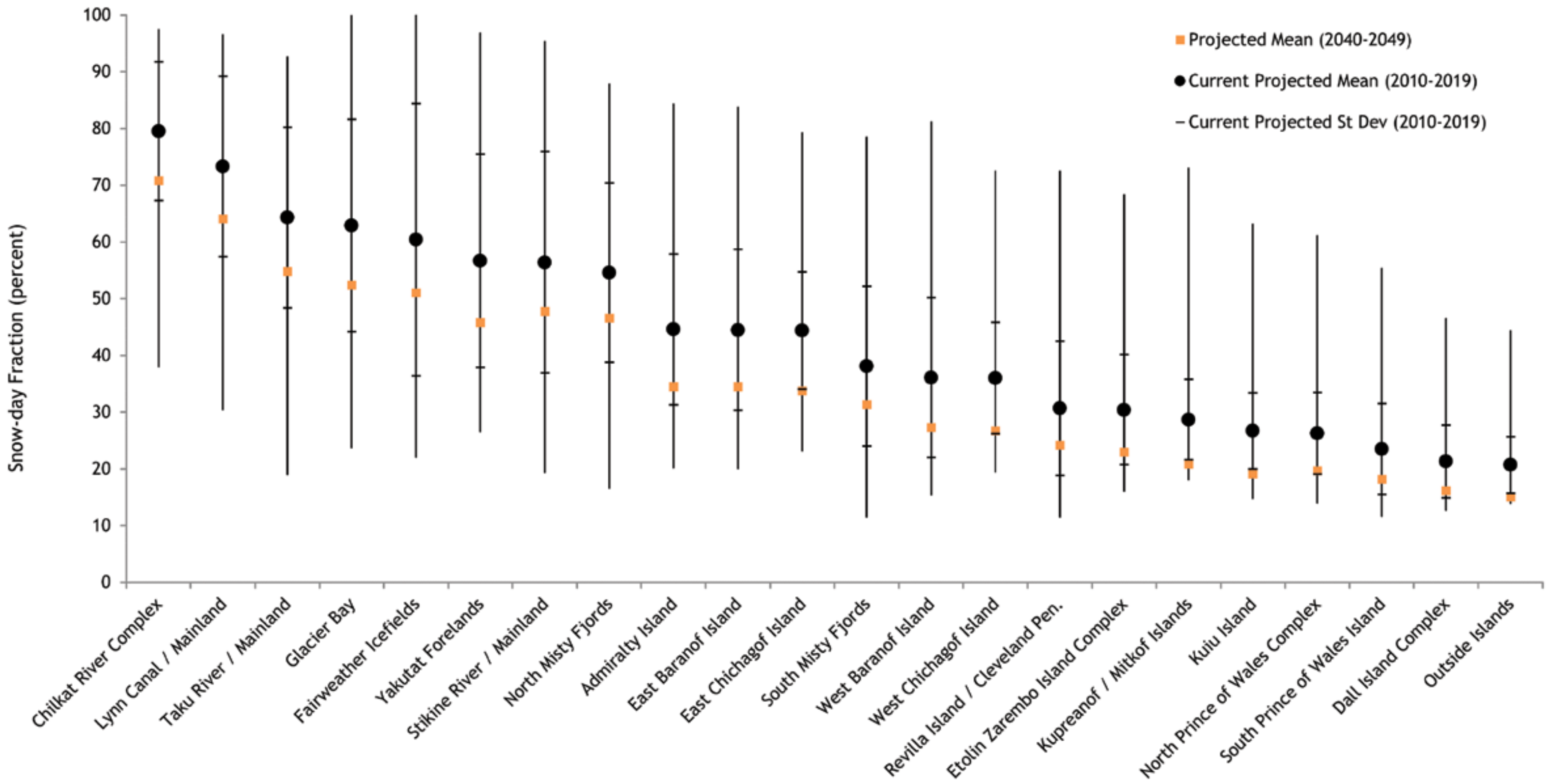
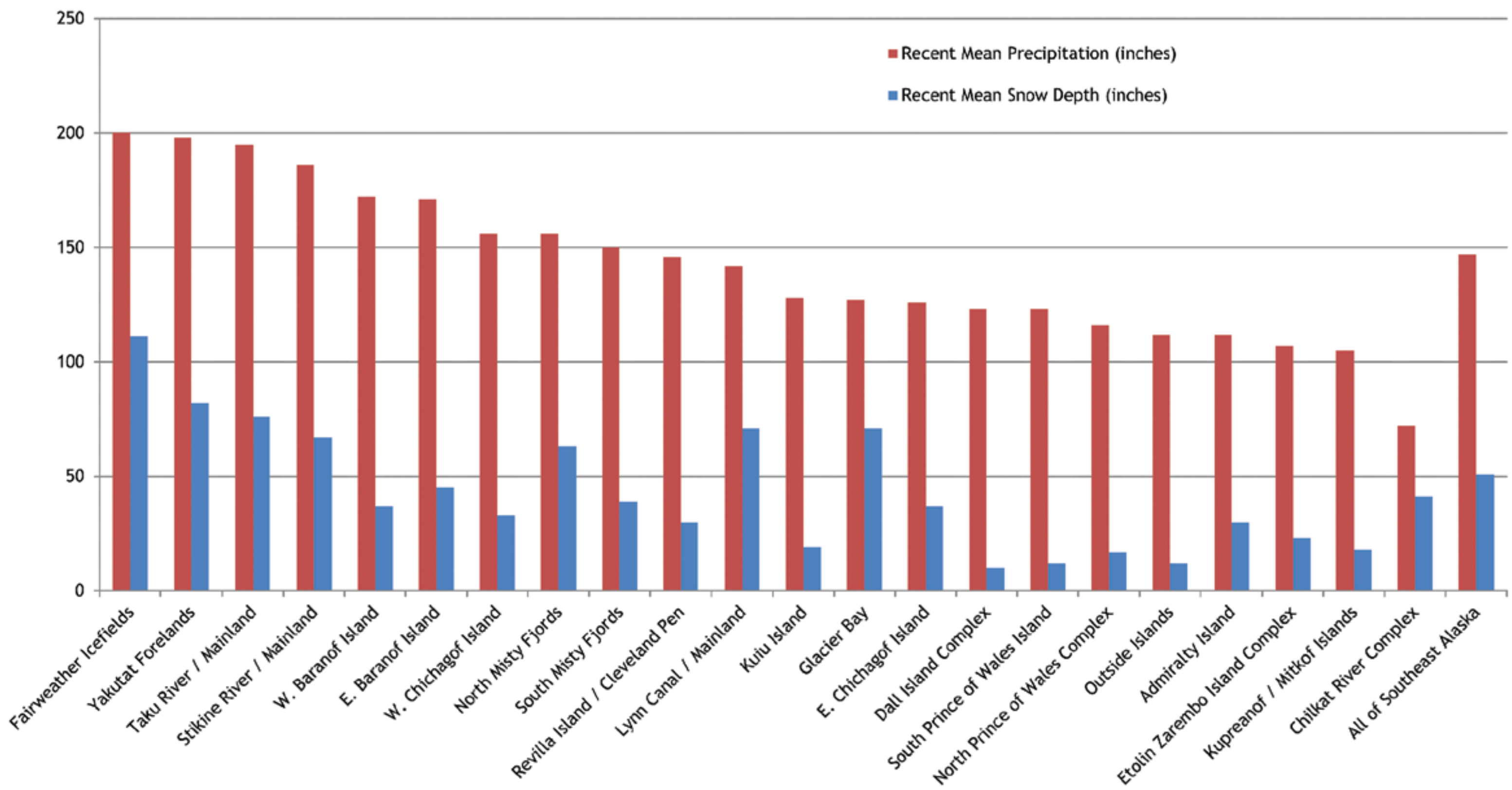


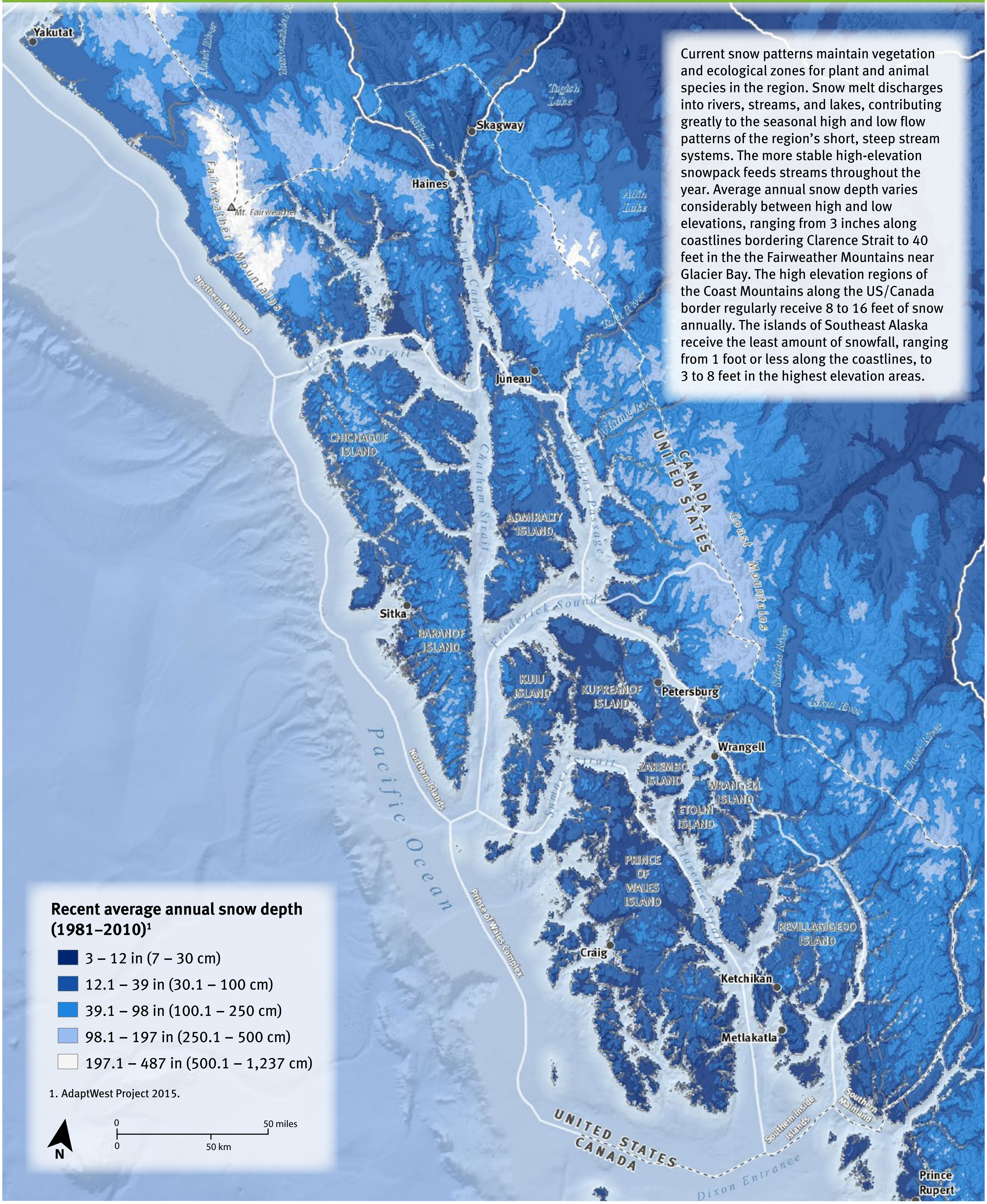
FIGURE 2-6 Mean annual precipitation and snow depth, by biogeographic province, for the recent 1980-2009 time period.



Audubon ALASKA

Snow Depth: Recent, 1981–2010

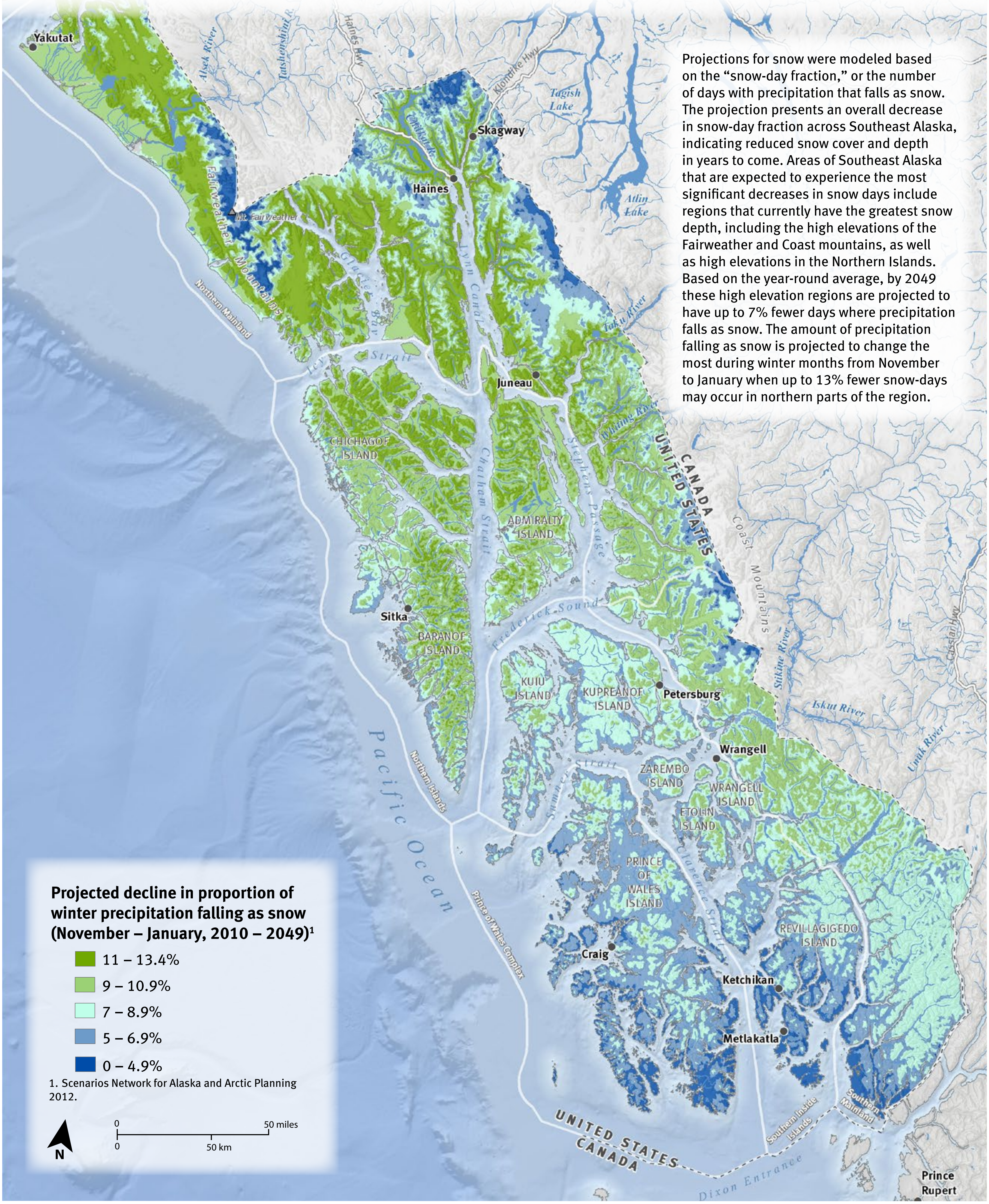
Current snow patterns maintain vegetation and ecological zones for plant and animal species in the region. Snow melt discharges into rivers, streams, and lakes, contributing greatly to the seasonal high and low flow patterns of the region's short, steep stream systems. The more stable high-elevation snowpack feeds streams throughout the year. Average annual snow depth varies considerably between high and low elevations, ranging from 3 inches along coastlines bordering Clarence Strait to 40 feet in the the Fairweather Mountains near Glacier Bay. The high elevation regions of the Coast Mountains along the US/Canada border regularly receive 8 to 16 feet of snow annually. The islands of Southeast Alaska receive the least amount of snowfall, ranging from 1 foot or less along the coastlines, to 3 to 8 feet in the highest elevation areas.



Map 2.8: Snow Depth: Recent, 1981–2010

Snow-Day Fraction: Projected Change, 2010–2049

Audubon ALASKA



Projections for snow were modeled based on the "snow-day fraction," or the number of days with precipitation that falls as snow. The projection presents an overall decrease in snow-day fraction across Southeast Alaska, indicating reduced snow cover and depth in years to come. Areas of Southeast Alaska that are expected to experience the most significant decreases in snow days include regions that currently have the greatest snow depth, including the high elevations of the Fairweather and Coast mountains, as well as high elevations in the Northern Islands. Based on the year-round average, by 2049 these high elevation regions are projected to have up to 7% fewer days where precipitation falls as snow. The amount of precipitation falling as snow is projected to change the most during winter months from November to January when up to 13% fewer snow-days may occur in northern parts of the region.

Map 2.9: Snow-Day Fraction: Projected Change, 2010–2049

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WATERSHEDS & VALUE COMPARISON UNITS (VCUS)

David Albert, John Schoen, and Melanie Smith

A watershed is a topographically distinguishable hydrologic unit bounded by ridges where all surface water drains to a common point. Boundaries between watersheds represent the dividing line from which water flows in two different directions. Characteristics of watersheds are determined by their size, geology, climate, biota, and history; they are functional units of landscapes that integrate ecosystem processes. The entire drainage basin, not just the stream network, contributes to watershed function (Lertzman and MacKinnon 2013).

Hydrologic units are mapped at six different scales by the Natural Resources Conservation Service (NRCS). A first-level hydrologic unit, the continental divide, separates all of North America into only two regions, where water flows either toward the Atlantic or Pacific oceans. At the fifth-level hydrologic classification, there are about 150 units in Southeast Alaska. The finest scale mapping conducted by the NRCS is the sixth-level hydrologic unit. There are approximately 1,000 sixth-level watersheds in Southeast Alaska, which are the units most commonly used for mapping and assessment in the region and are hereafter referred to simply as "watersheds." The watersheds of Southeast Alaska range in size from the 88,000-ac (35,612-ha) Johns Hopkins Glacier watershed melting into Glacier Bay to the 1,700-ac (688-ha) Dry Island watershed in the Stikine River Delta.

The Tongass National Forest uses a designation analogous to watersheds for mapping and assessment of biological values across the forest. Value Comparison Units, most often referred to as VCUs, are distinct geographic areas that typically encompass a watershed basin that contains one or more large stream systems, with the unit boundaries usually following topographic divides (US Forest Service 2008). The US Forest Service first created the concept of a VCU during the development of the 1979 Tongass Land Management Plan (TLMP). VCUs 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 have been divided into VCUs along management or ownership boundaries.

In addition to the 926 VCUs mapped by the Forest Service, TNC used consistent criteria to delineate an additional 80 VCUs for the rest of Southeast, including Glacier Bay National Park and lands near Haines and Skagway (Albert and Schoen 2007). The resulting 1,006 VCUs in Southeast Alaska provide a standardized system for the purposes of resource management and natural resource studies. The average size of a VCU is 18,000 ac (7,284 ha). The watershed area covered by a VCU is an appropriate scale of analysis for many ecosystem processes and certain animal species, as it represents an ecologically based unit with functional cohesiveness.

Numerous ecological studies suggest that conservation action and management should take place at the scale of entire watersheds (Naiman et al. 1997, Naiman et al. 2000, Pringle 2001, Baron et al. 2002, Lertzman and MacKinnon 2013) to maintain ecological integrity. Studies have shown that resident Sitka black-tailed deer in Southeast Alaska largely confine their movements to a single watershed (Schoen and Kirchhoff 1985, Colson et al. 2013). In another example, many of the species and trophic systems of Southeast (e.g., salmon spawning and rearing and the interactions between wildlife species and salmon) tend to be strongly linked to key ecological processes at a watershed scale (e.g., sedimentation, stream flow, and nutrient cycling).

The productivity of coastal ecosystems is strongly linked to salmon populations, which are considered keystone species (Willson and Halupka 1995). In fact, the panel of fish experts evaluating the 1997 TLMP recommended that the most effective protection of fish habitat on the Tongass would be reserves that included entire watersheds rather than only parts of watersheds (Dunlap 1997). Bryant and Everest (1998) also emphasized the importance of watershed-scale conservation:

"The presence, number and distribution of intact watersheds across the landscape of the TNF [Tongass National Forest] are critical elements for sustainable salmon populations in the face of habitat loss elsewhere in Southeast Alaska and the Pacific Northwest."

Melanie Smith

With its headwaters in British Columbia, the Stikine River drains one of the largest watersheds in Southeast Alaska.

MAP ON PAGE 29

CONSERVATION ISSUES

Although protecting habitat areas within watersheds has conservation value, substantial and different conservation benefits also accrue from protecting intact watersheds (Naiman et al. 1997, Naiman et al. 2000, Pringle 2001, Baron et al. 2002). Thus, because watersheds define an appropriate ecological unit where human impacts tend to accumulate and can be measured (Karr 1991, Muhar and Jungwirth 1998, Carignan and Villard 2002, Pess et al. 2002) and because of their value for supporting key ecological processes and the global rarity of intact watersheds, identifying and representing a range of intact watersheds should be included as a part of any credible, systematic, science-based conservation analysis (Lertzman and MacKinnon 2013).

An effective conservation strategy for Southeast should include a representative set of protected watersheds with high ecological values within each of the region's biogeographic provinces. See sections on A Conservation Area Design for Southeast Alaska and Tongass 77 Watersheds in the last chapter.

Protecting intact watersheds would essentially hedge our bets by maintaining conservation options in recognition of the high degree of uncertainty associated with ecological systems. Scientists and managers have incomplete knowledge of many of Southeast's ecological processes and species habitat requirements. We assume that by protecting intact watersheds—from ridge top to ridge top and headwaters to estuary—that the natural range of variability, population viability, and ecological integrity within those watersheds will also be maintained (Lertzman and MacKinnon 2013). Further, this landscape-scale strategy would increase the probability of protecting wide-ranging species such as brown bears and wolves that are placed at risk by expanding road systems and increased human access.

To maintain ecosystem integrity and conserve fish and wildlife populations and the natural range of variability of habitat types, we recommend consideration of the following conservation measures throughout Southeast and the Tongass:

1. Maintain and expand the existing conservation reserve network to include additional intact watersheds identified by the Audubon-TNC Conservation Assessment (Conservation Priority Watersheds)(Albert and Schoen 2007).

2. Give first priority for restoration activities to developed water-sheds which still maintain relatively high ecological values (e.g., Integrated Management Watersheds).

Refer to the Conservation Area Design map and summary (Chapter 7) for further information.

John Schoen

Idaho Inlet on northern Chichagof Island.

MAPPING METHODS

The US Forest Service first created the concept of a VCU during the development of the 1979 TLMP. The 1997 TLMP established 926 VCUs on the Tongass Forest. In addition to the VCUs mapped by the Forest Service and as part of the 2007 Conservation Assessment for Southeast Alaska, Albert and Schoen used consistent criteria to delineate VCUs for the rest of Southeast, including Glacier Bay National Park and lands near Haines and Skagway. An additional 80 VCUs were delineated, for a total of 1,006.

MAP DATA SOURCES

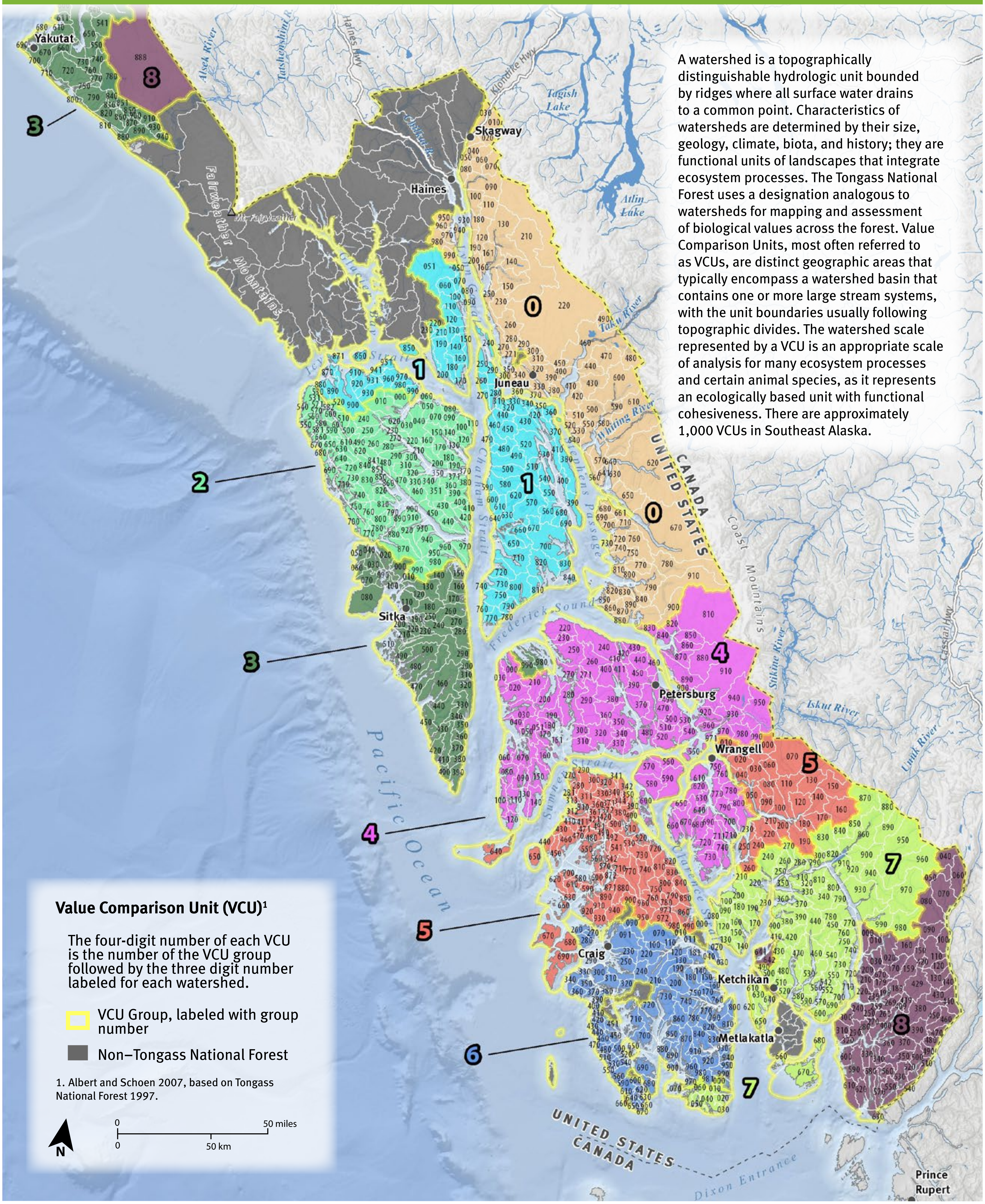
- VCUs: Albert and Schoen (2007), based on Tongass National Forest (1997).

John Schoen

Audubon ALASKA | The Nature Conservancy

Watersheds & Value Comparison Units (VCUs)

A watershed is a topographically distinguishable hydrologic unit bounded by ridges where all surface water drains to a common point. Characteristics of watersheds are determined by their size, geology, climate, biota, and history; they are functional units of landscapes that integrate ecosystem processes. The Tongass National Forest uses a designation analogous to watersheds for mapping and assessment of biological values across the forest. Value Comparison Units, most often referred to as VCUs, are distinct geographic areas that typically encompass a watershed basin that contains one or more large stream systems, with the unit boundaries usually following topographic divides. The watershed scale represented by a VCU is an appropriate scale of analysis for many ecosystem processes and certain animal species, as it represents an ecologically based unit with functional cohesiveness. There are approximately 1,000 VCUs in Southeast Alaska.



Map 2.10: Watersheds & Value Comparison Units (VCUs)

REFERENCES

AdaptWest Project. 2015. Gridded current and future climate data for North America at 1 km resolution, interpolated using the ClimateNA v5.10 software (T. Wang et al., 2015). Accessed online at adaptwest.databasin.org.

Alaska Department of Natural Resources - Land Records Information Section. 2007. Alaska Hydrography 1:63,360. Accessed online at http://dnr.alaska.gov/mdfiles/hydro_63360.html.

Albert, D. M. and J. W. Schoen. 2007. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Arendt, A. A., K. A. Echelmeyer, W. D. Harrison, C. S. Lingle, and V. B. Valentine. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. *Science* 297:382-386.

Baichtal, J. and D. Swanston. 1996. Karst Landscapes and Associated Resources: A Resource Assessment, General Technical Report PNW-GTR-383. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Baron, J. S., N. L. Poff, P. L. Angermeier, C. N. Dahm, P. H. Gleick, N. G. Hairston Jr., R. B. Jackson, C. A. Johnston, B. D. Richter, and A. D. Steinman. 2002. Meeting ecological and societal needs for freshwater. *Ecological Applications* 12:1247-1260.

BCGOV FOR Forest Analysis and Inventory Branch. 2002. Reconnaissance Karst Potential Mapping. Accessed online at https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=43911&recordSet=ISO19115.

Bryant, M. D. and F. H. Everest. 1998. Management and condition of watersheds in Southeast Alaska: The persistence of anadromous salmon. *Northwest Science* 72:249-267.

Carignan, V. and M.-A. Villard. 2002. Selecting indicator species to monitor ecological integrity: A review. *Environmental Monitoring and Assessment* 78:45-61.

Carstensen, R. 2007. Coastal habitats of Southeast Alaska, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds., pp. 1-4. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Colson, K. E., T. J. Brinkman, D. K. Person, and K. J. Hundertmark. 2013. Fine-scale social and spatial genetic structure in Sitka black-tailed deer. *Conservation Genetics* 14:439-449.

Cook, J. and S. MacDonald. 2001. Should endemism be a focus of conservation efforts along the North Pacific Coast of North America? *Biological Conservation* 97:207-213.

Cook, J. A. and S. O. MacDonald. 2013. Island life: Coming to grips with the insular nature of Southeast Alaska and adjoining coastal British Columbia, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 19-42. University of Washington Press, Seattle, WA.

Cowardin, L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. US Fish and Wildlife Service, Washington, DC.

Dunlap, R. 1997. Summary of the 1997 Fish Habitat Risk Assessment Panel. Appendix 1. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Earth Policy Institute. 2009. Eco-Economy Indicators: Ice Melting. Rutgers University, New Brunswick, NJ. Accessed online at http://www.earthpolicy.org/index.php?/indicators/C50/ice_melting_2009.

Edwards, R. T., D. D'Amore, E. Norberg, and F. Biles. 2013. Riparian ecology, climate change, and management in North Pacific Coastal Rainforests, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 43-72. University of Washington Press, Seattle, WA.

Esri. 2015. Terrain: Multi-directional Hillshade. Esri, Redlands, CA.

Federal Geographic Data Committee. 2013. Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and US Fish and Wildlife Service, Washington, DC.

Fels, J. and R. Zobel. 1995. Landscape position and classified landtype mapping for statewide DRASTIC mapping project. North Carolina State University technical report VEL.95.1. North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management, Raleigh, NC.

Geomatics Yukon: Natural Resources Canada: Canada Centre for Remote Sensing. 2003. The Atlas of Canada: National Scale Frameworks Hydrology - Drainage Network, Canada. Government of Canada, Ottawa, Ontario, Canada. Accessed online at http://geogratis.cgdi.gc.ca/download/frameworkdata/hydrology.

GLIMS. 2016. Randolph Glacier Inventory 5.0. Accessed online at http://www.glims.org/RGI/rgi50_dl.html.

Hall, J., W. Frayer, and B. Wilen. 1994. Status of Alaska Wetlands. US Fish and Wildlife Service, Anchorage, AK.

Hamann, A., T. Wang, D. L. Spittlehouse, and T. Q. Murdock. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. *Bulletin of the American Meteorological Society* 94:1307-1309.

Hennon, P. E., D. V. D'Amore, P. G. Schaberg, D. T. Wittwer, and C. S. Shanley. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. *BioScience* 62:147-158.

Karr, J. R. 1991. Biological integrity: A long-neglected aspect of water resource management. *Ecological Applications* 1:66-84.

Larsen, C. F., R. J. Motyka, J. T. Freymueller, K. A. Echelmeyer, and E. R. Ivins. 2005. Rapid viscoelastic uplift in Southeast Alaska caused by post-Little Ice Age glacial retreat. *Earth and Planetary Science Letters* 237:548-560.

Lertzman, K. and A. MacKinnon. 2013. Why watersheds: evaluating the protection of undeveloped watersheds as a conservation strategy in northwestern North America, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 189-226. University of Washington Press, Seattle, WA.

Liston, G. E. and C. A. Hiemstra. 2011. The Changing Cryosphere: Pan-Arctic Snow Trends (1979–2009). *Journal of Climate* 24:5691-5712.

MacDonald, S. O. and J. A. Cook. 1996. The land mammal fauna of Southeast Alaska. *Canadian Field-Naturalist* 110:571-598.

Mann, M. E. 2002. Little ice age. *Encyclopedia of global environmental change* 1:504-509.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102:187-223.

Mote, P., E. Parson, A. Hamlet, W. Keeton, D. Lettenmaier, N. Mantua, E. Miles, D. Peterson, D. Peterson, R. Slaughter, and A. Snover. 2003. Preparing for climatic change: The water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45-88.

Muhar, S. and M. Jungwirth. 1998. Habitat integrity of running waters—assessment criteria and their biological relevance. *Hydrobiologia* 386:195-202.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. *BioScience* 50:996-1011.

Naiman, R. J., P. A. Bisson, R. G. Lee, and M. G. Turner. 1997. Approaches to management at the watershed scale, In *Creating a Forestry for the 21st Century: The Science of Ecosystem Management*. K. Kohm and J. F. Franklin eds., pp. 239-253. Island Press, Washington, DC.

Neuheimer, A. B. and C. T. Taggart. 2007. The growing degree-day and fish size-at-age: The overlooked metric. *Canadian Journal of Fisheries and Aquatic Sciences* 64:375-385.

NOAA: National Marine Fisheries Service: Alaska Regional Office. 2014. Alaska ShoreZone Coastal Mapping and Imagery. Juneau, Alaska. Accessed online at http://alaskafisheries.noaa.gov/shorezone/.

Pess, G. R., D. R. Montgomery, E. A. Steel, R. E. Bilby, B. E. Feist, and H. M. Greenberg. 2002. Landscape characteristics, land use, and coho salmon (*Oncorhynchus kisutch*) abundance, Snohomish River, Wash., USA. *Canadian Journal of Fisheries and Aquatic Sciences* 59:613-623.

Plivelich, M. 2014. Southeast Alaska Hydrography (SEAK Hydro) Database Snapshot. University of Alaska Southeast, Juneau. Accessed online at http://seakgis03.alaska.edu/geoportal/catalog/search/resource/details.page?uuid=%7B9CAFFBF1-F1D0-4A25-8FD1-6CDCA89B051A%7D.

Poiani, K. A., B. D. Richter, M. G. Anderson, and H. E. Richter. 2000. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. *BioScience* 50:133-146.

Pringle, C. M. 2001. Hydrologic connectivity and the management of biological reserves: A global perspective. *Ecological Applications* 11:981-998.

Radic, V. and G. K. Clarke. 2011. Evaluation of IPCC models' performance in simulating late-twentieth-century climatologies and weather patterns over North America. *Journal of Climate* 24:5257-5274.

Rennert, K. J., G. Roe, J. Putkonen, and C. M. Bitz. 2009. Soil thermal and ecological impacts of rain on snow events in the circumpolar Arctic. *Journal of Climate* 22:2302-2315.

Scenarios Network for Alaska and Arctic Planning. 2011a. Projected Monthly Average Temperature 771m AR4. UAF SNAP, Fairbanks, AK. Accessed online at http://www.snap.uaf.edu/datamaps.php.

______. 2011b. Projected Monthly Total Precipitation 771m AR4. UAF SNAP, Fairbanks, AK. Accessed online at http://www.snap.uaf.edu/datamaps.php.

______. 2012. Projected Decadal Averages of Monthly Snow-day Fraction 771 m AR4. UAF SNAP, Fairbanks, AK. Accessed online at http://www.snap.uaf.edu/datamaps.php.

______. 2013. Alaska Climate Change Adaptation Series, Regional Climate Projections: Southeast Alaska. University of Alaska Fairbanks, Fairbanks, AK.

______. 2014a. Historical Monthly and Derived Precipitation Products - 771 m CRU TS. UAF SNAP, Fairbanks, AK. Accessed online at http://ckan.snap.uaf.edu/dataset/historical-monthly-and-derived-precipitation-products-771m-cru-ts.

______. 2014b. Historical Monthly and Derived Temperature Products - 771 m CRU TS. UAF SNAP, Fairbanks, AK. Accessed online at http://data.snap.uaf.edu/data/Base/AK_771m/historical/CRU_TS/Historical_Monthly_and_Derived_Temperature_Products_771m_CRU_TS/.

Scenarios Network for Alaska and Arctic Planning. 2014. SNAP Planning. University of Alaska Fairbanks. Accessed online at https://www.snap.uaf.edu/.

Schoen, J. and E. Dovichin eds. 2007. *The Coastal Forests and Mountains Ecoregion of Southeastern Alaska and the Tongass National Forest: A Conservation Assessment and Resource Synthesis*. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Schoen, J. W. and M. D. Kirchhoff. 1985. Seasonal distribution and home-range patterns of Sitka black-tailed deer on Admiralty Island, Southeast Alaska. *The Journal of Wildlife Management* 49:96-103.

Shanley, C. S. and D. M. Albert. 2014. Climate change sensitivity index for Pacific salmon habitat in Southeast Alaska. *PLoS ONE* 9:e104799.

Silberling, N. J., D. L. Jones, J. W. H. Monger, P. J. Coney, H. C. Berg, and G. Plafker. 1994. Lithotectonic terrane map of Alaska and adjacent parts of Canada, In *The Geology of Alaska.* G. Plafker and H. C. Berg eds. Geological Society of America, Boulder, CO.

Taylor, S. G. 2008. Climate warming causes phenological shift in pink salmon, *Oncorhynchus gorbuscha*, behavior at Auke Creek, Alaska. *Global Change Biology* 14:229-235.

Tongass National Forest. 1997. Value Comparison Units. Tongass National Forest, Ketchikan, AK.

US Fish and Wildlife Service. 2016. National Wetlands Inventory. USFWS, Madison, WI. Accessed online at http://www.fws.gov/wetlands/Data/Data-Download.html.

US Fish and Wildlife Service: National Wetlands Inventory. 2006. Tongass Wetlands Inventory. Accessed online at http://seakgis03.alaska.edu/geoportal/catalog/search/resource/details.page?uuid=%7B3833D5CE-0D2B-4606-8824-A76030BEEF5F%7D.

US Forest Service. 2008. Tongass National Forest Land and Resource Management Plan. US Forest Service, Juneau, AK.

US Forest Service. 2012. Karst and Cave Ecosystems, *In Tongass Monitoring and Evaluation Report*. Tongass National Forest, Ketchikan, AK.

Willson, M. F. and K. C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. *Conservation Biology* 9:489-497.

Nick Jans

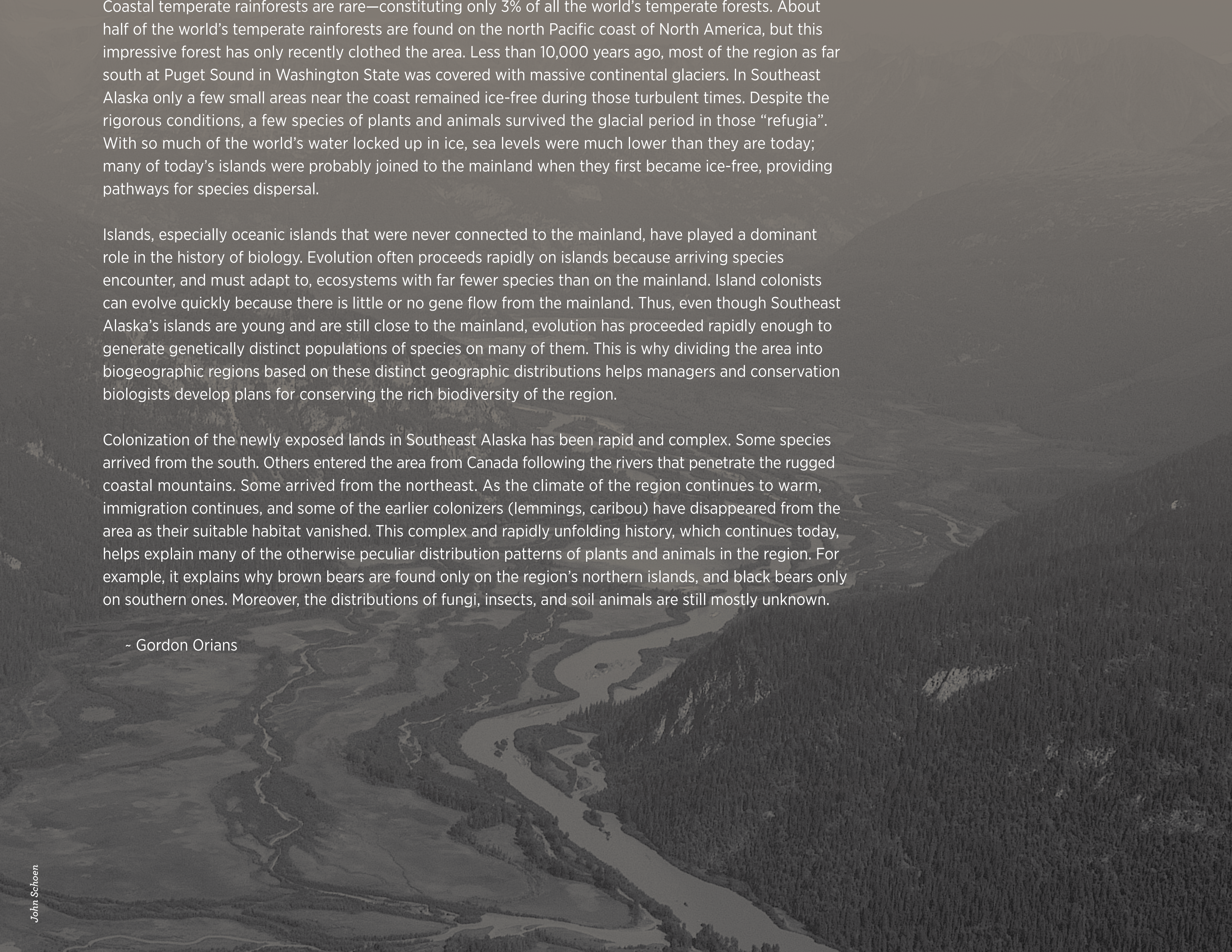
BIOLOGICAL SETTING

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

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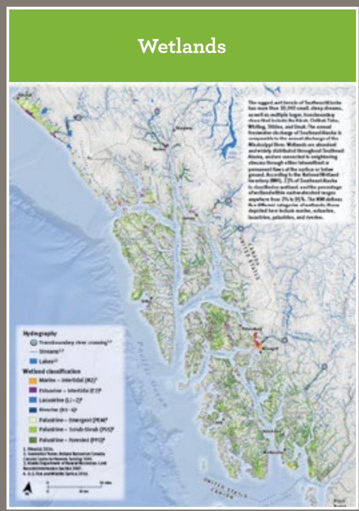

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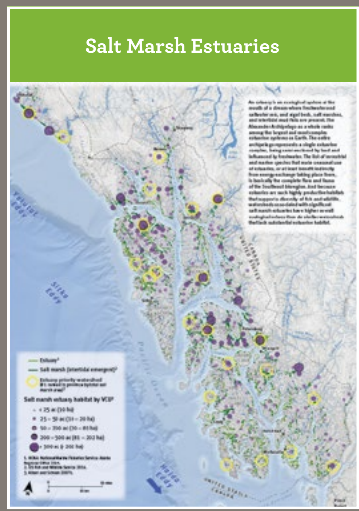

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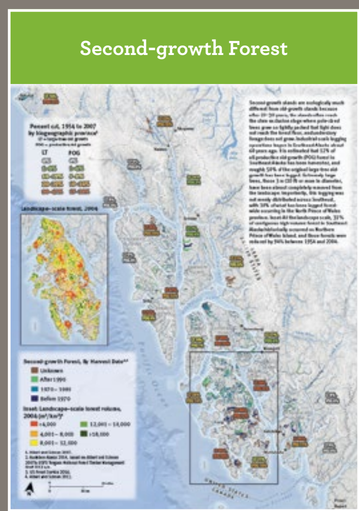

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BIOGEOGRAPHIC PROVINCES

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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John Schoen

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

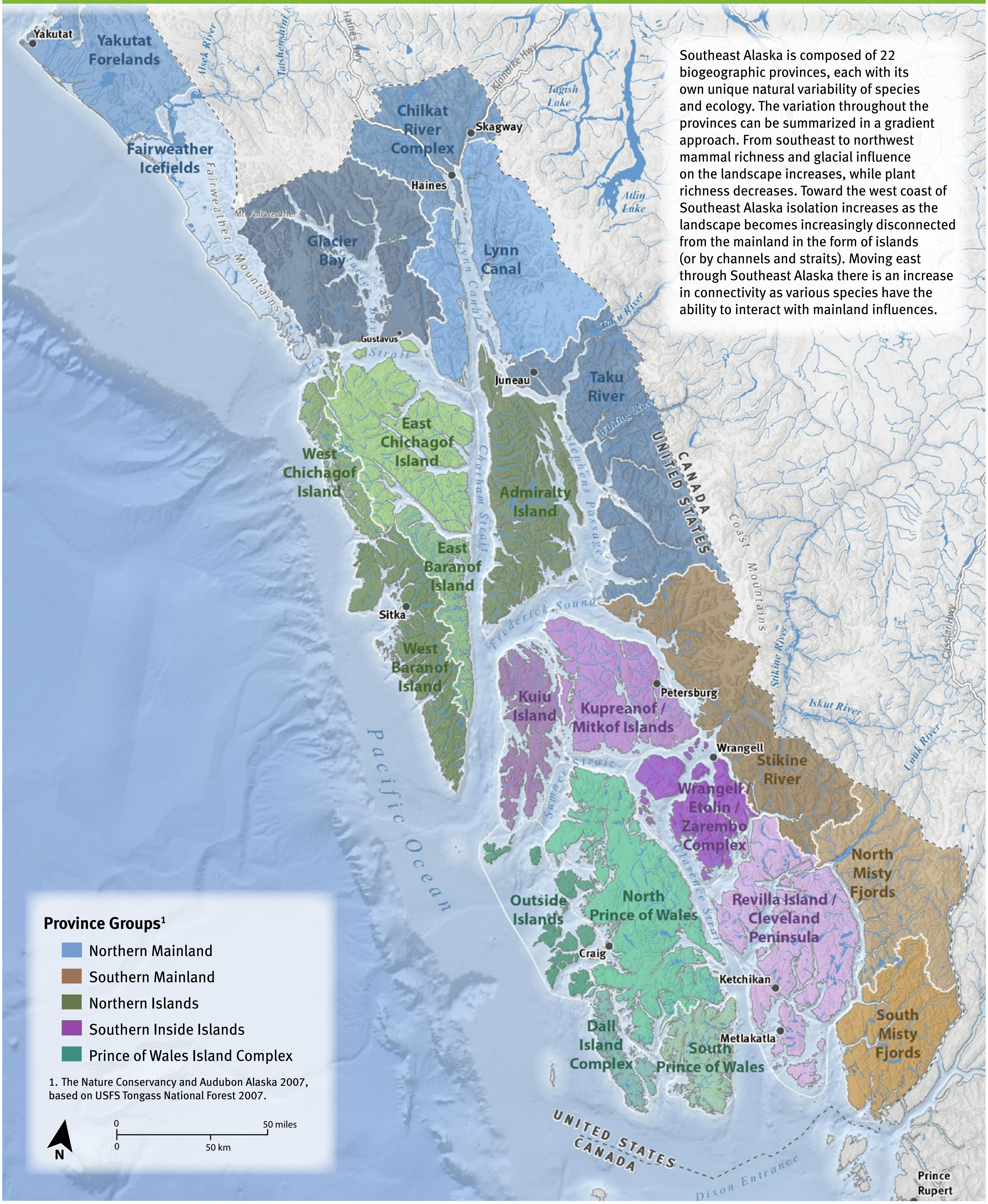
- Biogeographic Provinces: The Nature Conservancy and Audubon Alaska (2007), based on USFS Tongass National Forest (2007).

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

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.

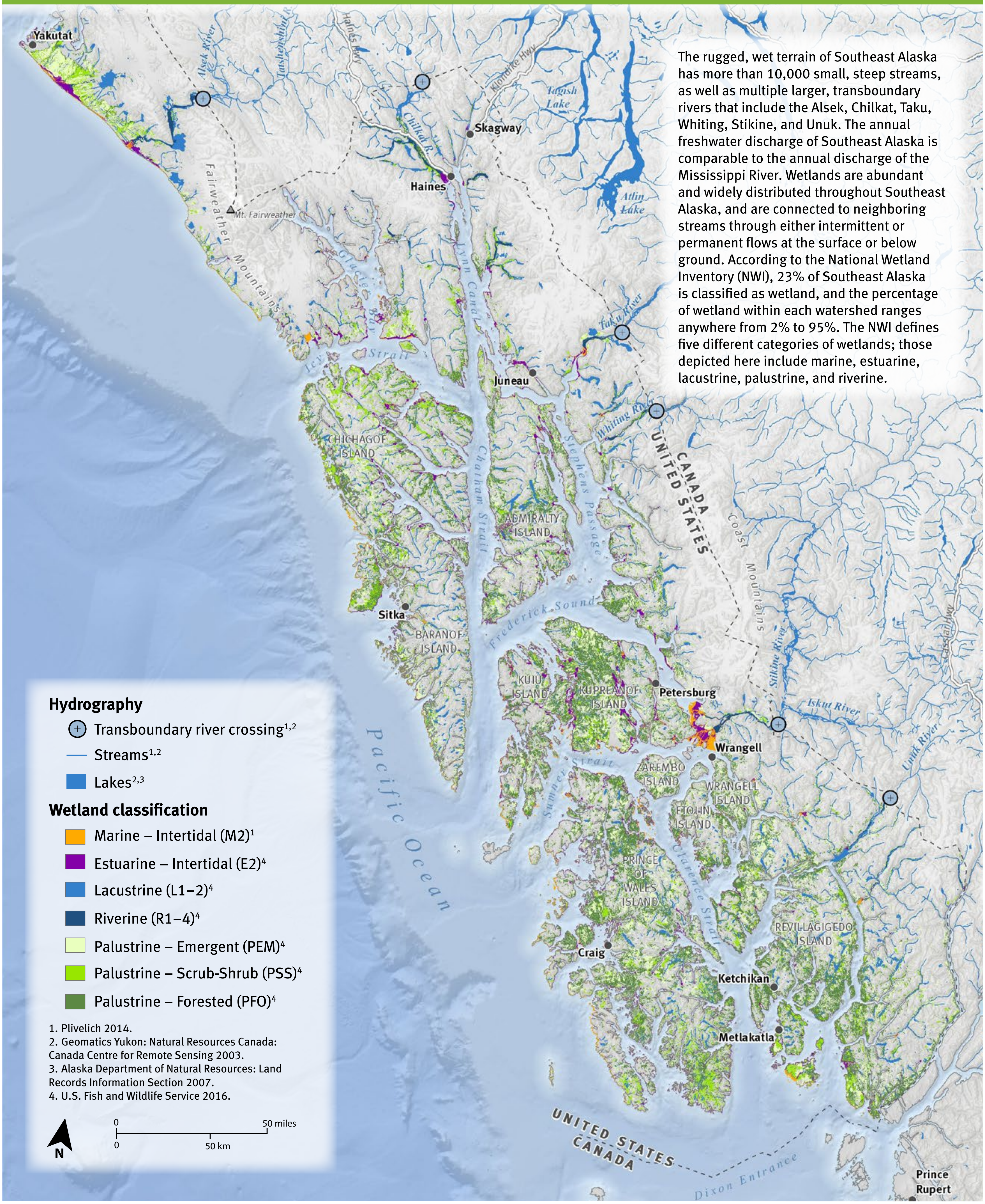
MAP DATA SOURCES

- 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 freshwater 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.

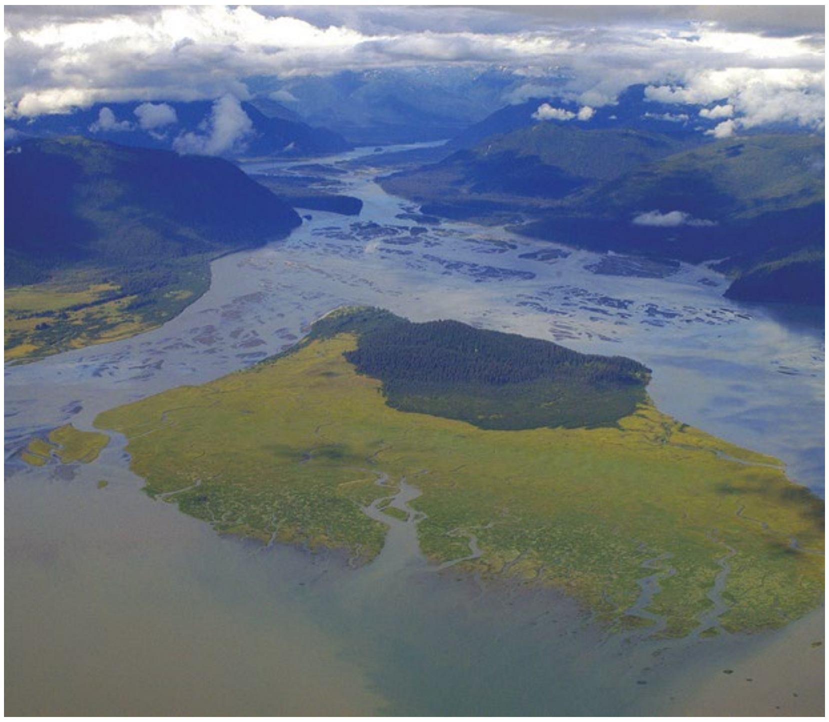
In many watersheds, estuaries and floodplains are small, because most watersheds are small and primarily rain-fed. In Southeast Alaska, estuaries fed by rivers, rain, glaciers, and snowpack are common, and can be very large, such as the mouths of the Taku, Chilkat, and Stikine rivers. The Alexander Archipelago 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.

ESTUARIES 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).

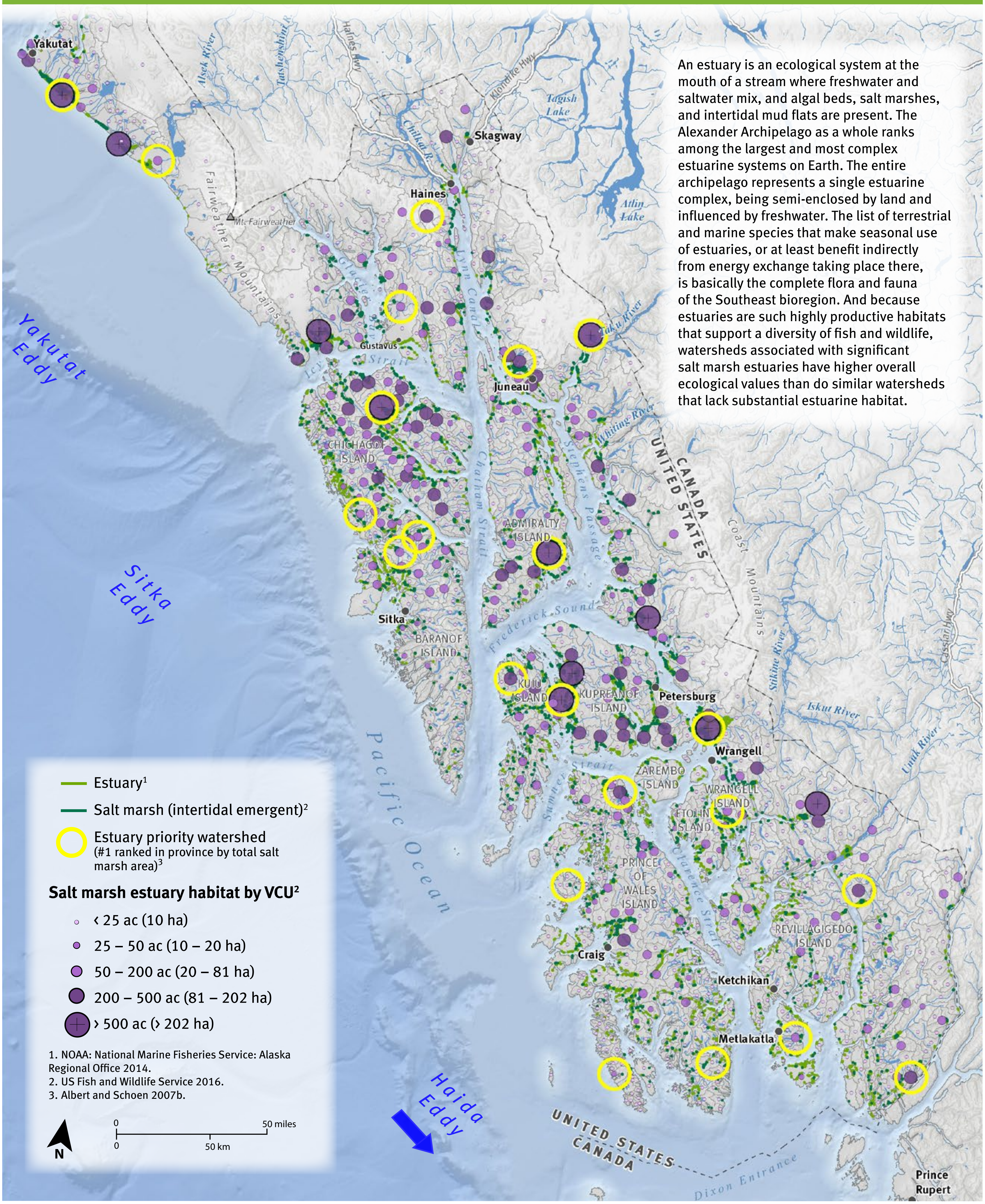
MAP DATA SOURCES

- 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.



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.

LAND COVER & FOREST VEGETATION
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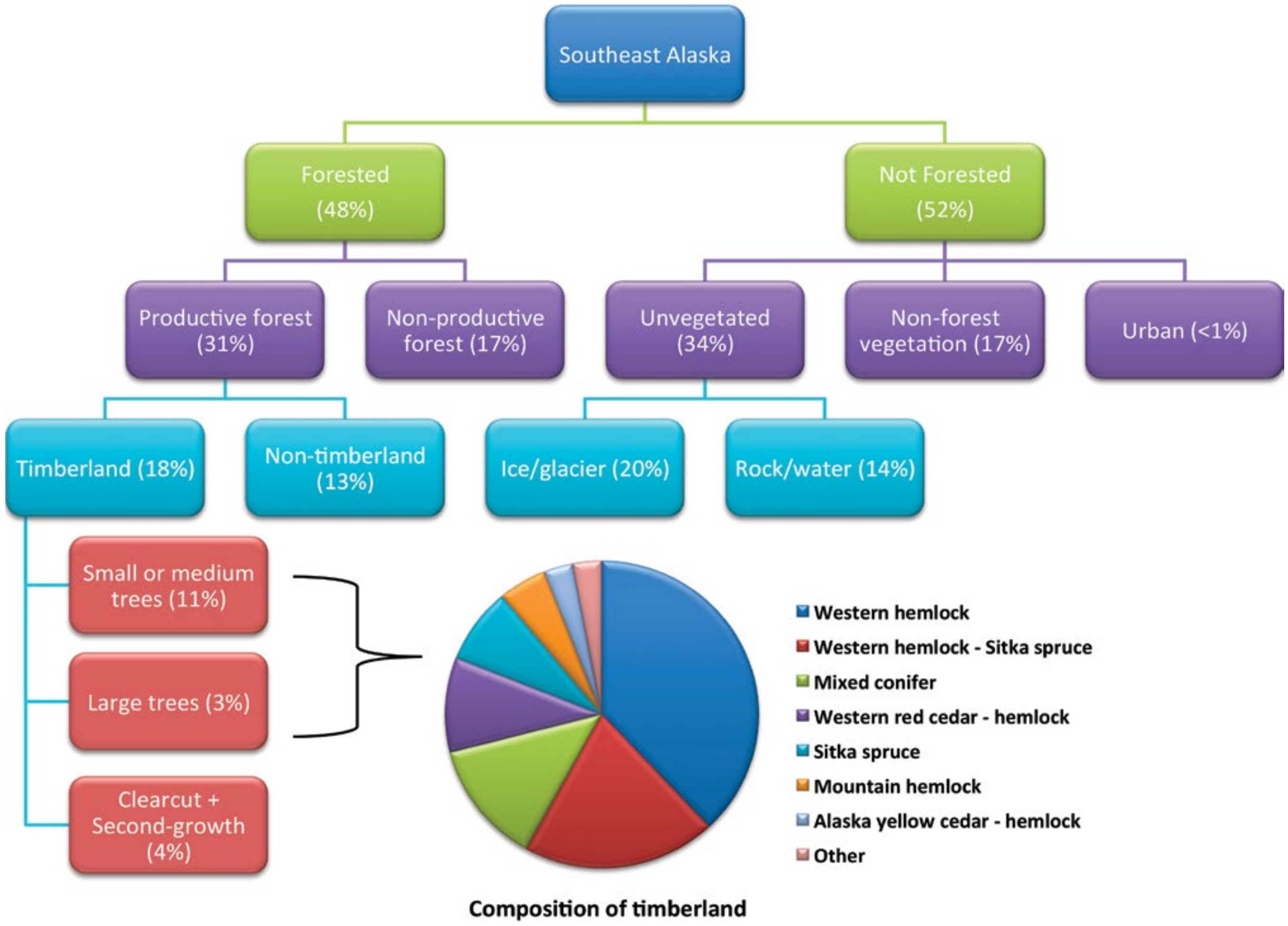

FIGURE 3-1 Land cover classes and timberland composition in Southeast Alaska.

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

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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.

Land Cover Classification[1,2]

- Coniferous Forest: Productive Old Growth
- Coniferous Forest: Other
- Harvested
- Deciduous Forest
- Shrubland
- Herbaceous
- Non–forested, Other
- Ice[3,4]
- Unvegetated

1. 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.
2. US Forest Service 2016.
3. Arendt 2002.
4. BCGOV FLNRO GeoBC 2008.

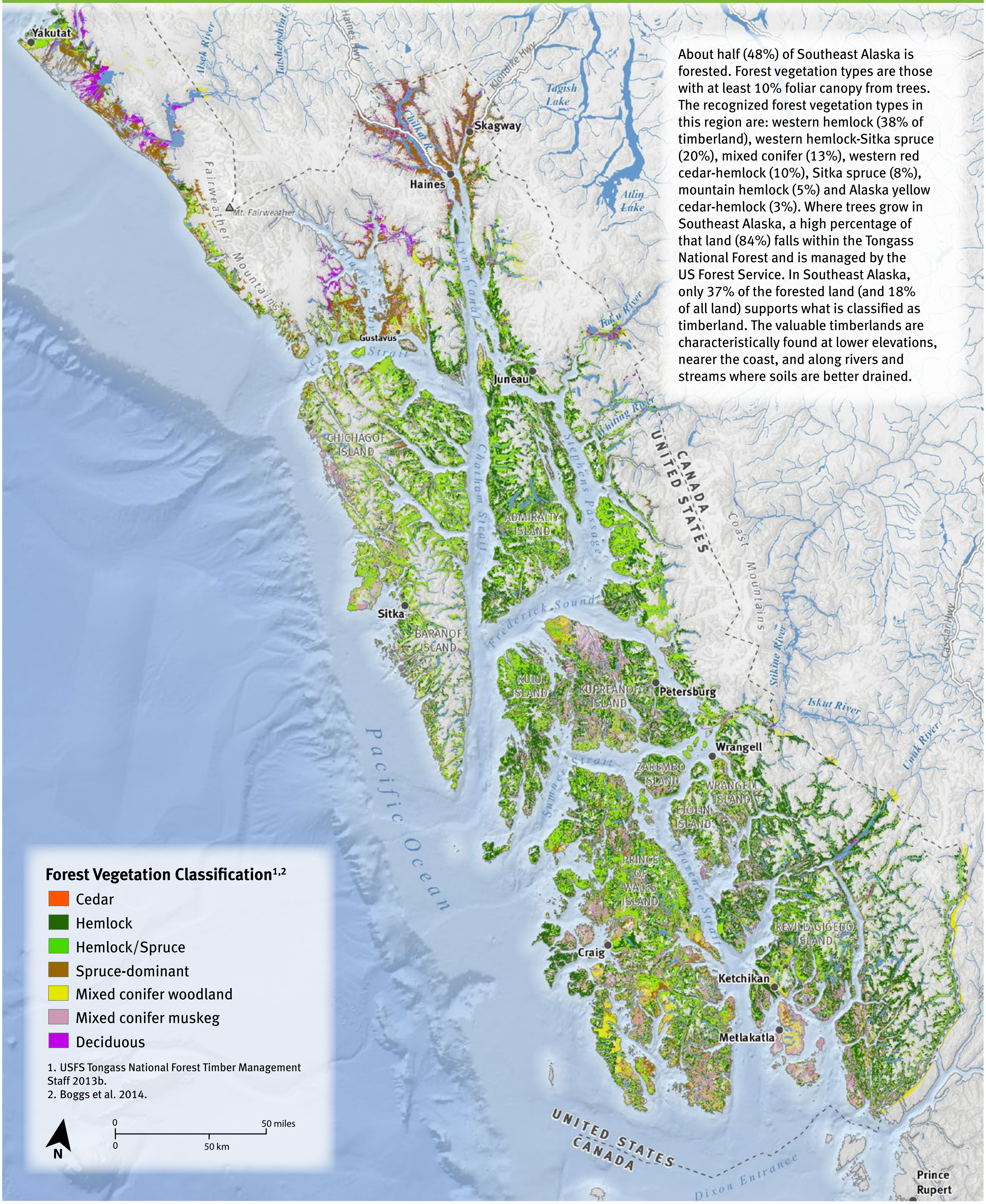
N | 0 — 50 miles | 0 — 50 km

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

OLD-GROWTH & SECOND-GROWTH FOREST
MAPS ON PAGES 55, 56

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).

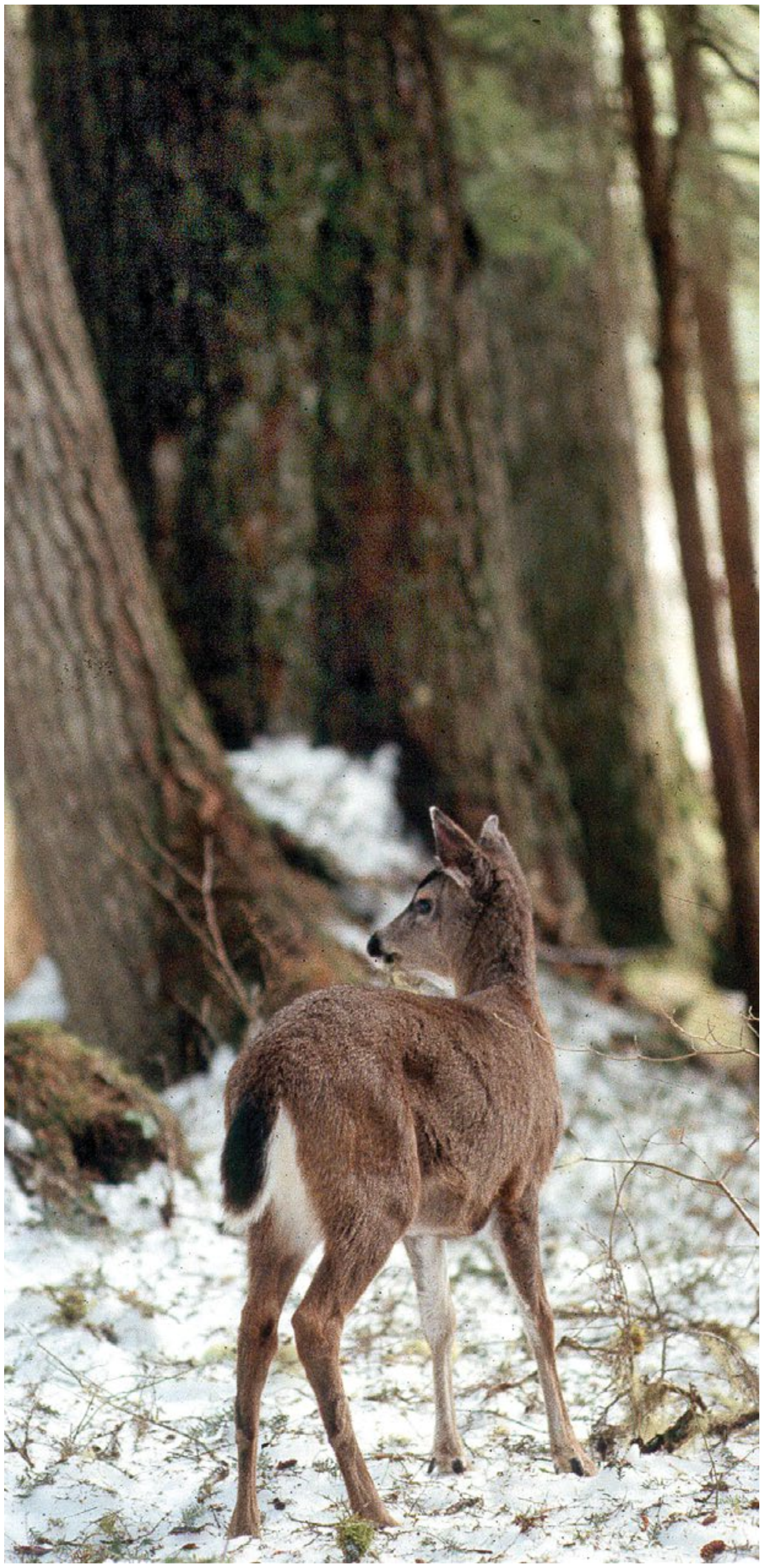
This is a good technical definition, but what is lacking is a sense of the size of the trees in these forest stands, their natural history, and their importance to the ecology of Southeast Alaska. Productive old-growth forest may contain trees that exceed 1,000 years of age; dominant trees typically 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.

- 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.

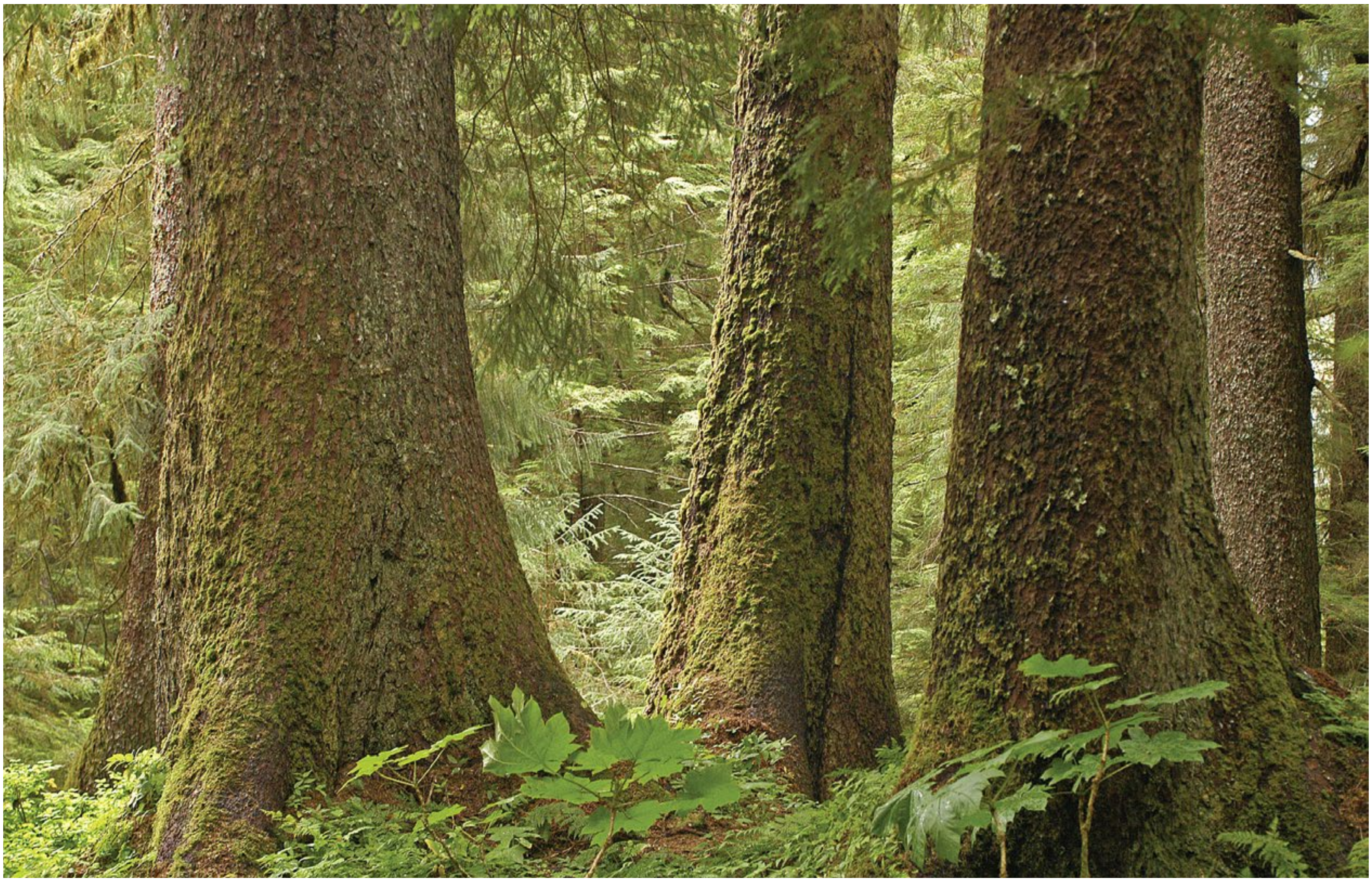
Landscape-scale Forest Change

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.

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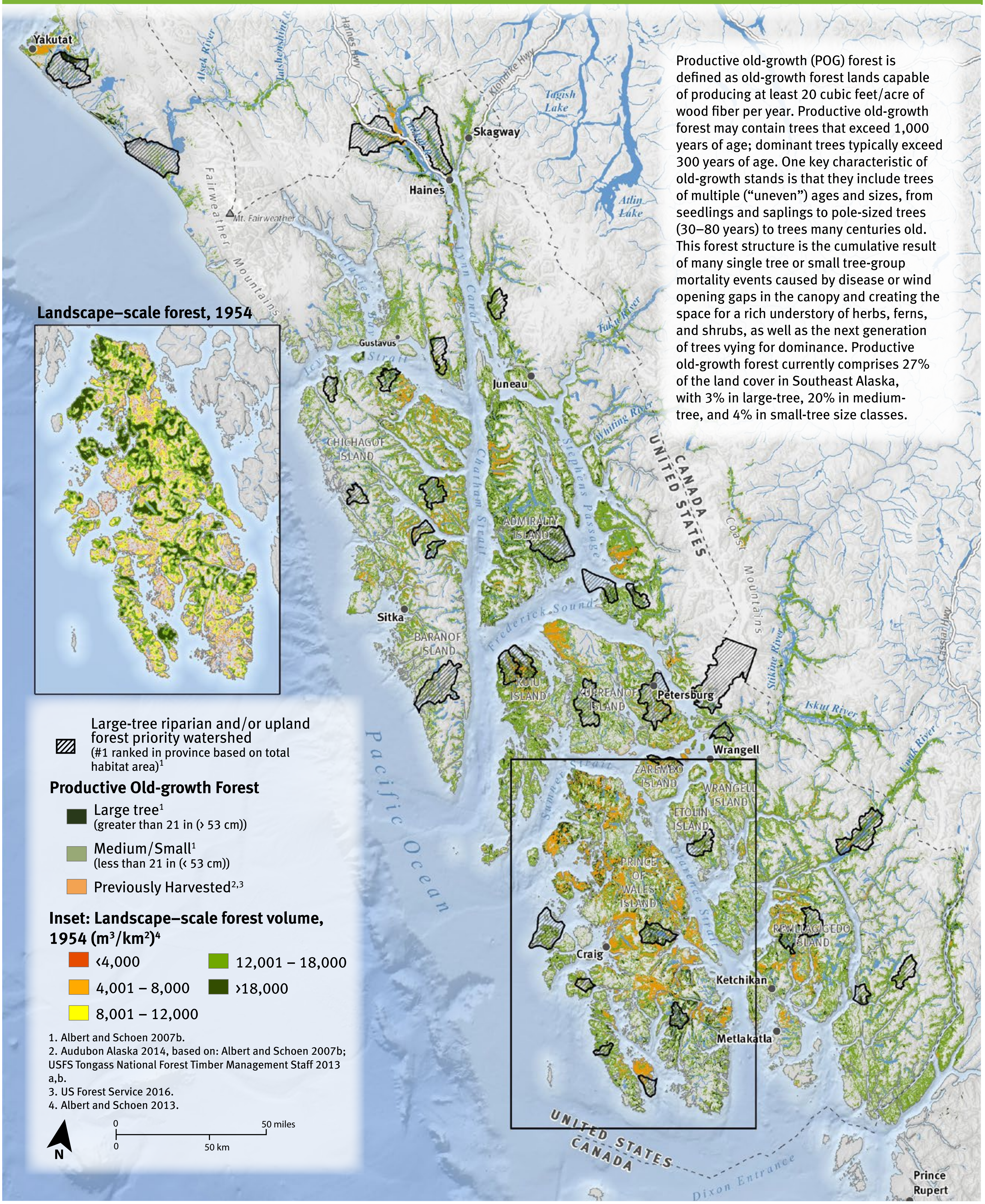
Productive Old-growth Forest

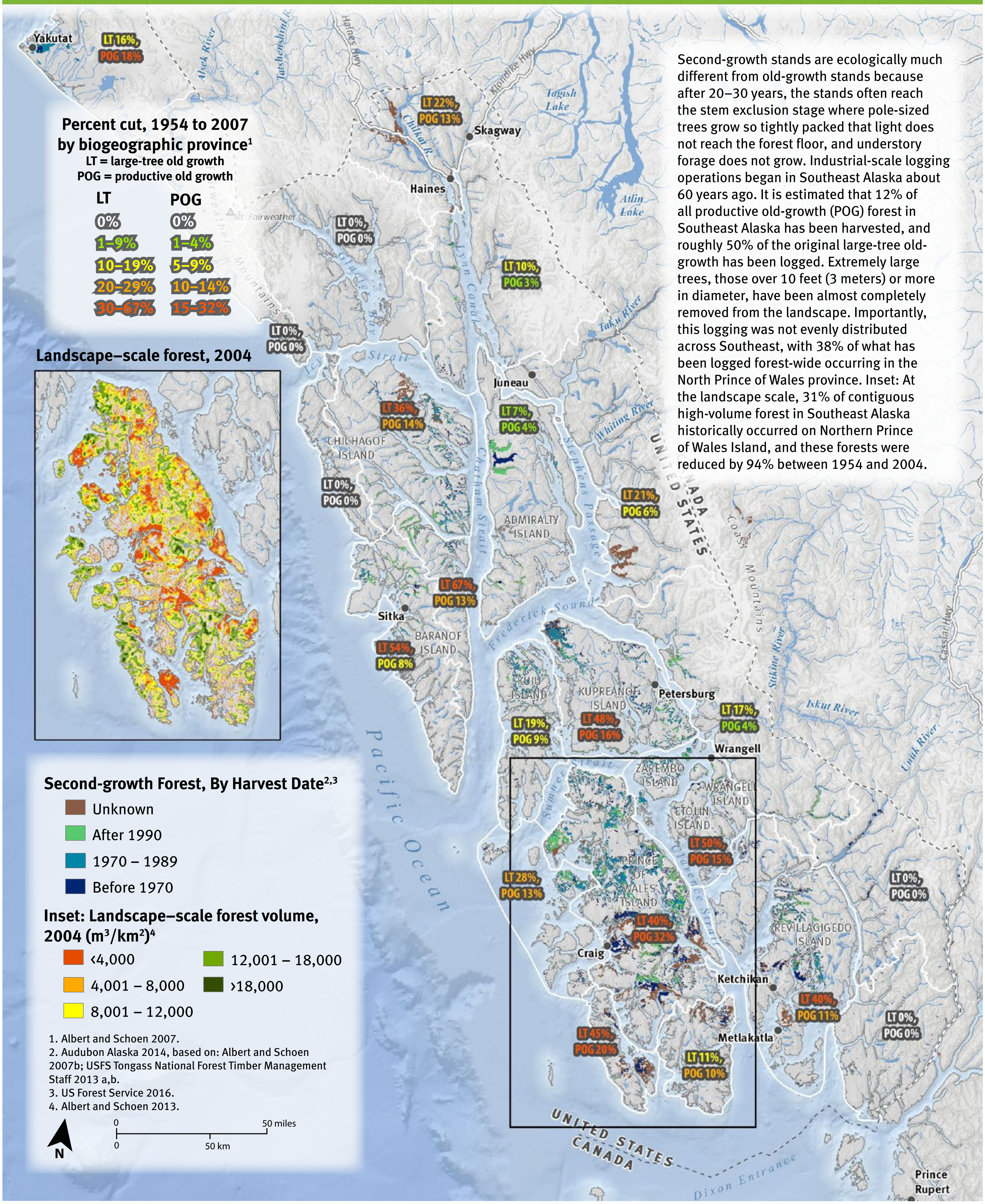
Productive old-growth (POG) forest is defined as old-growth forest lands capable of producing at least 20 cubic feet/acre of wood fiber per year. Productive old-growth forest may contain trees that exceed 1,000 years of age; dominant trees typically exceed 300 years of age. One key characteristic of 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

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.



1. Albert and Schoen 2007.
2. Audubon Alaska 2014, based on: Albert and Schoen 2007b; USFS Tongass National Forest Timber Management Staff 2013 a,b.
3. US Forest Service 2016.
4. Albert and Schoen 2013.

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 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.


Nils Warnock

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

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).

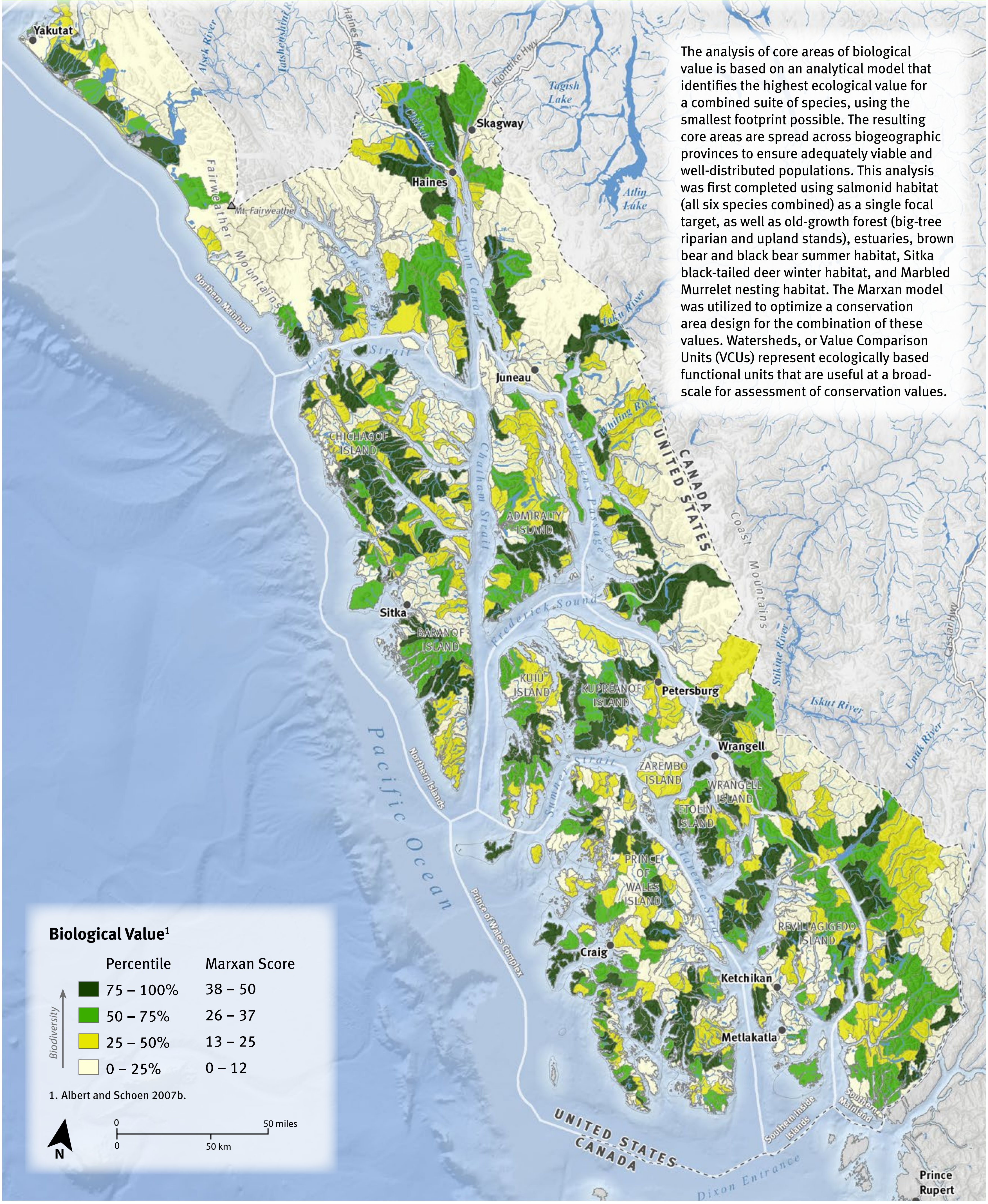
Core Areas of High Biological Value

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

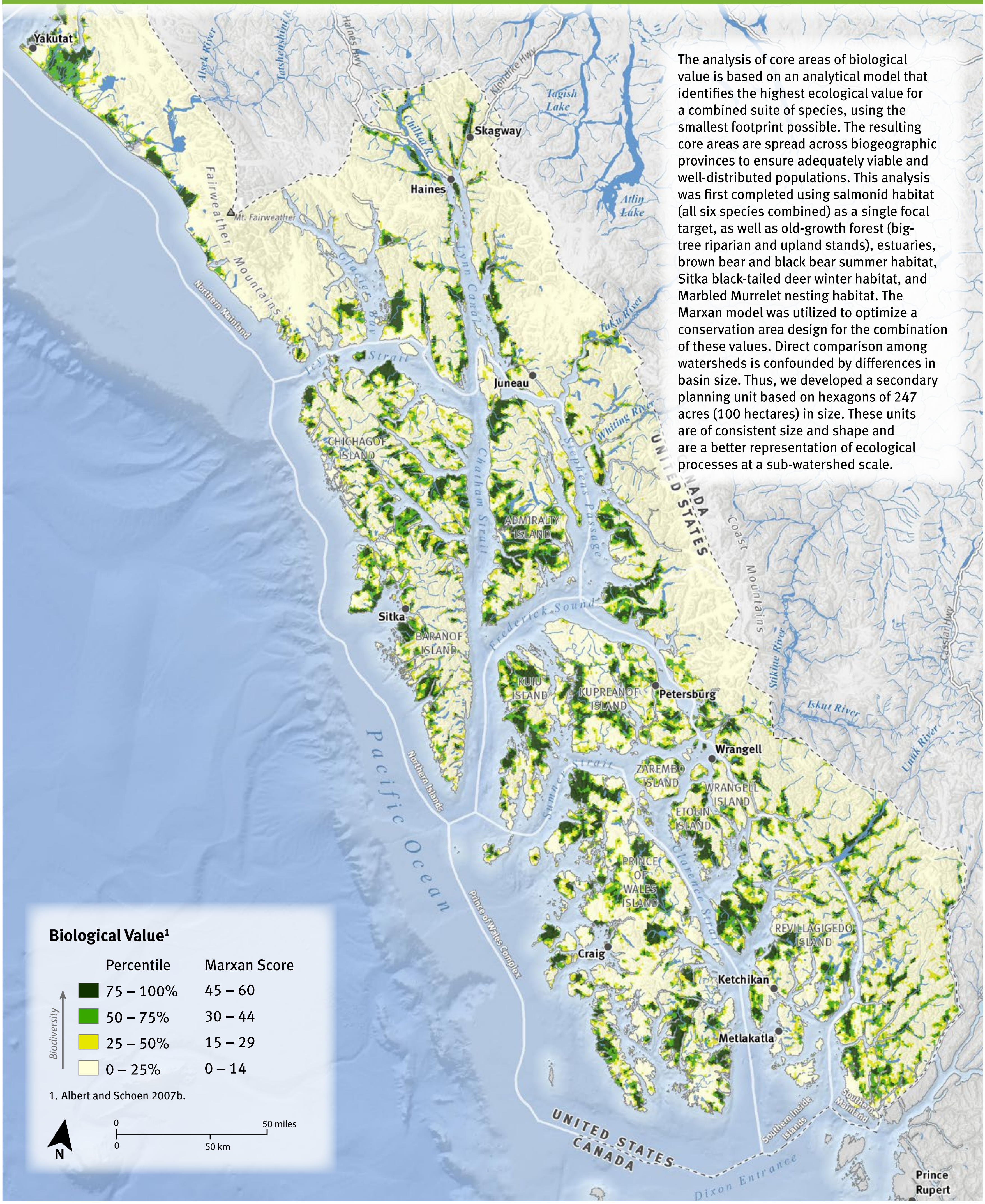
Audubon ALASKA

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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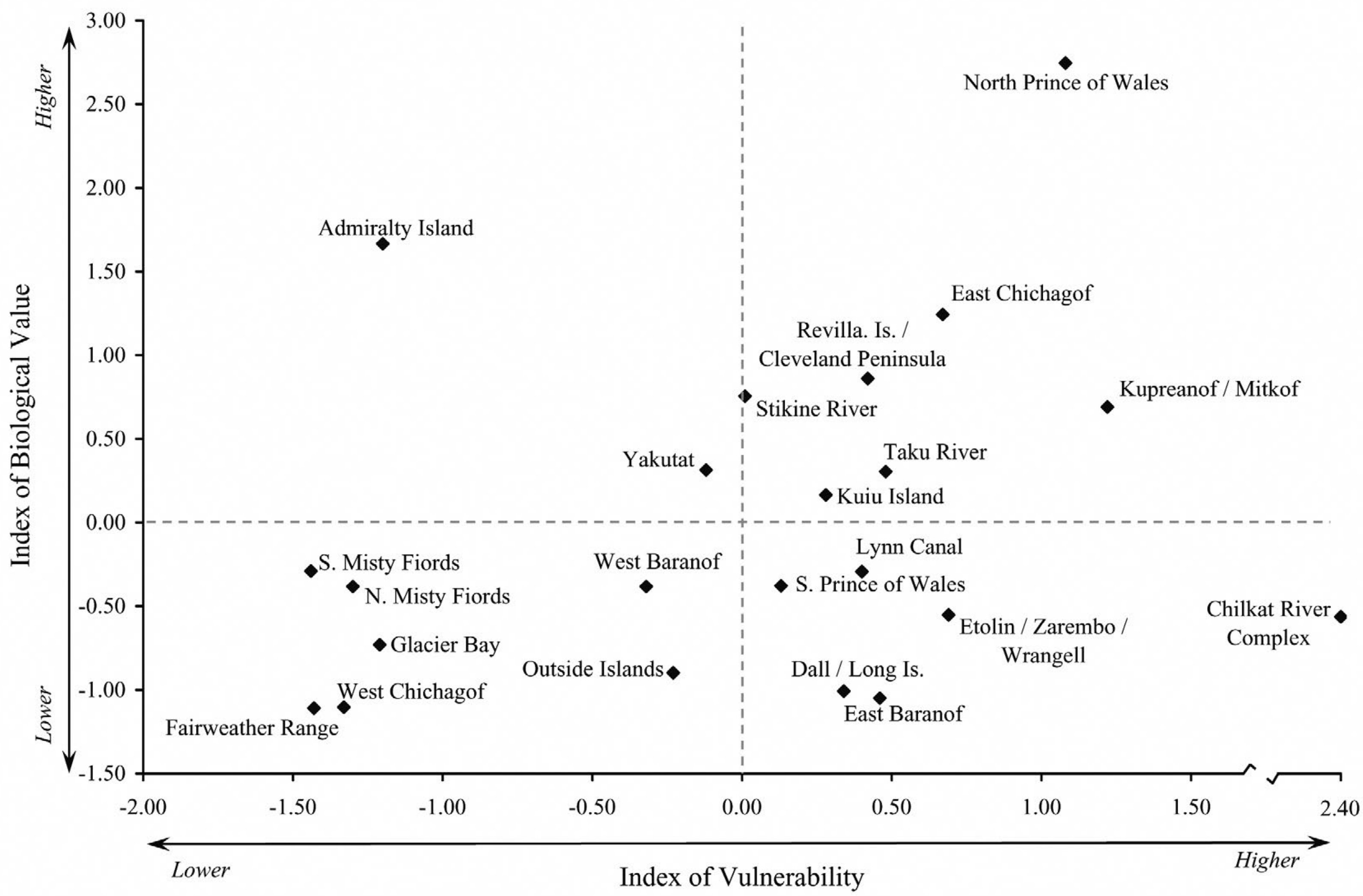
FIGURE 3-2 The index of biological value is a combined index based on relative contribution of each province to the regional distribution of habitat values, and the index of vulnerability reflects the percent of habitat values within each province that are designated within development Land Use Designations (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)]

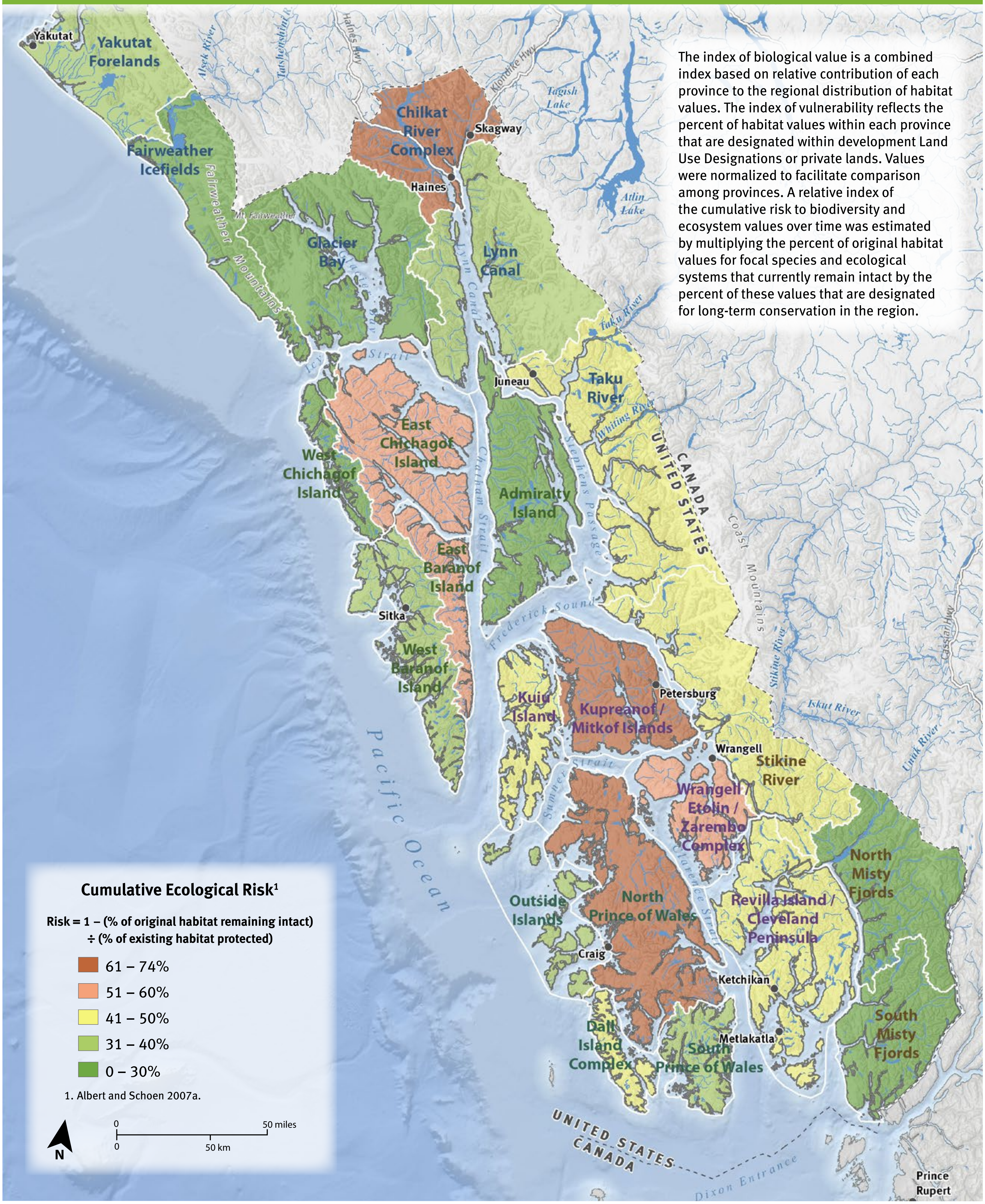
For mapping methods of individual species and focal targets, refer to those maps' summaries in this and other sections.

MAP DATA SOURCES

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

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

REFERENCES

Alaback, P., G. Nowacki, and S. Saunders. 2013. Natural disturbance patterns in the temperate rainforests of Southeast Alaska and adjacent British Columbia, In *North Pacific Temperate Rainforests: Ecology and Conservation*. eds J. W. Schoen, and G. H. Orians, pp. 73–88. University of Washington Press, Seattle, WA.

Alaback, P. B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. *Ecology* 63:1932-1948.

Albert, D. M., and J. W. Schoen. 2006. The Preliminary Classification of Terrestrial Ecosystems in Southeast Alaska.

Albert, D. M., and J. W. Schoen. 2007a. A comparison of relative biological value, habitat vulnerability, and cumulative ecological risk among biogeographic provinces in Southeastern Alaska, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. eds J. W. Schoen, and E. Dovichin. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

______. 2007b. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. eds J. W. Schoen, and E. Dovichin. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

______. 2013. Use of historical logging patterns to identify disproportionately logged ecosystems within temperate rainforests of southeastern Alaska. *Conservation Biology* 27:774–784.

Arendt, A. 2002. AK Hydro Glaciers in Southeast Alaska. Geophysical Institute, University of Alaska Fairbanks, Fairbanks, Alaska. Accessed online at http://seakgis03.alaska.edu/geoportal/catalog/search/resource/details.page?uuid=%7B92443F14-29A3-42B3-9CC8-8FED56E2E61E%7D.

Audubon Alaska. 2014. Southeast Alaska Second Growth. Audubon Alaska, Anchorage, AK.

Audubon Alaska, The Nature Conservancy, United States Forest Service, Province of British Columbia, GeoBase, United States Geological Survey, Glacier Bay National Park, and D. Leversee. 2012. Transboundary Land Classification. Audubon Alaska, Anchorage, Alaska.

BC Ministry of Forests: Lands and Natural Resource Operations. 2011. Baseline Thematic Mapping Present Land Use, version 1. Accessed online at http://catalogue.data.gov.bc.ca/dataset/baseline-thematic-mapping-present-land-use-version-1-spatial-layer.

BCGOV FLNRO GeoBC. 2008. Freshwater Atlas Glaciers. Accessed online at https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50638&recordSet=ISO19115.

BCGOV FOR Forest Analysis and Inventory Branch. 2011. VRI - Forest Vegetation Composite Polys and Rank 1 Layer. Accessed online at https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=62399&recordSet=ISO19115.

Boggs, K., T. V. Boucher, and T. Kuo. 2014. Vegetation Map and Classification: Southern Alaska and Aleutian Islands. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, Alaska.

Brady, W. W., and T. A. Hanley. 1984. The role of disturbance in old-growth forests: Some theoretical implications for Southeastern Alaska, In *Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium (Juneau, Alaska, 12-15 April 1982)*. eds W. R. Meehan, T. R. Merrell Jr, and T. A. Hanley, pp. 213-218. American Institute of Fishery Research Biologists, Morehead City, NC.

Caouette, J., and E. J. DeGayner. 2005. Predictive mapping for tree sizes and densities in Southeast Alaska. *Landscape and Urban Planning* 72:49-63.

Carey, A. B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. *Ecological Applications* 5:648-661.

Carstensen, R. 2013. Sealaska lands Bill S 340. Global treasures in the karst and cedar shell game.

Cook, J., and S. MacDonald. 2001. Should endemism be a focus of conservation efforts along the North Pacific Coast of North America? *Biological Conservation* 97:207-213.

Cook, J. A., N. G. Dawson, and S. O. MacDonald. 2006. Conservation of highly fragmented systems: The north temperate Alexander Archipelago. *Biological Conservation* 133:1-15.

Csuti, B., S. Polasky, P. H. Williams, R. L. Pressey, J. D. Camm, M. Kershaw, A. R. Kiester, B. Downs, R. Hamilton, and M. Huso. 1997. A comparison of reserve selection algorithms using data on terrestrial vertebrates in Oregon. *Biological Conservation* 80:83-97.

DellaSala, D. A. 2011. *Temperate and Boreal Rainforests of the World: Ecology and Conservation*. Island Press, Washington, DC.

DellaSala, D. A., J. C. Hagar, K. A. Engel, W. C. McComb, R. L. Fairbanks, and E. G. Campbell. 1996. Effects of silvicultural modifications of temperate rainforest on breeding and wintering bird communities, Prince of Wales Island, Southeast Alaska. *Condor* 98:706-721.

Doerr, J. G., E. J. Degayner, and G. Ith. 2005. Winter habitat selection by Sitka black-tailed deer. *The Journal of Wildlife Management* 69:322-331.

Donovan, G. H. 2004. Consumer willingness to pay a price premium for standing-dead Alaska yellow-cedar. *Forest Products Journal* 54:38-42.

Erickson, A. W., B. Hanson, and J. J. Brueggeman. 1982. Black Bear Denning Study, Mitkof Island, Alaska. University of Washington, School of Fisheries, Fisheries Research Institute, Seattle, WA.

Farr, W. A., and A. Harris. 1979. Site index of Sitka spruce along the Pacific coast related to latitude and temperatures. *Forest Science* 25:145-153.

Flatten, C., K. Titus, and R. Lowell. 2001. Northern Goshawk monitoring, population ecology and diet on the Tongass National Forest. Alaska Department of Fish and Game, Anchorage, AK.

Flynn, R., T. Schumacher, and M. Ben-David. 2004. Abundance, prey availability and diets of American martens: Implications for the design of old-growth reserves in Southeast Alaska. US Fish and Wildlife Service final report. Alaska Department of Fish and Game.

Gaston, K., R. Pressey, and C. R. Margules. 2002. Persistence and vulnerability: Retaining biodiversity in the landscape and in protected areas. *Journal of Biosciences* 27:361-384.

Gende, S. M., R. T. Edwards, M. F. Willson, and M. S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. *BioScience* 52:917-928.

Glacier Bay National Park and Preserve. 2008. GLBA Landcover- 2007. Accessed online at https://irma.nps.gov/App/Reference/Profile/2214975.

Halupka, K. C., M. D. Bryant, M. F. Willson, and F. H. Everest. 2000. Biological Characteristics and Population Status of Anadromous Salmon in Southeast Alaska. USDA Forest Service, Pacific Northwest Research Station.

Harris, A. S. 1974. Clearcutting, reforestation and stand development on Alaska's Tongass National Forest. *Journal of Forestry* 72:330-337.

Harris, A. S., and W. A. Farr. 1974a. Forest ecology and timber management, In *The Forest Ecosystem of Southeast Alaska*. eds A. S. Harris, J. S. Hard, and W. R. Meehan. Pacific Northwest Forest and Range Experiment Station, Portland, OR.

______. 1974b. The Forest Ecosystem of Southeast Forest Ecology and Timber Management. US Forest Service, Pacific Northwest Forest and Range Experiment Station, Juneau, AK.

Harris, A. S., and W. A. Farr. 1979. Timber Management and Deer Forage in Southeast Alaska. US Forest Service, Region 10, Juneau, AK.

Heifetz, J., M. L. Murphy, and K. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. *North American Journal of Fisheries Management* 6:52-58.

Helfield, J. M., and R. J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. *Ecology* 82:2403-2409.

Hennon, P. E., D. T. Wittwer, J. Stevens, and K. Kilborn. 2000. Pattern of deterioration and recovery of wood from dead yellow-cedar in Southeast Alaska. *Western Journal of Applied Forestry* 15:49-58.

Houde, I., S. Leech, F. L. Bunnell, T. Spribille, and C. Björk. 2007. Old forest remnants contribute to sustaining biodiversity: The case of the Albert River valley. *Journal of Ecosystems and Management* 8:43-52.

Hutchison, O. K., and V. J. LaBau. 1975. The Forest Ecosystem of Southeast Alaska. USDA Forest Service, Portland, OR.

Iverson, G. C., G. Hayward, K. Titus, E. DeGayner, R. Lowell, D. Crocker-Bedford, P. Schempf, and J. Lindell. 1996. Conservation Assessment for the Northern Goshawk in Southeast Alaska. USDA Forest Service. General Technical Report PNW-GTR-387. Pacific Northwest Research Station, Juneau, AK.

Kirchhoff, M. D., and J. W. Schoen. 1987. Forest cover and snow: Implications for deer habitat in Southeast Alaska. *The Journal of Wildlife Management* 51:28-33.

Leslie, H., M. Ruckelshaus, I. R. Ball, S. Andelman, and H. P. Possingham. 2003. Using siting algorithms in the design of marine reserve networks. *Ecological Applications* 13:185-198.

Mackovjak, J. 2011. Tongass Timber: A History of Logging and Timber Utilization in Southeast Alaska. *Environmental History* 16:719-720.

Margules, C. R., and R. L. Pressey. 2000. Systematic conservation planning. *Nature* 405:243-253.

Maser, C., and Z. Maser. 1988. Interactions among squirrels, mycorrhizal fungi, and coniferous forests in Oregon. *Western North American Naturalist* 48:358-369.

Murphy, M. L. 1985. Die-offs of pre-spawn adult pink salmon and chum salmon in southeastern Alaska. *North American Journal of Fisheries Management* 5:302-308.

Murphy, M. L., J. Heifetz, S. W. Johnson, K. V. Koski, and J. F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. *Canadian Journal of Fisheries and Aquatic Sciences* 43:1521-1533.

Murphy, M. L., and K. V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. *North American Journal of Fisheries Management* 9:427-436.

Nie, M. 2006. Governing the Tongass: National forest conflict and political decision making. *Environmental Law* 36(2):385–481.

Noss, R. F., M. O'Connell, and D. D. Murphy. 1997. *The Science of Conservation Planning: Habitat Conservation Under the Endangered Species Act*. Island Press.

Olson, S. 1979. The Life and Times of the Black-tailed Deer in Southeast Alaska. US Forest Service, Juneau, AK.

Person, D. K., and A. L. Russell. 2009. Reproduction and den site selection by wolves in a disturbed landscape. *Northwest Science* 83:211-224.

Poiani, K. A., B. D. Richter, M. G. Anderson, and H. E. Richter. 2000. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. *BioScience* 50:133-146.

Possingham, H., I. Ball, and S. Andelman. 2000. Mathematical methods for identifying representative reserve networks, In *Quantitative Methods for Conservation Biology*. ed. M. B. Scott Ferson, pp. 291-305. Springer-Verlag, New York.

Pressey, R., I. Johnson, and P. Wilson. 1994. Shades of irreplaceability: towards a measure of the contribution of sites to a reservation goal. *Biodiversity & Conservation* 3:242-262.

Price, K., A. Roburn, and A. MacKinnon. 2009. Ecosystem-based management in the Great Bear Rainforest. *Forest Ecology and Management* 258:495-503.

Schoen, J. W., and M. D. Kirchhoff. 1990. Seasonal habitat use by Sitka black-tailed deer on Admiralty Island, Alaska. *The Journal of Wildlife Management* 54:371-378.

Scrivener, J., and M. Brownlee. 1989. Effects of forest harvesting on spawning gravel and incubation survival of chum (*Oncorhynchus keta*) and coho salmon (*O. kisutch*) in Carnation Creek, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 46:681-696.

Talbot, S. L., and G. F. Shields. 1996a. A phylogeny of the bears (*Ursidae*) inferred from complete sequences of three mitochondrial genes. *Molecular Phylogenetics and Evolution* 5:567-575.

Talbot, S. L., and G. F. Shields. 1996b. Phylogeography of brown bears (*Ursus arctos*) of Alaska and paraphyly within the Ursidae. *Molecular Phylogenetics and Evolution* 5:477-494.

The Nature Conservancy, and Audubon Alaska. 2007. Biogeographic Provinces of Southeast Alaska. Audubon Alaska, Anchorage, Alaska.

The Nature Conservancy of Alaska. 2006. Preliminary Classification of Terrestrial Ecosystems in Southeast Alaska. Anchorage, AK.

Tschaplinski, P., and G. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. *Canadian Journal of Fisheries and Aquatic Sciences* 40:452-461.

US Forest Service. 2008a. Tongass Land and Resource Management Plan, Final Environmental Impact Statement, Plan Amendment, Record of Decision. US Forest Service, Washington, DC.

______. 2008b. Tongass Land and Resource Management Plan, Final Environmental Impact Statement, Plan Amendment, Volume I. 1:R10-MB-603c. US Forest Service, Juneau, AK.

______. 2008c. Tongass National Forest Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 2016. Timber Harvests (S_USA.Activity_TimberHarvest). FSGeodata Clearinghouse. Accessed online at http://data.fs.usda.gov/geodata/edw/datasets.php.

USFS Tongass National Forest. 2007. Biogeographic Provinces of the Tongass National Forest. Audubon Alaska, Anchorage, Alaska.

USFS Tongass National Forest, The Nature Conservancy, and Audubon Alaska. 2014. Biogeographic Province Groups of Southeast Alaska. Audubon Alaska, Anchorage, Alaska.

USFS Tongass National Forest Timber Management Staff. 2013a. Tongass National Forest, Activity Polygon. Accessed online at http://seakgis03.alaska.edu/geoportal/rest/document?id=%7B21A93098-2497-4DBB-AE5C-24872DA7EDE0%7D.

______. 2013b. Tongass National Forest, Cover Type, 2013. Ketchikan, Alaska. Accessed online at http://seakgis.alaska.edu/data/CoverType.zip.

van Hees, W. W., and B. R. Mead. 2005. Extensive, strategic assessment of Southeast Alaska's vegetative resources. *Landscape and Urban Planning* 72:25-48.

Viereck, L. A., C. Dyrness, A. Batten, and K. Wenzlick. 1992. The Alaska Vegetation Classification.

Wallmo, O. C., and J. W. Schoen. 1980. Response of deer to secondary forest succession in Southeast Alaska. *Forest Science* 26:448-462.

ANADROMOUS FISH

Many fishes migrate on time scales ranging from daily to annually or longer, and on spatial sales ranging from a few yards to thousands of miles. Many marine fish migrate long distances between areas where they spawn and areas where they feed and grow. Most prime spawning areas are coastal shallow waters where eggs cannot sink to great depths. Many freshwater fishes undergo short migrations from the lakes where they feed to nearby rivers where they spawn. Anadromous fishes feed and grow in the sea but migrate into freshwater to spawn. Catadromous fishes live in freshwater but migrate to the sea to spawn. The best known anadromous fishes are the species of North Pacific salmon. Anadromous fishes predominate at temperate latitudes where oceans are more productive than freshwaters. Catadromous fishes are found primarily in tropical regions were freshwater productivity typically exceeds that of the oceans (Gross et al. 1988).

Anadromous fishes are prominent components of Alaska's freshwater fish fauna owing to the region's isolation from the major North American river drainages. Most of Alaska's freshwater fishes are recent colonists that arrived only after the massive glaciers that covered much the region melted away. Most came from the Pacific Ocean but a few entered from the interior. All of Southeast Alaska's freshwater fishes are anadromous. They vary in how far upstream they migrate, how long they stay in freshwater, and how long they live in the ocean before returning to freshwater to spawn. They are major transporters of marine nutrients to freshwaters and adjacent riparian vegetation. Their decaying bodies feed a variety of terrestrial mammals and birds. While at sea they are important sources of food for seals, sea lions, porpoises, whales, and seabirds. In Southeast Alaska, anadromous fishes are major integrators of terrestrial, freshwater, and marine ecosystems.

~ Gordon Orians

Nils Warnock

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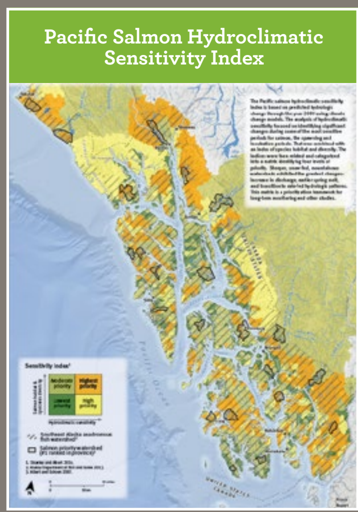

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ANADROMOUS FISH HABITAT

Bob Armstrong, Marge Osborn, Melanie Smith, and Nathan Walker

Anadromous fish are an essential part of Southeast Alaska's ecology and economy. Nine anadromous fish species are abundant in Southeast: king (Chinook; *Onchorhynchus tshawytscha*), red (sockeye; *O. nerka*), silver (coho; *O. kisutch*), pink (humpy; *O. gorbuscha*), and chum (dog; *O. keta*) salmon; steelhead (*O. mykiss*), Dolly Varden (*Salvelinus malma*), and cutthroat trout (*O. clarki*); and eulachon (hooligan; *Thaleichthys pacificus*) (Mecklenberg et al. 2002). A single river system in the region, the Chilkoot, is also known to support Pacific lamprey and an unspecified species of whitefish (Alaska Department of Fish and Game 2013). Bull trout may also be present in the Taku and Stikine, but are likely limited to the Canadian portions of those rivers (COSEWIC 2012).

After hatching, anadromous fish spend months or sometimes years in fresh water before migrating to marine waters to feed and grow in size. Eventually they return to fresh water where they spawn in streams and lakes. Pacific salmon species are semelparous, meaning that they die after spawning, whereas trout species are typically iteroparous (spawn in multiple years), although approximately 75% of steelhead trout die after a single spawning cycle (Alaska Department of Fish and Game 2014g). The cycle is responsible for the idea of the "salmon forest," because fish distribute nutrients, influence the survival of other wildlife, and even affect vegetation along stream banks and in the forest.

Pacific salmon in particular are a major vector for the transport of marine and freshwater nutrients to the forest ecosystem. Millions of salmon carcasses left behind in the forest by wildlife (such as bears) nourish the Sitka spruce-hemlock forests of Southeast Alaska (Willson and Halupka 1995). Following spawning, salmon carcasses release nutrients into the region's rivers and streams, and these nutrients are taken up by aquatic and terrestrial life (Cederholm et al. 1999). Salmon have been termed a keystone species within Southeast Alaska because they provide a resource base that supports much of the coastal ecosystem, including wildlife such as brown and black bears (*Ursus arctos* and *U. americanus*, respectively), Bald Eagles (*Haliaeetus leucocephalus*), and wolves (*Canis lupus*) (Willson et al. 1998). These predators eat anadromous fish eggs, juveniles, live adults, and carcasses. In all, salmon provide forage for more than 40 different species of mammals and birds in fresh waters of Southeast (Willson and Halupka 1995). Salmon also feed saltwater predators such as seabirds, seals, sea lions, porpoises, and orcas.

John Schoen

Pacific salmon are a critical food resource for Alaska's coastal black and brown bear populations. All five species are used wherever they are accessible to bears. Individual bears display many different fishing techniques. Bears are highly selective of fresh salmon and specific fish parts such as eggs and brains which have the highest nutritional value. Bears with access to salmon are larger, more productive, and have smaller home ranges and higher densities than bears without access to salmon.

Anadromous fish have played a major role in the history and economy of Alaska and its commercial, sport, and subsistence fisheries. Commercial harvest of Southeast Alaska salmon began in the late 1870s. In Southeast, harvests of all species except Chinook salmon have increased dramatically since the 1970s. The record total commercial harvest in Southeast was 112.4 million salmon in 2013 (Conrad and Gray 2014). In 2012, the total commercial harvest in Southeast Alaska and Yakutat was 37 million salmon with an estimated ex-vessel value of $157 million. Southeast Alaska salmon are an important subsistence species for Alaskans and are part of the Southeast Alaskan fishing industry worth $1 billion per year.

Despite historic success, fish stocks in Southeast are vulnerable to potential future impacts. The species face an uncertain future from climate change, and increases in human population and development. The numbers of some anadromous fish have decreased in parts of the region because of increasing pressure from anglers. These declines prompted the Alaska Board of Fisheries to reduce bag limits, completely close some systems to harvest, and establish catch-and-release-only fisheries on other streams (Larson 1990, Harding and Jones 1992;1993).

Aside from recent declines in Chinook salmon abundance (Alaska Department of Fish and Game 2015b), most Southeast salmon populations are healthy, as indicated by systematic surveys (Baker et al. 1996, Halupka et al. 2000) and fishery harvest reports (Conrad and Gray 2014). Maintaining intact watersheds is a critical factor in sustaining healthy salmon runs in Southeast (Bryant and Everest 1998). Factors associated with high levels of productivity and abundance include: (1) relatively pristine and undeveloped habitats (since much of the region is inaccessible); (2) successful habitat and salmon management policies within Alaska; (3) enhancement by hatcheries; and (4) favorable environmental conditions (Royce 1989, Meacham and Clark 1994). Marine conditions favorable to high survival of Alaska salmon have contributed to record returns (Beamish and Bouillon 1993, Francis and Hare 1994).

Anadromous fish depend on healthy freshwater habitat for spawning, rearing, and wintering. Because the landscape of Southeast is predominantly forest, the ability to maintain healthy freshwater habitats for anadromous fish is inextricably tied to the health of the forests and watersheds around them. Many of the areas most important to anadromous fish are also those most valued as sources of timber, however, and those forests and watersheds have been or could be exposed to impacts from timber harvest on a large scale. Maintaining a balance between the value and contribution of timber to the regional economy and the value and contribution of anadromous fish, especially salmon, is a major challenge to resource management and political decision-making.

As part of the 2007 Conservation Assessment and Resource Synthesis (Schoen and Dovichin 2007), Audubon Alaska and The Nature Conservancy worked together to develop a science-based process for ranking the ecological values of watersheds within biogeographic provinces across Southeast Alaska. The ability to assess and rank ecological values provides resource managers and conservationists with a tool for setting conservation priorities and evaluating and refining reserve networks.

The condition and management status of floodplain forests associated with anadromous fish streams were evaluated among 22 biogeographic provinces in Southeast Alaska. Based on the assessment, North Prince of Wales Island contained the most anadromous freshwater habitat, followed by Yakutat Forelands, East Chichagof Island, Kupreanof/Mitkof Islands and the Stikine River/Mainland. Anadromous habitat in transboundary watersheds outside of Alaska were not accounted for in the analysis.

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An estimated 20% of the approximately 500,000 ac (202,343 ha) of floodplain forests associated with anadromous fish have been logged since 1954 (Albert and Schoen 2007). The highest proportion of logging of flood plain forests occurred on Baranof Island, North Prince of Wales, the Chilkat River and East Chichagof Island. Regionwide, approximately 52% of anadromous floodplain forests are within non-development designations, with 38% in watershed-scale reserves. Provinces with the lowest representation in watershed-scale reserves include the Chilkat River (0%), North Prince of Wales (9%), Kupreanof/Mitkof (17%), and Dall Island Complex (19%). Provinces with highest levels of watershed-scale protection include Fairweather, Misty Fiords, West Chichagof Island, and Admiralty Island.

Fish are facing and will continue to face additional stresses due to a changing climate. Both an increase and a decrease in flow patterns can negatively affect anadromous fish populations. Warm temperatures in winter result in decreased snowpack as more precipitation falls as rain rather than snow; overall this causes reduced stream flows and thereby elevated stream temperatures (Service 2015). Another aspect of climate change is a shift in the timing of peak flows due to an earlier spring melt, and periods of increased stream flows from faster melting, as well as an increase of rain-fed events (not collecting in the form of slow-melting snow pack). Increased peak discharge can scour streams of eggs and fry which appear to be an important limiting factor for Pacific salmon populations (Shanley and Albert 2014).

Considering the benefits of anadromous fish to the economy and to the lifestyle of Southeast Alaskans, the importance of anadromous fish as food for a diverse assemblage of wildlife, and the indirect benefits of anadromous fish to Southeast ecosystems as a whole, safeguarding fish habitat is an investment worth making.

CONSERVATION ISSUES

Logging can have myriad impacts on anadromous fish habitat, as described by Murphy (1995):

"Salmonid habitat is a product of interactions among the stream, flood-plain, riparian area, and uplands—in short, the entire watershed. Effects of timber harvest, road construction, and other activities anywhere in the watershed can be transmitted through changes in hydrologic and erosional processes to modify habitat for salmonids."

In this report, Murphy (1995) also presented the following recommendations:

- Design buffer zones to protect fish habitat while enabling economic timber production
- Implement effective Best Management Practices (BMPs) to prevent nonpoint-source pollution
- Develop watershed-level procedures across property boundaries to prevent cumulative impacts
- Develop restoration procedures to contribute to recovery of ecosystem processes
- Enlist support of private landowners in watershed planning, protection, and restoration.

Rapid declines of salmon populations in Washington, Oregon, and California were brought about in part by loss of freshwater habitat from dams and watershed damage. A panel of fisheries experts assessed the levels of risk to fish habitat from timber harvest and other activities associated with management alternatives in the 1997 Tongass Land Management Plan revision. Panel evaluators identified Prince of Wales Island, Kupreanof Island, Kuiu Island, and Chichagof Island as currently having road densities high enough to warrant concern for maintaining adequate fish habitat. The panel stated in conclusion that, "A reduction of road development in any alternative reduces risks to fish habitat." The panel expressed five primary issues of concern (Dunlap 1997):

1. Roads may have negative effects on fish habitat. These effects could come from sedimentation when roads are constructed on slopes that are too steep. Stream-crossing structures, especially culverts, may block movement of juvenile fish and result in a long-term reduction of available fish habitat. In addition, the panel expressed concern about an increased risk of overharvests of fish, especially sockeye salmon and steelhead and cutthroat trout, because fishermen would have improved access from roads.

   The amount of timber harvested under any alternative was the second highest risk to fish habitat. This risk increased as the number of acres harvested increased.

Pink salmon in a Southeast Alaskan stream.

Nils Warnock

MAPS ON PAGES 71,72

2. Allocation of reserves free of timber harvest reduce the risk to fish stocks. The panel recommended that the most effective protection of fish habitat would be reserves that included entire watersheds rather than only parts of watersheds.
3. Results of watershed analysis may affect management decisions. The panel recommended that a watershed analysis be conducted before decisions are made on how management activities would be applied on the ground.
4. Timber harvest activities in the upper reaches of watersheds where fish do not occur may affect habitat. The panel pointed out that protection of these areas would help maintain and protect fish habitat farther downstream. Timber harvest in these areas is especially important in affecting the rate and amount of wood and sediment delivery.

The addition of millions of salmon from hatcheries has potential to change the genetic composition of local populations. The precise mechanisms driving salmon homing ability (when sexually mature salmon return to their natal site for spawning) are still not well understood, but hatchery-reared fish likely have elevated straying rates or impaired homing ability (Hard and Heard 1999, Candy and Beacham 2000). Although they may be poorly adapted to a new site, captive-reared salmon often hybridize with wild salmon when straying to a new spawning site, producing less viable offspring that can ultimately destabilize a wild salmon run (Bailey et al. 2010). Thus, an unintended consequence of hatchery production is the weakening of local adaptations and reduction of biodiversity (Willson 2007).

Climate change adds additional stress to fish due to changes in hydrology and stream temperatures. Some of the ways in which climate change is expected to affect streams utilized by anadromous fish populations include:

- Faster glacial melt and increased meltwater output (Motyka et al. 2002)
- An elevational shift in the snowline, and a change in precipitation from snow to rain below that line (Edwards et al. 2013)
- Reduction in snowpack (Mote et al. 2003) and an increase in rain-on-snow events (Rennert et al. 2009)
- Hydrologic changes including changes in peak and base flows, seasonal low flows, peak output, timing, and flooding (Mantua et al. 2010)
- General reduction in productivity due to hydrologic changes during spawning and incubation periods (Shanley and Albert 2014)
- Changes in lake temperatures, which would shift trophic relationships and alter food availability for juvenile salmon (Bryant 2009).

Conserving existing habitat and restoring degraded habitat are even more important as they increase watershed resiliency and potential for species adaptation to changing conditions.

MAPPING METHODS

Anadromous Waters

The Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Anadromous Waters Catalog) is maintained by the Alaska Department of Fish and Game (ADFG), with annual updates to incorporate nominations of new streams to the database or revisions of old ones. To be entered into this catalog, each waterbody must have documentation verifying the presence of an anadromous fish species. Statewide, this catalog currently contains over 18,000 waterbodies; however, more thorough surveys of localized areas suggest that this represents less than half of the total, with an additional 20,000 or more anadromous streams, rivers, and lakes not yet documented in this catalog. This map represents 5,614 streams and tributaries in 842 watersheds known to support the presence, spawning, or rearing of anadromous fish species (Alaska Department of Fish and Game 2013). These totaled 6,936 mi (11,163 km), or 50% of the model-estimated anadromous stream length.

The map features the total number (richness) of anadromous species known to occur in each stream segment, including streams where chum salmon, silver salmon, cutthroat trout, Dolly Varden, king salmon, eulachon, pink salmon, red salmon, and/or steelhead trout are either spawning, rearing, or present.

Top-ranked Watersheds

In addition, this map represents the top-ranked watersheds for salmonids in each biogeographic province based upon work done in the 2007 Audubon-TNC Conservation Assessment. The assessment of top-ranked watersheds included consideration of six species of salmonids: king salmon, chum salmon, silver salmon, red salmon, pink salmon, and steelhead trout. Available data on distribution and abundance of each species as well as populations with unique life history, timing of spawning runs, and genetics were reviewed. In addition, the limitations in existing data on salmon distribution and habitats were recognized. To improve the ability to identify areas of likely salmon habitat in unmapped stream channels, a landscape model was developed to identify floodplain habitats associated with documented anadromous fish streams.

The presence of salmon was estimated using the Anadromous Waters Catalog. This database is recognized to underrepresent the total distribution of salmon because of its (1) strict criteria for listing and (2) lack of complete stream surveys. The alternative database is the US Forest Service (USFS) Stream Inventory, which attributes stream segments by potential for anadromous fish based on channel characteristics (Paustian et al. 1992). The USFS database is sensitive to two types of bias: (1) it does not account for stream barriers that limit the actual distribution of salmon; and (2) mapping effort was more intensive in areas where timber sales have occurred. In general, side channels that provide important habitat for salmon tend to be underrepresented in both the USFS and ADFG datasets. The USFS database is beneficial because it provides information on fluvial processes, which determine how streams function in the life histories of salmon, as well as the interactions of salmon with other species (for example, availability to bears).

A floodplain model was developed to associate Class I streams (potential anadromous) in the USFS database with occupied streams in the ADFG database. This model was a function of slope and distance from the stream. Class I streams within this anadromous floodplain are likely to be used by salmon, and provide a better estimate of total freshwater habitat than the Anadromous Waters Catalog alone. Planning units were evaluated both on the number of species present as well as the estimated amount of habitat available.

We utilized the salmon distribution data to rank watersheds. First, the total acreage of modeled habitat was calculated for each watershed, then watersheds were ranked from most to least salmon habitat acreage within each biogeographic province for each of the six species and for the total sum of habitat for all six species combined. Shown here is the top-ranked watershed in each province for the six species combined. In total, approximately 13,750 mi (22,000 km) of anadromous or potentially anadromous fish habitat were identified in Southeast, which is considered an underestimate of actual habitat (e.g. omission of anadromous lake habitat, limited knowledge total distribution). Coho or silver salmon was the species most widely distributed, followed by pink salmon, chum salmon, steelhead trout, red, and finally king salmon.

Data on Pacific salmon climate change sensitivity was provided by TNC from their recent publication in PLoS One (Shanley and Albert 2014).

MAP DATA SOURCES

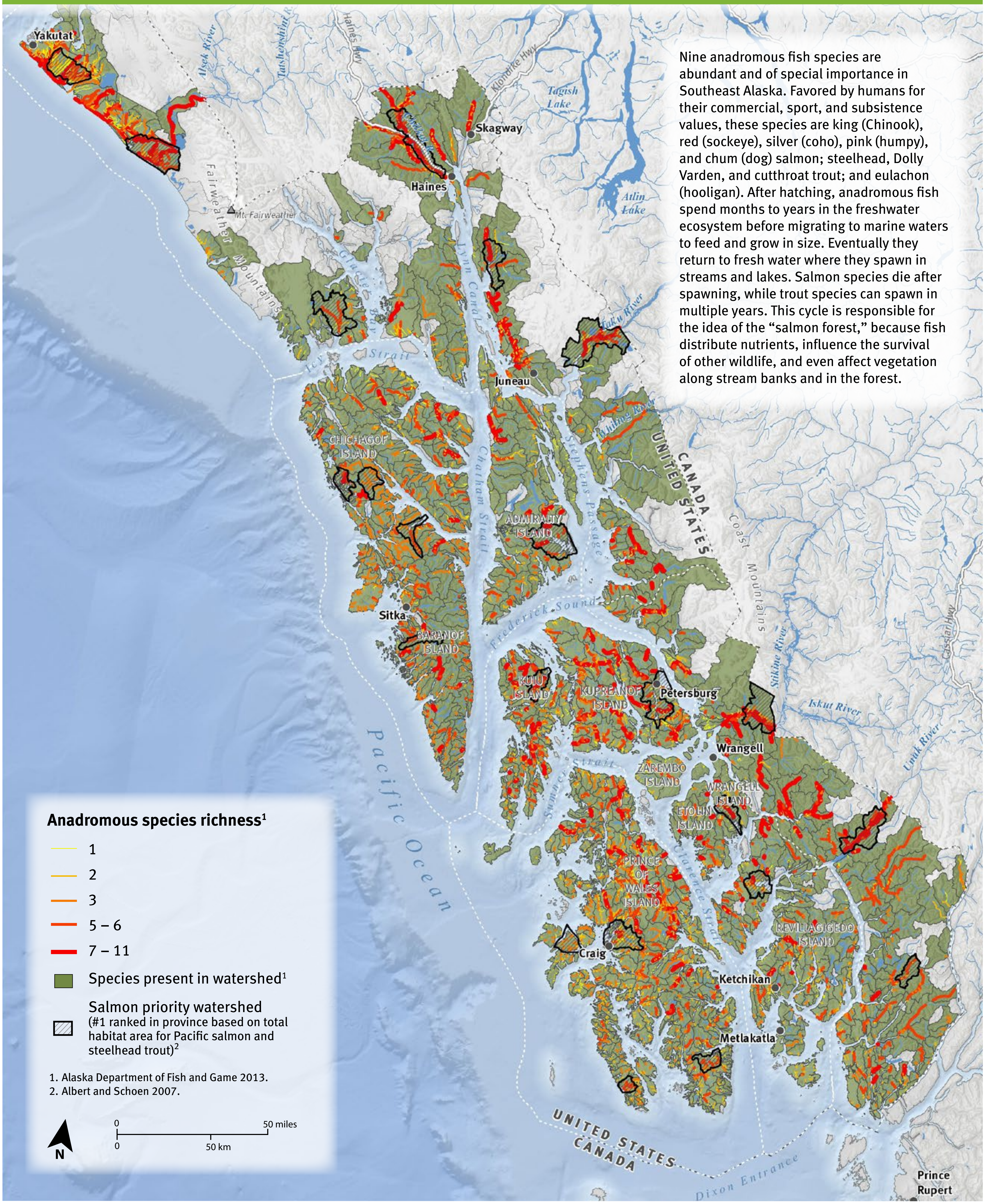
- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007).
- Pacific salmon hydroclimatic sensitivity index: Shanley and Albert 2014

Audubon ALASKA

The Nature Conservancy

Anadromous Fish Species Richness

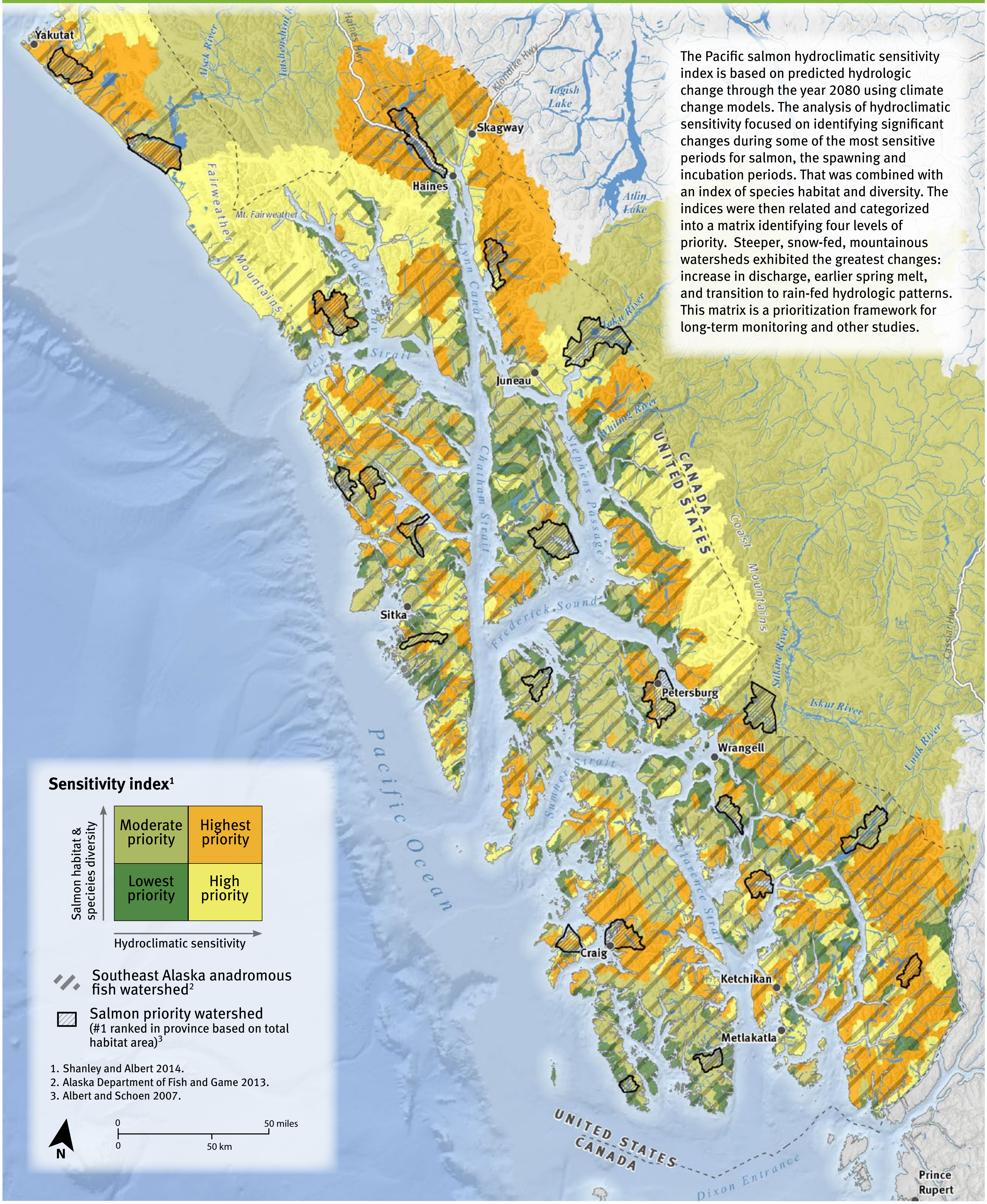
Nine anadromous fish species are abundant and of special importance in Southeast Alaska. Favored by humans for their commercial, sport, and subsistence values, these species are king (Chinook), red (sockeye), silver (coho), pink (humpy), and chum (dog) salmon; steelhead, Dolly Varden, and cutthroat trout; and eulachon (hooligan). After hatching, anadromous fish spend months to years in the freshwater ecosystem before migrating to marine waters to feed and grow in size. Eventually they return to fresh water where they spawn in streams and lakes. Salmon species die after spawning, while trout species can spawn in multiple years. This cycle is responsible for the idea of the "salmon forest," because fish distribute nutrients, influence the survival of other wildlife, and even affect vegetation along stream banks and in the forest.



Map 4.1: Anadromous Fish Species Richness

Pacific Salmon Hydroclimatic Sensitivity Index

Audubon Alaska
The Nature Conservancy



The Pacific salmon hydroclimatic sensitivity index is based on predicted hydrologic change through the year 2080 using climate change models. The analysis of hydroclimatic sensitivity focused on identifying significant changes during some of the most sensitive periods for salmon, the spawning and incubation periods. That was combined with an index of species habitat and diversity. The indices were then related and categorized into a matrix identifying four levels of priority. Steeper, snow-fed, mountainous watersheds exhibited the greatest changes: increase in discharge, earlier spring melt, and transition to rain-fed hydrologic patterns. This matrix is a prioritization framework for long-term monitoring and other studies.

Map 4.2: Pacific Salmon Hydroclimatic Sensitivity Index

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KING (CHINOOK) SALMON

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Ocean phase.

Spawning phase.

Alaska Department of Fish & Game

King, or Chinook, salmon (*Oncorhynchus tshawytscha*) are largest of the Pacific salmon, averaging about 15 lbs (6.8 kg) (Alaska Department of Fish and Game 2014a), but commonly weigh over 30 lbs (14 kg) (Alaska Department of Fish and Game 2014b). Spawning stocks of king salmon are found on the east coast of Asia from northern Hokkaido in Japan to the Anadyr River in Russia, and on the west coast of North America from central California to Kotzebue Sound, Alaska (Healey 1991). Most king salmon harvested in Southeast marine waters come from rivers in British Columbia, Washington, and Oregon (Orsi and Jaenicke 1996). Chinook that frequent Alaska marine waters outside of Southeast, especially in the very northern part of the Pacific Ocean and the Bering Sea, are primarily of Alaskan origin, though some salmon deriving from British Columbia and the west coast U.S. stocks are also present (Armstrong 1996, Guthrie III et al. 2012).

Compared with other salmon, kings spawn in a limited number of the streams and rivers that empty into marine waters of Southeast. There are 34 documented watersheds in Southeast that support spawning populations of king salmon (Pahlke 2009), and most of these fish have spawned in the Canadian portions of the rivers (Heard et al. 1995).

Most king salmon stocks in Southeast are referred to as “stream-type” (age 1) because they spend one year in fresh water before migrating to sea. Most king salmon from the Situk River near Yakutat are “ocean-type” or “zero-check” (age 0)—fish that migrate to sea during their first year without spending a winter in fresh water (Thedinga et al. 1998). Unlike kings in other Alaskan rivers, those in the Situk River attain sufficient size in their first summer to migrate to sea as age-0 smolts (Johnson et al. 1992, Thedinga et al. 1998).

Because of its large size, eating quality, and fighting capabilities, kings are the salmon most sought after and prized by sportfishers. A 57-kg (126-lb) king salmon taken in a fish trap near Petersburg, Alaska, in 1949 is the largest on record. The largest sport-caught king salmon was a 44-kg (97-lb) fish taken in the Kenai River in 1986. Chinook salmon are very similar to silver salmon in appearance while at sea (blue-green back with silver flanks), except for their large size, small black spots on both lobes of the tail, and black gums. At spawning, kings turn red to copper to almost black.

Among the watersheds that support spawning populations of kings in Southeast, the largest populations are found in the Taku, Stikine, and Alsek rivers (Heard et al. 1995). These rivers originate in the Canadian provinces of British Columbia and the Yukon Territory, where the subarctic climate is drier and colder than the temperate maritime climate of Southeast; in these rivers king salmon spawn exclusively in Canada. The other mainland coast streams supporting spawning king populations are generally shorter and less productive. Only three naturally occurring stocks of king salmon have been found on islands in Southeast, all on Admiralty Island (Armstrong 2004).

Annual spawning escapements (the number of fish that escape a fishery to spawn) of king salmon in all systems in Southeast averaged 76,271 fish during 1991 to 1993 (Heard et al. 1995). Major systems (greater than 10,000 spawners) were the Alsek, Taku, and Stikine rivers. Medium systems (between 1,500 and 10,000 spawners) included Andrew Creek and Blossom, Chickamin, Keta, Situk, Chilkat, and Unuk rivers. Minor systems (fewer than 1,500 spawners) included systems such as King Salmon River on Admiralty Island.

Because salmon abundance fluctuates according to complex, site-specific cycles (Drake and Naiman 2007), it is difficult to assess region-wide population status. If salmon habitat is compromised through timber harvest or mining activities, individual runs and eventually entire populations may be extirpated (Jennings et al. 2008, USEPA 2014). In general, most Southeast watersheds that support king salmon have been spared significant human disturbance. However, anecdotal reports suggest that as many as four historic small king stocks in Southeast may have been extirpated, and that logging in the Bradfield River drainage during the 1950s likely contributed to a temporary decline in the river’s king stocks (Halupka et al. 2000).

Commercial harvest of Southeast Alaska salmon began in the late 1870s. Patterns of king salmon productivity and abundance generally have varied over time and among different areas of Alaska. However, recent declines in productivity, abundance, and inshore harvests appear widespread and persistent throughout Alaska, prompting the ADFG to publish the King Salmon Stock Assessment and Research Plan in 2013. This report assessed the downturns in king salmon stocks, including the Southeast stocks of the Unuk, Stikine, Taku, and Chilkat rivers. As productivity and run abundances trended downward statewide, management of fisheries became more restrictive to achieve established escapement goals. As a result, average annual inshore harvest of king salmon in all Alaska fisheries have decreased during both the 13-year period prior to downturns in run abundance (1994–2006) and the 5-year period afterward (2007–2011). Specifically, subsistence and personal use is down from 175,000 to 154,000 fish (about a 12% reduction); commercial harvest is down from 584,000 to 425,000 fish (about a 27% reduction); and sport take is down from 178,000 to 141,000 fish (about a 21% reduction). These decreases in inshore commercial harvest of king salmon occurred in all management areas of Alaska (ADFG Chinook Salmon Research Team 2013). In 2014 and 2015, the commercial and sport harvest of Chinook increased significantly (Alaska Department of Fish and Game 2015a), with an influx from salmon production in the Columbia River and southern US states (Ed Jones, ADFG, personal communication 2015).

Compared with other species of Pacific salmon, king salmon have a slightly different set of spawning habitat preferences. Almost all salmon tend to spawn only in areas that have a good flow of subsurface water through a bed of gravel, but because spawning king salmon are larger than most other salmon, they select rivers with larger gravel, faster stream flow, and a good supply of dissolved oxygen for their larger eggs (Alaska Department of Fish and Game 2002).

Orsi and Jaenicke (1996) identified the importance of marine waters of Southeast as a nursery and feeding area for king salmon stocks originating between Oregon and Southeast, a range of 1,125 mi (1,800 km). These marine waters are also important to residents of Southeast because king are the only salmon caught in inside waters during the winter.

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Because most of the Chinook salmon in Southeast spawn in the Canadian portions of the larger transboundary Alsek, Taku, and Stikine Rivers, there is concern that activities outside of Alaska could significantly impact local fisheries. For example, acid mine-drainage from the former Tulsequah Chief mine in British Columbia flows into the transboundary Taku River and its tributary, the Tulsequah River. Proposed reopening of the mine, if done without proper environmental safeguards, threatens king salmon in the Taku River and the multimillion-dollar Taku River fishery near Juneau. Twenty-one mining projects in Northwest British Columbia are active or in various stages of exploration and threaten fisheries on Stikine, Taku, and Unuk rivers (Southeast Alaska Conservation Council 2014).

There is some risk that the release of hatchery-reared king into Southeast waters could disrupt or alter native stocks. Although they may be poorly adapted to a new site, captive-reared salmon often hybridize with wild salmon when straying to a new spawning site, producing less viable offspring that can ultimately destabilize a wild salmon run (Bailey et al. 2010).

CONSERVATION ISSUES

Deterioration and loss of natural habitats due to industrialization, urbanization, other land-use practices, and especially the damming of rivers in southern parts of the range (i.e., the Pacific Northwest) are thought to be the main factors in the coastwide decline of many stocks (Heard et al. 1995). Conserving healthy Southeast king salmon populations will depend on the following considerations:

- Maintaining and enhancing protection of freshwater habitat in the limited number of watersheds suitable for king salmon runs
- Controlling logging, mining, and other human impacts on habitat
- Continuing to develop international cooperation on habitat for transboundary river stocks
- Monitoring of straying patterns in Southeast hatchery king salmon to (1) document interactions with wild populations and (2) identify aquacultural practices that reduce risks to natural salmon populations posed by straying
- Recognizing that king salmon originating from other US states and Canada rely on the marine waters of Southeast Alaska for nursery and feeding areas.

MAPPING METHODS

This map represents 226 streams and tributaries in 87 watersheds known to support the presence, spawning, or rearing of king salmon (Alaska Department of Fish and Game 2013). These totaled 940 mi (1,510 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for king salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

MAP DATA SOURCES

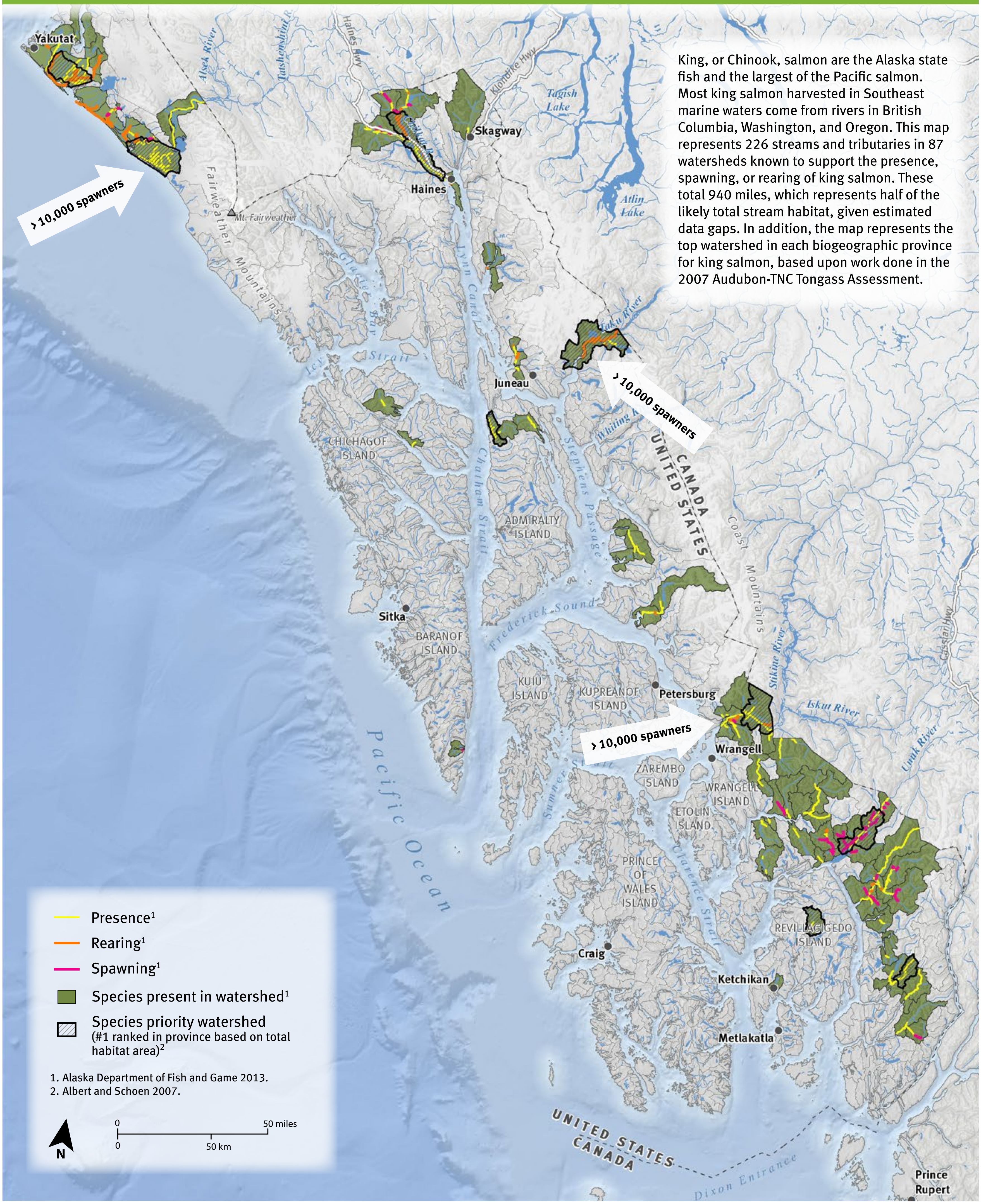
- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

USFWS

King (Chinook) salmon.

King (Chinook) Salmon

King, or Chinook, salmon are the Alaska state fish and the largest of the Pacific salmon. Most king salmon harvested in Southeast marine waters come from rivers in British Columbia, Washington, and Oregon. This map represents 226 streams and tributaries in 87 watersheds known to support the presence, spawning, or rearing of king salmon. These total 940 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for king salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.3: King (Chinook) Salmon

MAP ON PAGE 78

RED (SOCKEYE) SALMON

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Ocean phase.

Spawning phase.

Alaska Department of Fish & Game

Sockeye, or red salmon (*Oncorhynchus nerka*), are the second most abundant species of salmon (Heard 2002). While at sea they have iridescent silver flanks, a white belly, and a metallic green-blue top. There may be some fine black speckling that can occur on the back, but they are absent of the large spots of other Pacific salmon. When reds return to freshwater to spawn, their heads turn green and their bodies turn bright red, hence their common name, red salmon. Breeding males develop a humped back and hooked jaws filled with tiny teeth.

Sockeyes are one of the smaller species of Pacific salmon, weighing in at 4 to 15 lbs (2 to 6 kg), and have a lifespan of 3 to 7 years. Globally, reds range from the Klamath River in Oregon to the Chukchi Sea in north-western Alaska (and potentially as far as Bathurst Inlet, Canada) and from the Anadyr River of Siberia south to Hokkaido, Japan. The largest red was caught in 1974 at the Kenai River and weighed 16 lbs (7.3 kg).

About 200 populations, or stocks, of red salmon have been found in Southeast Alaska and are distributed fairly evenly throughout the region (Halupka et al. 2000). Most populations are closely connected to lakes, which provide spawning habitat (Armstrong 1996) and which, in turn, receive significant nutrient subsidies from returned red salmon (Kline Jr et al. 1993). Lakes in Southeast that are accessible from the sea are important to the region's red salmon, especially for the rearing of young before their migration to sea. In this aspect, the red salmon differs from the other Pacific salmon species in Southeast, which normally do not depend on lake rearing during the juvenile stage (Burgner 1991). Red salmon are the only salmon species to spawn extensively in shoal beach areas along lake shores, typically in areas of upwelling groundwater that provides circulation through the nest (Burgner 1991). Interestingly, Halupka et al. (2000) describe some anecdotal reports of sockeye salmon spawning in the caves of Kook Lake.

Bob Armstrong

Black bear with a red (sockeye) salmon.

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Young red salmon typically spend up to three years in these nursery lakes before migrating to sea. While in lakes, they usually stay near shore during the day and move offshore at night, where they feed on aquatic insects and zooplankton that migrate from the lake depths to the surface at night. Sockeye acquire their brilliant orange flesh-color from eating orange krill while in the ocean and filtering the zooplankton and small fish they eat through "gill rakers." Sockeye that migrate to the sea spend one to four years in salt water before returning to fresh water to spawn. Salmon die after spawning is complete. Over geologic time, some reds have become land-locked and are called "kokanee." These freshwater kokanee reds rarely exceed 14 in (0.4 m) in length compared to the anadromous sea-going sockeye that measure 16 to 30 in (0.5 to 0.8 m).

Some populations, or a portion of some populations, do not use lakes as nursery areas and instead migrate to sea at age 0, the same year as hatching (Heifetz et al. 1989, Thedinga 1993, Rice et al. 1994). Also, some populations rear in rivers, rather than lakes, for one year (Rice et al. 1994, Murphy et al. 1997). At least two systems in Southeast Alaska, the Taku and Stikine rivers, produce all three types of red salmon: lake type, 0-age stream type, and stream-rearing type (Rice et al. 1994).

In the Pacific region, sockeye were the first salmon species to be commercially harvested, and because of their color, rich oil content, flavor, and superior flesh quality they are the most sought after of all the Pacific salmon. Sockeyes are the most economically important species in Alaska, and in Southeast they are the salmon most harvested by personal use and subsistence fishers. Bristol Bay in Southwest Alaska has the largest harvest of sockeye salmon in the world, with 10 million to more than 30 million caught each year. In Southeast Alaska in 2012, the total harvest in commercial, personal use, and subsistence salmon fisheries was 0.9 million sockeye, below the long-term average of 1.3 million (Conrad and Davidson 2013), but in 2014 the commercial take alone was nearly 1.6 million fish.

A recent study of sockeye salmon in Bristol Bay found that maintaining population diversity has a "portfolio effect" in which the genetic diversity among the hundreds of smaller sub-populations stabilizes the overall population to ensure healthy returns and lower risks from exploitation (Schindler et al. 2010). Guthrie (1994) observed substantial divergence among red salmon collected from 52 Southeast stocks, which is consistent with what is known about the accurate homing of red salmon. They identified three geographic groupings that differed genetically. These groups corresponded to the southern inside waters; the far southeastern islands—including Prince of Wales Island; and inside waters of northern and central Southeast.

CONSERVATION ISSUES

Habitat loss, habitat degradation, climate change, and overfishing are potential future threats for red salmon throughout Alaska. The status of sockeye populations in Southeast is currently stable, but Halupka et al. (2000) identify several potential risks:

- Increased demand for this commercially valuable species
- Over-exploitation of small, artificially enhanced, or weak stocks in mixed-stock fisheries
- Heavy and poorly monitored subsistence harvests
- Lack of adequate information about small populations
- Human-caused and natural habitat alterations.

The following considerations seem most important for conserving healthy populations of red salmon in Southeast:

- Recognize the importance of genetic diversity in red populations (Schindler et al. 2010).
- Ensure proper management of key sockeye watersheds, especially the highest ranked sockeye watershed within each biogeographic province
- Identify and protect individual lakes that support populations of red salmon and kokanee
- Identify and protect the few red salmon populations that do not use lakes as nursery areas.
- Prevent the transmission of diseases from hatchery-reared sockeye to wild stocks.

MAPPING METHODS

This map represents 537 streams and tributaries in 241 watersheds known to support the presence, spawning, or rearing of red salmon (Alaska Department of Fish and Game 2013). These totaled 1,415 mi (2,277 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for red salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

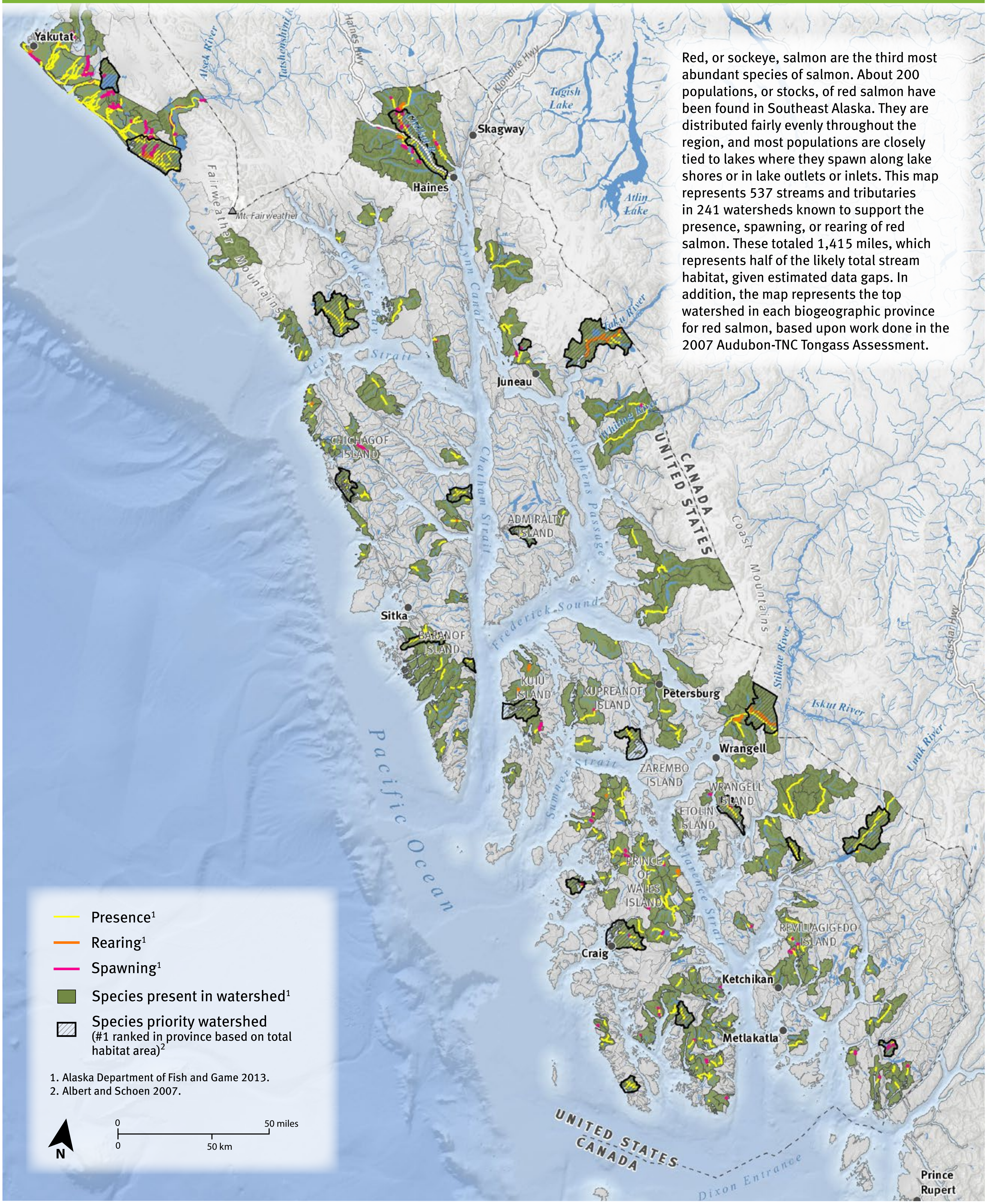
MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

Public Domain

Red (Sockeye) Salmon

Red, or sockeye, salmon are the third most abundant species of salmon. About 200 populations, or stocks, of red salmon have been found in Southeast Alaska. They are distributed fairly evenly throughout the region, and most populations are closely tied to lakes where they spawn along lake shores or in lake outlets or inlets. This map represents 537 streams and tributaries in 241 watersheds known to support the presence, spawning, or rearing of red salmon. These totaled 1,415 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for red salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.4: Red (Sockeye) Salmon

MAP ON PAGE 81

SILVER (COHO) SALMON

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Ocean phase.

Spawning phase.

Alaska Department of Fish & Game

Silver, or coho salmon (*Oncorhynchus kisutch*), have dark metallic blue or geenish backs with silver sides and a light belly with small black spots on the back and upper lobe of the the tail while in the ocean. Their gumline in the lower jaw has lighter pigment than king salmon. They weigh in at an average 8 lbs (3.6 kg). The state angling record was a 26 lb (12 kg) fish caught in 1976 in Icy Strait.

Silver salmon are the third most abundant salmon species in Alaska (Heard 2002); however, their young seem to be in almost every accessible body of fresh water within their range. Adult silvers can leap vertically more than 6 ft (1.8 m) and migrate during fall floods when water levels are higher and most other species have ceased spawning.

At spawning, males have green backs and red on the sides while females are bronze to reddish on the sides. Juvenile coho have white on the leading edge of the dorsal and anal fins, and all fins may be tinted orange. Adults return to their stream of origin to spawn and die, usually at around three years old, although some males return as two-year-old spawners (known as "jacks"). Spawning males develop a strongly hooked snout and large teeth. Females prepare several redds (nests), where the eggs will remain for six to seven weeks until they hatch. Coho smolt migrate to sea usually after one to four years in freshwater streams and lakes. In streams, they prefer glides and pool habitats with cover and generally avoid fast riffles. Good winter habitat with deep pools, log jams, and undercut banks with woody debris are essential for silver salmon. In salt water, they gradually move offshore and travel within major current systems (Mecklenberg et al. 2002). About 85% return to their natal streams.

In Alaska, silver salmon occur in coastal salt water from Southeast to Point Hope on the Chukchi Sea, and in the Yukon River to the Alaska-Yukon border in streams and rivers of all sizes as well as in lakes and beaver ponds. In Southeast Alaska, silver salmon typically spawn in short, coastal streams. Some travel more than 1,200 mi (1,920 km) up the Yukon River (Armstrong 1996). In Southeast, silver salmon spawn in nearly 4,000 watercourses, including the headwaters of transboundary rivers in British Columbia and the Yukon Territory (Alaska Department of Fish and Game 1994). Silver salmon can be found in almost every body of water capable of supporting fish that is accessible from the sea.

Coho salmon typically spawn later than other species of salmon. They enter fresh water in September and October, and most spawning takes place in late October and November (Halupka et al. 2000). Therefore, these late-running stocks are available to feed other animals after fish from earlier stocks have disappeared (Armstrong 1996). Those few coho that do return to freshwater earlier, in late July and August, exhibit a smaller body size, presumably a trade off between missing the extra two months of marine feeding, but take advantage of higher water flow rates, which allows easier passage across barriers (Halupka et al. 2000). Good water quality is critical for rearing and sustaining silver salmon during the one-to-four-year period when they are in coastal streams. Road building and timber harvests exacerbate erosion, sedimentation, and poor water quality.

Adult coho salmon.

Alaska Department of Fish & Game

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In 2012, the total commercial, personal use, and subsistence harvest of coho was 2.1 million fish, well below the 10-year average harvest of 2.6 million. (Conrad and Davidson 2013), but in 2014 the commercial harvest alone was over 3.6 million (Alaska Department of Fish and Game 2015a). Although the ADFG currently identifies no stocks of concern, there are areas in previously logged watersheds that are impacted and losing their stream structure. In the North Pacific region, recent climate patterns which have both freshwater and marine effects are causing some fluctuations in runs. Lower coho production is occuring in more northern stream systems but there are strong returns in southern streams.

CONSERVATION ISSUES

Halupka et al. (2000) suggest three focal issues that seem most important for conserving healthy stocks of silver salmon in Southeast:

- Lack of sufficient information to make management decisions
- Adverse effects from hatchery fish through introduction of genes from hatchery stock to wild coho runs
- Silver salmon habitat degradation from clearcut logging and road building.

The single most important thing that can be done to protect silver salmon habitat is to establish and maintain adequate buffer strips along streams during clearcut logging and other types of development. Buffer strips are important to protect the riparian habitat that silver salmon need. However, buffers can be difficult to maintain since coho use most of the small tributaries and streams in the watersheds of Southeast. Coho may therefore especially benefit from watershed-scale protection, which addresses the protection of both major and lower-order waterways.

MAPPING METHODS

This map represents 4,971 streams and tributaries in 772 watersheds known to support the presence, spawning, or rearing of silver salmon (Alaska Department of Fish and Game 2013). These totaled 6,460 mi (10,396 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for silver salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

Upper Tenakee estuary, typical silver salmon rearing habitat.

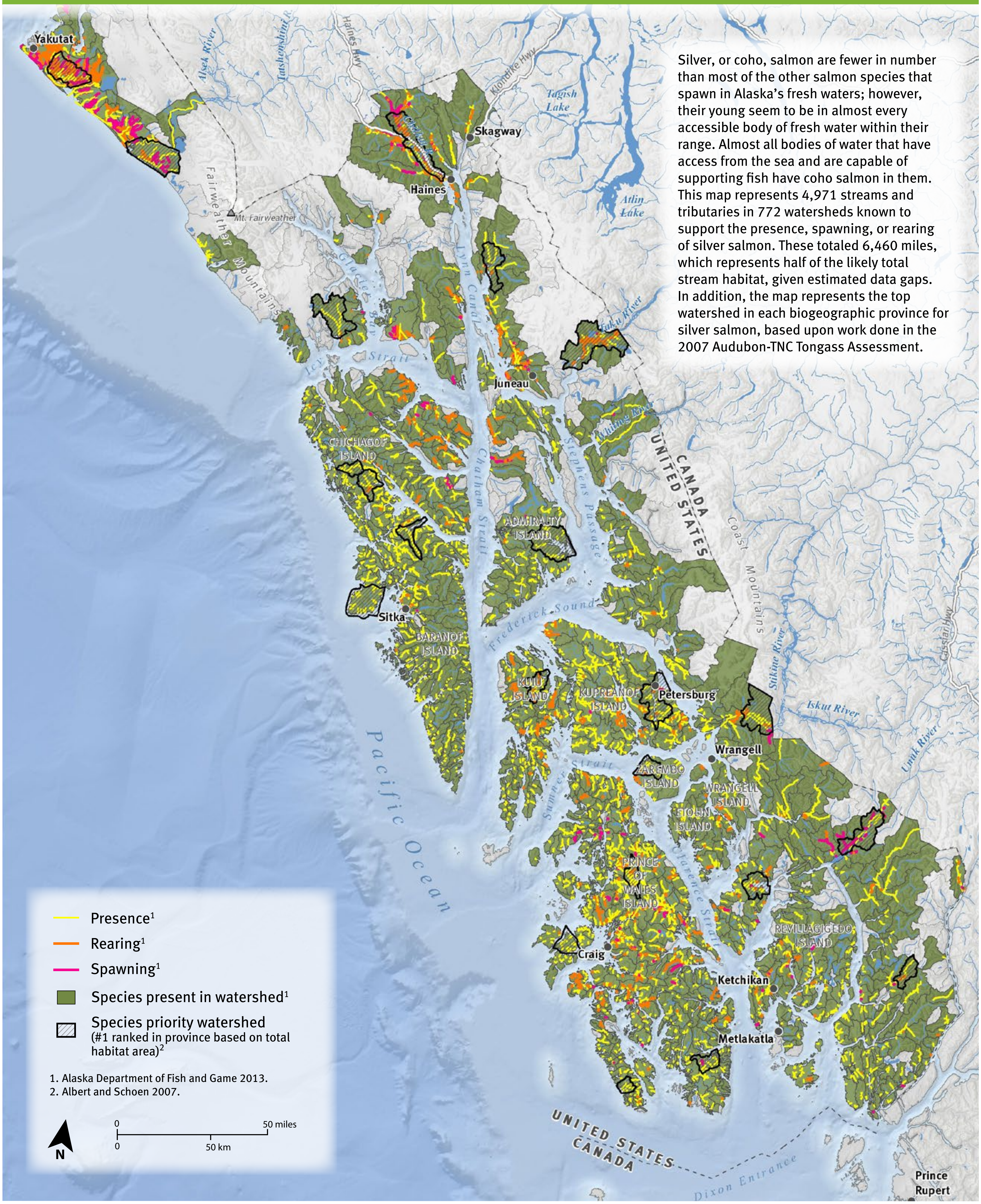
John Schoen

Audubon ALASKA

The Nature Conservancy

Silver (Coho) Salmon

Silver, or coho, salmon are fewer in number than most of the other salmon species that spawn in Alaska's fresh waters; however, their young seem to be in almost every accessible body of fresh water within their range. Almost all bodies of water that have access from the sea and are capable of supporting fish have coho salmon in them. This map represents 4,971 streams and tributaries in 772 watersheds known to support the presence, spawning, or rearing of silver salmon. These totaled 6,460 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for silver salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.5: Silver (Coho) Salmon

MAP ON PAGE 84

PINK (HUMPY) SALMON

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Ocean phase.

Spawning phase.

Alaska Department of Fish & Game

Pink salmon, also called humpback or humpy salmon (*Oncorhynchus gorbuscha*), are the most abundant Pacific salmon in North America and Asia (Heard 2002). They are found throughout the North Pacific including the Bering Sea, and in the southern Chukchi and Beaufort seas in the Arctic Ocean, as well as from the Lena River in Siberia to the south to Korea and Kyushu, Japan. Pink salmon are the smallest of the Pacific salmon and have the shortest and simplest life cycle.

Pink salmon are a bright greenish-blue on top with silvery sides when at sea. When they are ready to return to freshwater to spawn they develop large black spots on their back and tail. Males are brown to black above with a white belly, large hump, and a hooked jaw called a kype, and the females are olive green with dusky patches above and a light-colored belly. Adults weigh an average of 4 lbs (1.8 kg) and are 18 to 25 in (0.5 to 0.6 m) long. The state angling record was a 13 lb (6 kg) fish caught on the Moose River on the Kenai Peninsula in 1974.

Young pink salmon go to sea almost immediately after emerging from the gravel, so the condition and type of spawning beds are the most important requirements in their freshwater habitat (Heard 1991). Pink salmon prefer uniform gravel in both small and large streams when spawning and avoid quiet deep water, pools, areas with a slow current, and heavily silted or muddy streambeds. For a short time, pinks may be abundant in estuarine tidal channels, although pinks typically spend minimal time in estuaries.

Juvenile pinks use specific nursery areas for feeding in their first few weeks in salt water. The nurseries are located along irregular shorelines with complex eddies; ideally, the nursery is constantly replenished with zooplankton while offering shelter from wind-generated waves and strong tidal currents. Pink salmon feed on small crustaceans, zooplankton, squid, and small fish. Young pink salmon are also a food source for other fish. Examples are silver salmon (*O. kisutch*) smolts, Dolly Varden (*Salvelinus malma*), at least three species of sculpin (Mortensen et al. 2000), and cutthroat trout. (*O. clarki*)

After about 18 months at sea, pinks return to their natal streams to spawn. Their entire life cycle is completed in two years. Pink salmon are unusual in that they have even-year and odd-year populations that may differ considerably in numbers. These even- and odd-year runs are genetically separated with observable though minor morphological differences (Mecklenberg et al. 2002). Extreme northern and southern pink salmon stocks also can be distinguished by genetic differences (Gharrett and Smoker 1993).

The center of North American distribution of pink salmon is in Southeast Alaska where populations are numerous and often large. Pink salmon occupy more than 3,000 Southeast streams and tend to spawn in short coastal streams although some rivers in Southeast also have large numbers of pinks (Heard 1991, Noll et al. 2001). Positive trends in pink salmon escapements may be a result of factors such as state efforts to rebuild pink salmon stocks, previous years of favorable ocean conditions, and the generally good quality of spawning habitat in Southeast (Halupka et al. 2000). Lower harvests can be attributed in some years to their two-year life cycle rather than declining populations.

Earl Harper

Pink (humpy) salmon.

In the early 1990s, the annual commercial catches of pink salmon exceeded 30 million fish (Hofmeister 1994). Commercial salmon harvests began in the late 1870s, catching mainly red salmon until the early 1900s, when pink salmon began to dominate. In the past 10 years, pink salmon comprised 74% of Southeast's total salmon harvest. Although the 2012 pink salmon harvest (21.3 million) was below the 10-year average, 2013 brought in a record harvest of 89.2 million (Conrad and Davidson 2013, Alaska Department of Fish and Game 2015a). During 2014 and 2015, commercial harvest averaged around 35 million fish. The economic contribution of this harvest is immense, as commercial pink salmon harvest in 2012 was valued at more than $101.1 million (Conrad and Davidson 2013).

For the past several years, the Southeast Alaska Coastal Monitoring project at the National Oceanic and Atmospheric Administration's (NOAA) Alaska Fisheries Science Center has measured juvenile pink salmon abundance at sea as part of their study of the marine ecosystem of Southeast Alaska and the adjacent Gulf of Alaska. As a result, scientists and managers have been able to improve their forecasts of pink salmon harvests (NOAA 2014); in Alaska, pink salmon populations are well managed and stable at this time (NOAA 2014).

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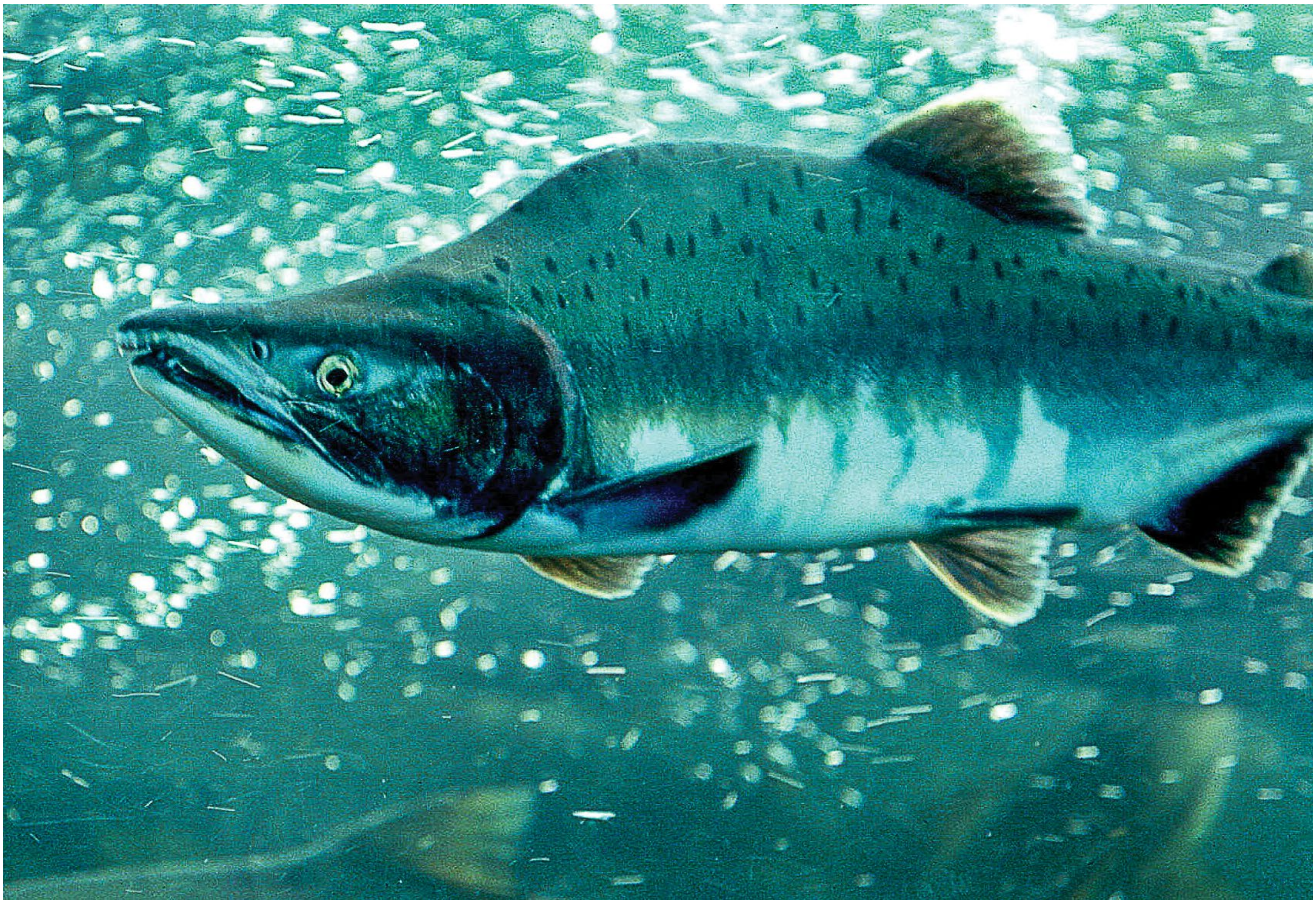


John Schoen

Adult male pink salmon in spawning condition in Southeast Alaska.

CONSERVATION ISSUES

Although pink salmon populations are currently stable, there are some factors to consider that could threaten pink runs in the future (Halupka et al. 2000):

- Sex-biased catches that lead to a predominance of males in escapements
- Pre-spawning mortality
- Egg and alevin mortality associated with changed hydrologic and thermal regimes of streams in logged watersheds
- An ongoing decline in pink salmon body size that could reduce productivity.

The five most important considerations for maintaining healthy pink salmon populations in Southeast are (Halupka et al. 2000):

- Protect spawning areas from disruption or pollution
- Maintain adequate buffer strips along streams during logging activity
- Identify and protect nearshore salt water nursery areas, where the young fish feed during their first weeks at sea
- Determine and monitor the effects of large-scale releases of hatchery fish on wild pink salmon populations
- Recognize the importance of size variation to population fitness, especially in wild stocks.

MAPPING METHODS

This map represents 3,199 streams and tributaries in 765 watersheds known to support the presence, spawning, or rearing of pink salmon (Alaska Department of Fish and Game 2013). These totaled 3,654 mi (5,881 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for pink salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

MAP DATA SOURCES

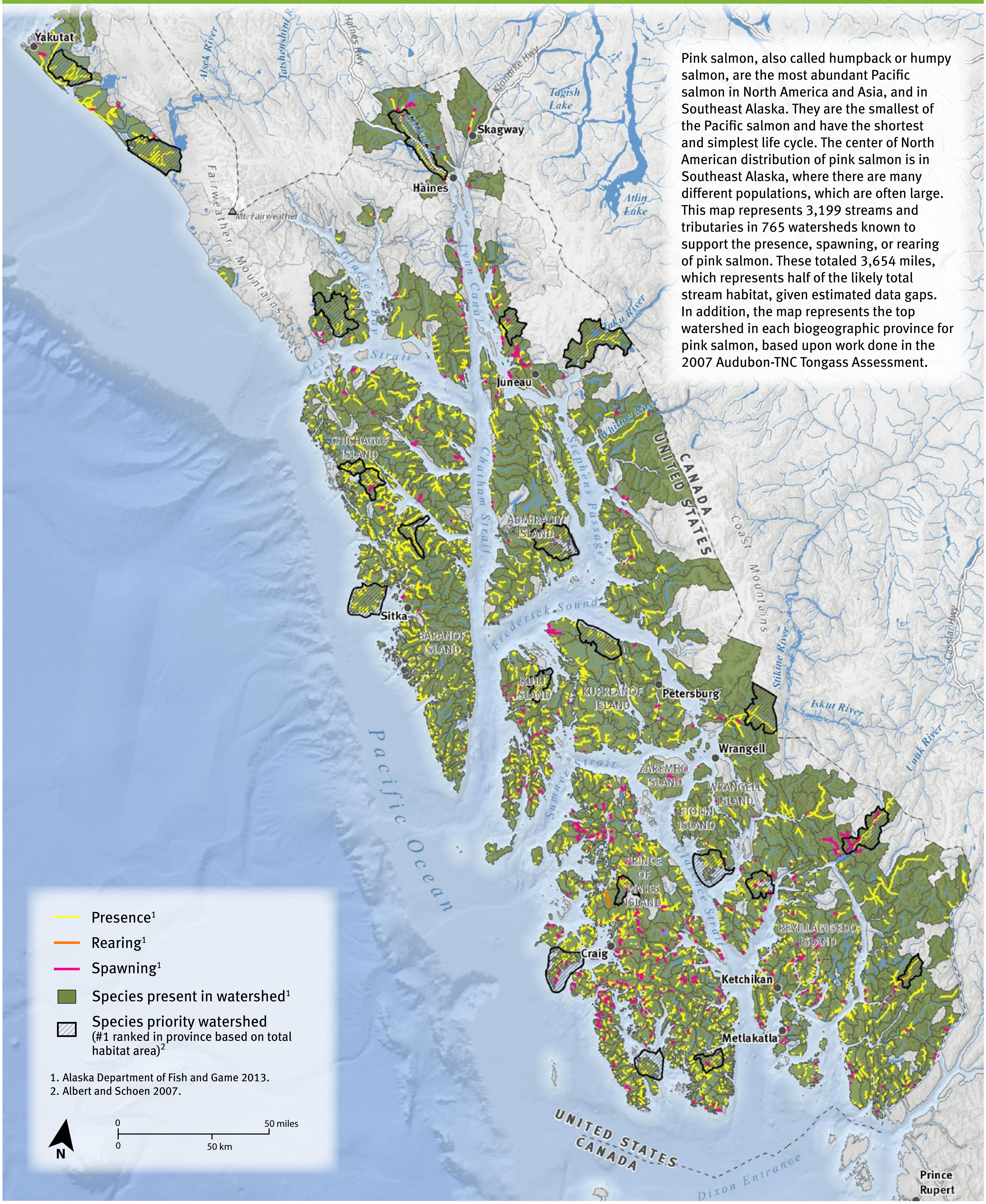
- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

Pink (Humpy) Salmon

Audubon ALASKA

The Nature Conservancy

Pink salmon, also called humpback or humpy salmon, are the most abundant Pacific salmon in North America and Asia, and in Southeast Alaska. They are the smallest of the Pacific salmon and have the shortest and simplest life cycle. The center of North American distribution of pink salmon is in Southeast Alaska, where there are many different populations, which are often large. This map represents 3,199 streams and tributaries in 765 watersheds known to support the presence, spawning, or rearing of pink salmon. These totaled 3,654 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for pink salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.6: Pink (Humpy) Salmon

CHUM (DOG) SALMON
MAP ON PAGE 87

CHUM (DOG) SALMON

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Ocean phase.

Spawning phase.

Alaska Department of Fish & Game

Chum, or dog salmon (*Oncorhynchus keta*), are the most widely distributed of all the Pacific salmon species. The name dog salmon comes from the sharp dog-like teeth of spawning males and because these fish have often been used to feed sled dogs. Females also have canine-like teeth, but less noticeable than those of males. While in the ocean, chum salmon are metallic bluish-green with silver streaks along the rays of their tail fin and some black speckling on the back. Spawning chum have a dark horizontal strip down their sides and calico coloration.

Chums are up to 3.6 ft (1.1 m) long and weigh on average 8 to 15 lbs (4 to 7 kg), although the state record chum salmon, caught in 1985 near Ketchikan, weighed 32 lbs (14.5 kg). Chum salmon are found throughout Alaska, but scarce north of Kotzebue Sound. They are also found along the east and west coasts of the North Pacific Ocean from northern California to Kyushu, Japan. Most of Alaska's chum salmon spend their life at sea in the eastern Chukchi and Bering seas and the Gulf of Alaska.

Chum salmon are abundant and widespread in Southeast. They reside in more than 3,000 streams and have two population types: those that spawn primarily in mainland or northern-island drainages are called summer populations; those that spawn in ground-water fed streams mostly in southern-island drainages are referred to as fall populations. Stocks of chum are more evenly and densely distributed in southern Southeast than in northern Southeast (Halupka et al. 2000).

Their large size and abundance make chum valuable food for a variety of animals and are important for subsistence harvest. Chum salmon are a traditional dried winter food for humans and dogs in Arctic, Western, and Interior Alaska.

Chum salmon return to spawn in their natal streams after three to five years at sea. They typically spawn in the lower 125 mi (200 km) of rivers and occasionally use the intertidal zone (Halupka et al. 2000). Chum salmon are considered poor jumpers compared to the rest of the Pacific salmon, and waterfalls can impede their travel to spawning grounds. Because chums are reluctant or unable to jump barriers, this limits their stream habitat (Hale 1985).

Young chum salmon head out to sea after spending several months close to shore in river and stream estuaries. While upriver, they feed on insect larvae and while in nearshore estuaries, chum salmon eat crustaceans, terrestrial insects, and young herring. In the ocean, they grow rapidly, feeding on copepods, tunicates, mollusks, and some fish. Landlocked or entirely freshwater chum salmon have not been found.

Chum salmon is a major food source for bears in Southeast because of their large size and abundance, and chum fry in fresh water are a valuable food for young silver salmon (*O. kisutch*), Dolly Varden (*Salvelinus malma*), cutthroat trout (*O. clarki*), rainbow trout (*O. mykiss*), sculpins, mergansers (*Mergus spp.*), and belted kingfishers (*Megaceryle alcyon*) (Armstrong 1996).

Bob Armstrong

In October and November, a late run of chum salmon provides food for a large gathering of Bald Eagles, numbering up to 3,500 at a time along the Chilkat River north of Haines.

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There are a few rivers in Southeast where chum escapements have been large throughout the years. The Chilkat River has the largest run of chum, usually averaging more than 54,000 fish (Halupka et al. 2000). With an unusual and famous late run of chum salmon in October and November, the Chilkat provides food for a large gathering of Bald Eagles (Haliaeetus leucocephalus) numbering up to 3,500 at a time (Armstrong 1996). Reproductive success of Bald Eagles may be influenced by the late chum run (Hansen 1987). The State of Alaska acknowledged the importance of the area to eagles, salmon, and surrounding habitat, and established the 48,000 ac (19,425 ha) Alaska Chilkat Bald Eagle Preserve in 1982.

Escapements of more than 60,000 chum in some years have occurred at Fish Creek near Hyder (Armstrong 2004). The chum salmon from Fish Creek are thought to be the largest in North America, weighing more than 30 lbs (14 kg), and are designated as a sensitive species by the USFS because of their size (Armstrong 2004).

Most chum production comes from hatcheries in the region (Conrad and Gray 2014). Commercial harvest of Southeast Alaska salmon began in the late 1870s. Due largely to the establishment of the state hatchery program in 1971, the population of chum salmon has more than doubled since the 1980s. According to Conrad and Davidson (2013), “the recent 10-year average chum harvest is six times pre-hatchery production and the 2012 fishery was nearly eight times that amount.” In 2012, the total harvest of chums in commercial, personal use, and subsistence was 12.4 million.

Logging that results in increased sediment deposition into spawning streams could lead to the decline of chum stocks, and, accordingly, areas of intensive timber harvest have caused declines in chum salmon populations in the past. However, several other chum salmon stocks in Southeast declined without apparent cause (Halupka et al. 2000).

CONSERVATION ISSUES

Habitat degradation and loss from logging, climate change, overfishing, and competition from hatchery fish are potential future threats to chum salmon in Alaska. Considerations for conserving healthy populations of Southeast chum salmon are:

- Develop research to establish baseline data on habitat condition and spawner abundance to determine status of populations and changes in size of fish at maturity
- Employ conservative management practices for known threats such as logging and large-scale hatchery production activities.

MAPPING METHODS

This map represents 2,032 streams and tributaries in 658 watersheds known to support the presence, spawning, or rearing of chum salmon (Alaska Department of Fish and Game 2013). These totaled 3,047 mi (4,903 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for chum salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

MAP DATA SOURCES

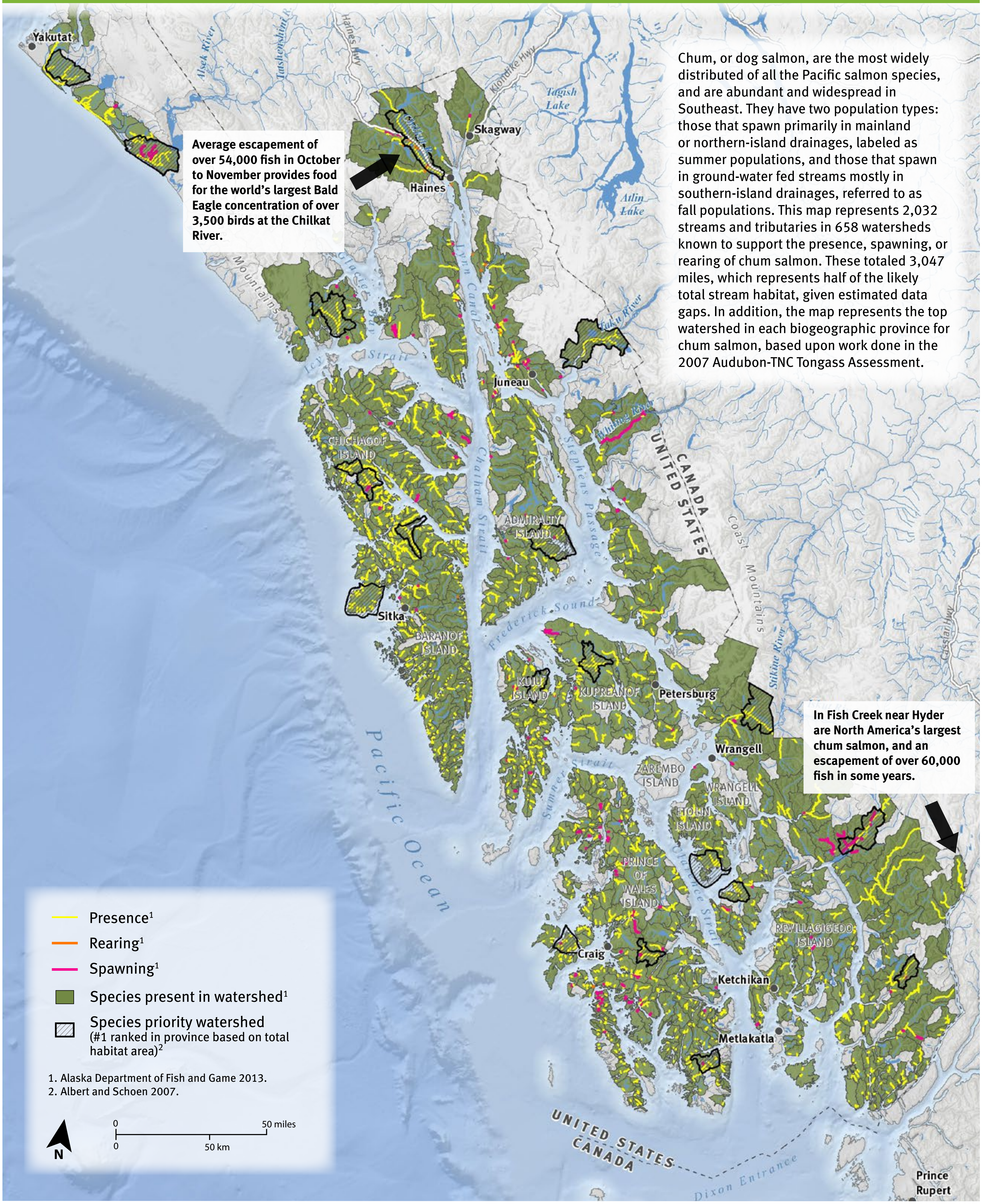
- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

John Schoen

Spawning adult male chum salmon.

Chum (Dog) Salmon

Chum, or dog salmon, are the most widely distributed of all the Pacific salmon species, and are abundant and widespread in Southeast. They have two population types: those that spawn primarily in mainland or northern-island drainages, labeled as summer populations, and those that spawn in ground-water fed streams mostly in southern-island drainages, referred to as fall populations. This map represents 2,032 streams and tributaries in 658 watersheds known to support the presence, spawning, or rearing of chum salmon. These totaled 3,047 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for chum salmon, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.7: Chum (Dog) Salmon

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STEELHEAD TROUT

Beth Peluso

Steelhead (*Oncorhynchus mykiss*) are an anadromous variety of rainbow trout, spending part of their life in the ocean. Unlike their freshwater counterparts, they sport a silvery sheen while in the ocean. They range from Southern California to the Kamchatka Peninsula. In Alaska, steelhead inhabit coastal streams from Dixon Entrance up through the Gulf of Alaska to the Cold Bay area on the Alaska Peninsula (Harding and Coyle 2011). Although more than 500 streams in Southeast Alaska are known to support steelhead, this species occurs in much smaller numbers than Pacific salmon, with many streams in Southeast Alaska containing less than 200 fish. A few larger rivers may have runs of up to 1,000 fish. By far the most productive steelhead river in the Tongass is the Situk, near Yakutat, with runs ranging from 3,000 to more than 15,000 fish (Harding and Coyle 2011).

Depending on water temperature, the young steelhead hatch from between a few weeks to four months after the spawning season. The small fry hide in the safety of the gravel for a few more weeks, then emerge to feed (Alaska Department of Fish and Game 2014g). Steelhead spend their first several years (usually three) in their natal stream before traveling to the ocean. They feed in saltwater for two to three years, then return to freshwater to spawn (Harding and Coyle 2011). Steelhead mortality is high in the ocean—only about 5 to 10 out of 100 young steelheads that reach the ocean survive to spawn (Alaska Department of Fish and Game 2008a). The abundance of food in the ocean allows the fish to grow rapidly, sometimes up to an inch per month (Alaska Department of Fish and Game 2014g).

Unlike salmon, steelhead can spawn multiple years. Some fish may spawn as many as five times, although they may take a spawning season off to recover before returning (Alaska Department of Fish and Game 2014g). Adults that survive the spawning season are called "kelts." Usually about one-third of a run may be returning fish. Males fight vigorously for females, resulting in a much lower survival rate, with 65 to 80% of returnees being female versus a 50/50 split between the sexes for first-time spawners (Harding and Coyle 2011).

The timing of steelhead runs varies widely, with runs occuring in spring (about mid-April through May), summer (July), and fall (September through November and sometimes through the rest of the winter). In Southeast Alaska, most steelhead runs occur in spring, with very few summer runs. About 36 fall runs occur in Southeast, but it is thought that spring runs in those areas are still higher. West of Yakutat, fall runs are dominant, including on the Kenai Peninsula, Kodiak Island, and Alaska Peninsula (Alaska Department of Fish and Game 2014g). Regardless of which run brings them back to freshwater, all steelhead spawn from mid-April through early June, when water temperatures reach 6° to 9°C (43° to 48°F) (Harding and Coyle 2011).

Steelhead are prized by sport anglers for their fighting abilities. They are also managed as a subsistence resource through a combination of federal and state management. The state angling record for steelhead/rainbow trout was a 42 lb (19 kg) fish caught in 1970 at Bell Island near Sitka.

Melanie Smith / Nick Jans

Releasing a steelhead trout.

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Steelhead populations decreased sharply enough in the mid-1980s that ADFG and the public became concerned about abundance. At the time, there was a limit of one steelhead per day, with a limit of two in possession. There were no size limits. Although there was not much information about the number of sport anglers fishing for steelhead, by the early 1990s the escapement (fish that pass upriver before harvest is allowed) levels on the Situk, the largest steelhead fishery, were declining alarmingly (Harding and Coyle 2011). In 1994, ADFG changed the regulations. Steelhead could no longer be sold commercially, although steelhead caught unintentionally (bycatch) could be kept for personal use as long as they were reported (Harding and Coyle 2011). As of 2014, state sportfishing regulations allow anglers to keep steelhead that are a minimum of 36 in (0.9 m) and have set the daily allowable bag limit to one steelhead, with an annual limit of two. Anglers are required to report the steelhead they keep (Alaska Department of Fish and Game 2014e). A series of international and national legal agreements banning the use of high seas drift nets with regard to salmon may have also played a role in recent steelhead population recovery (see also National Marine Fisheries Service 2013).

Until 1999, the State of Alaska handled the regulations for subsistence steelhead fisheries in Southeast Alaska. Except for an annual subsistence harvest of a maximum of 300 steelhead in the Situk and Ahrnklin rivers (near Yakutat), other subsistence harvest was limited to steelhead bycatch under subsistence salmon permits. In 2003, the Federal Subsistence Board expanded subsistence steelhead fishing substantially. Currently, there is some tension between state-managed and federally managed subsistence steelhead fisheries. The ADFG, which is responsible for managing state waters and sport fisheries, has tried (unsuccessfully) to oppose increases in harvest limits, citing concern for the impacts on steelhead population levels in Southeast Alaska (Harding and Coyle 2011).

CONSERVATION ISSUES

To avoid overharvest, conservation recommendations include continuation of harvest restrictions, monitoring of steelhead populations and the number of fish taken in all fisheries (including incidental take) for both federal and state subsistence fisheries. Based on limited stock information, Southeast Alaska steelhead stocks are relatively stable, having increased from 2003 to 2007 before decreasing more recently. Some systems have not rebounded from depressed abundance levels in the 1980s to 1990s (Alaska Department of Fish and Game 2014f).

NOAA

Steelhead trout.

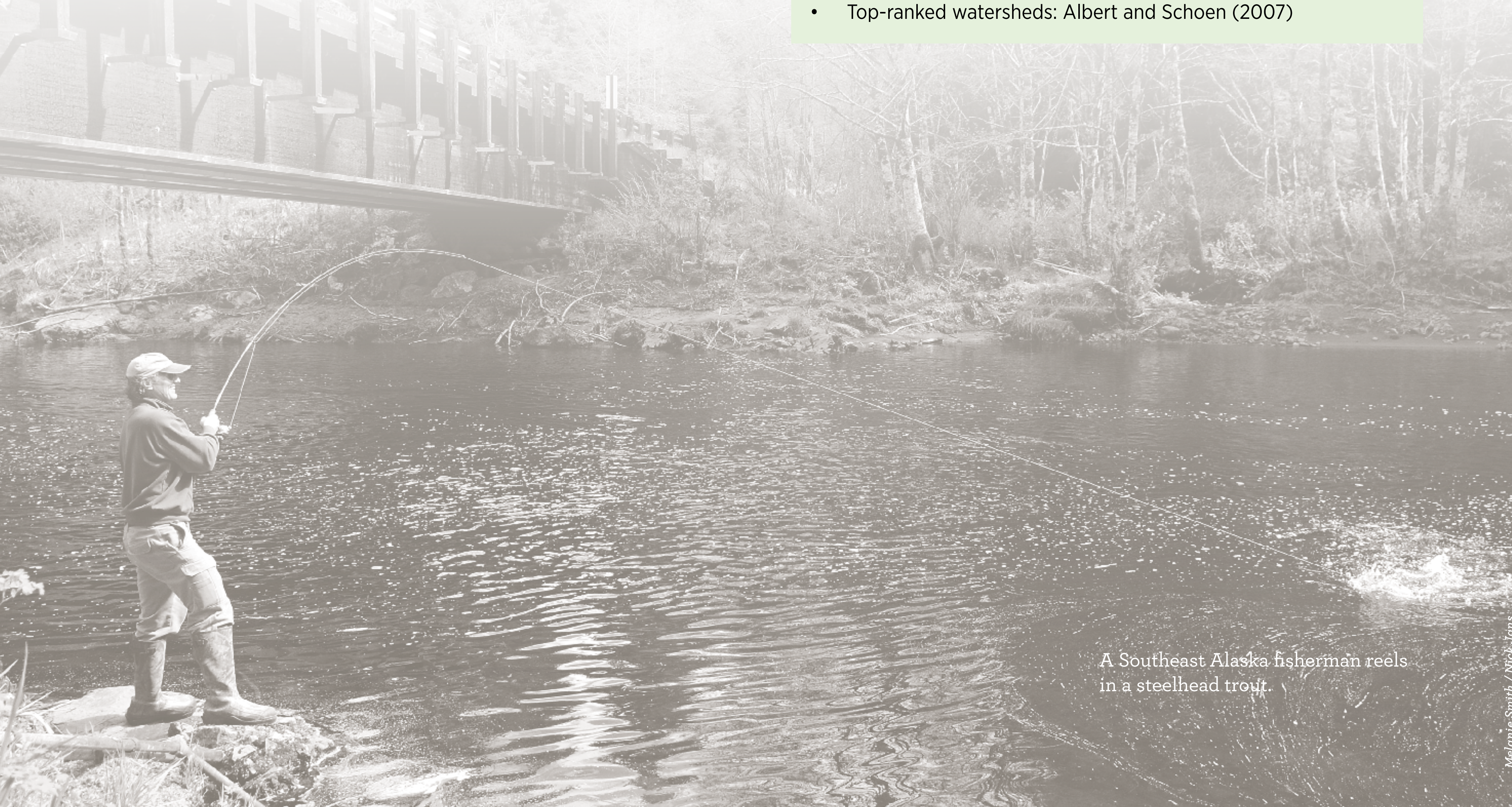
Climate change may impact conditions in the North Pacific, which in turn affect survival of juvenile steelhead. The biggest threat to steelhead, as well as to rainbow trout, is habitat degradation (Alaska Department of Fish and Game 2014f) caused by urbanization, road building, hydroelectric power, logging, mining, and wetland loss.

MAPPING METHODS

This map represents 588 streams and tributaries in 320 watersheds known to support the presence, spawning, or rearing of steelhead (Alaska Department of Fish and Game 2013). These totaled 1,674 mi (2,694 km), which is likely only 50% of the model-estimated anadromous stream length. In addition, this map represents the top watershed in each biogeographic province for steelhead, based upon work done in the 2007 Audubon-TNC Tongass Assessment. For more information on mapping methods see the Anadromous Fish Habitat methods section.

MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)
- Top-ranked watersheds: Albert and Schoen (2007)

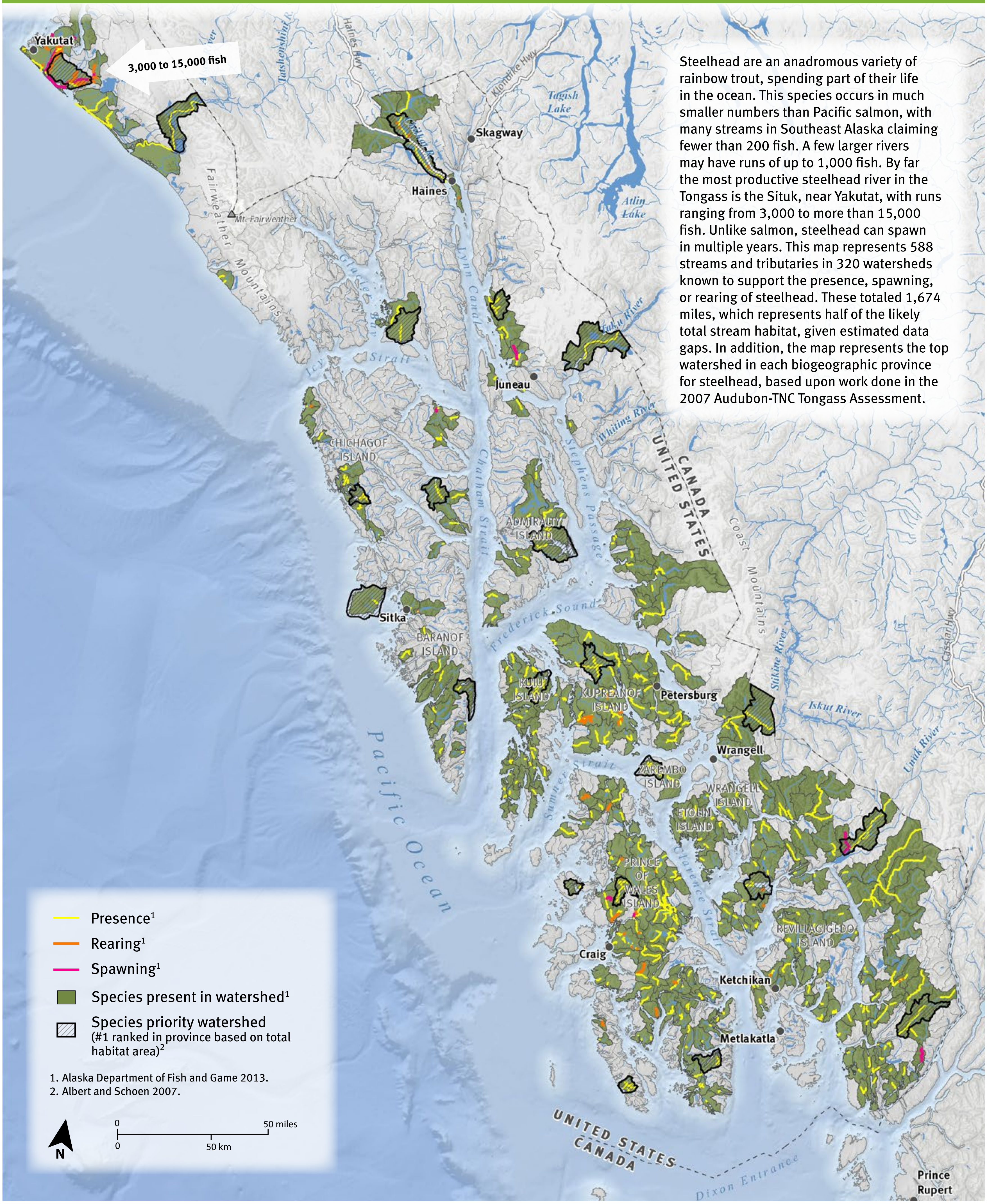


A Southeast Alaska fisherman reels in a steelhead trout.

Melanie Smith / Nick Jans

Steelhead Trout

Steelhead are an anadromous variety of rainbow trout, spending part of their life in the ocean. This species occurs in much smaller numbers than Pacific salmon, with many streams in Southeast Alaska claiming fewer than 200 fish. A few larger rivers may have runs of up to 1,000 fish. By far the most productive steelhead river in the Tongass is the Situk, near Yakutat, with runs ranging from 3,000 to more than 15,000 fish. Unlike salmon, steelhead can spawn in multiple years. This map represents 588 streams and tributaries in 320 watersheds known to support the presence, spawning, or rearing of steelhead. These totaled 1,674 miles, which represents half of the likely total stream habitat, given estimated data gaps. In addition, the map represents the top watershed in each biogeographic province for steelhead, based upon work done in the 2007 Audubon-TNC Tongass Assessment.



Map 4.8: Steelhead Trout

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DOLLY VARDEN

Bob Armstrong and Marge Osborn
Revised by Kathy Wells

Bob Armstrong

Adult Dolly Varden.

Dolly Varden (*Salvelinus malma*), a type of char, are found from northern Washington to the Mackenzie River in Arctic Canada, and from Eastern Russia to Japan and Korea. Dolly Varden are widely distributed in western North America and are particularly abundant throughout Southeast Alaska.

This species is prized by some anglers as a sport fish and for eating. Dolly Varden are a traditional subsistence food in Southeast Alaska. The sea-run Dolly Varden has an overall silvery appearance with olive-green to brown on its dorsal surface and numerous red to orange spots on its sides. At maturity the lower body of the breeding male turns brilliant red. The name Dolly Varden originated from a character in Charles Dickens' novel, *Barnaby Rudge*, noted for her vividly colored dresses (Alaska Department of Fish and Game 2008a).

The taxonomic status of Dolly Varden has been debated for years. Originally identified by Johann Walbaum in 1792 from specimens found in Kamchatka, Russia, the Dolly Varden has been variously considered a valid, independent species, a subspecies of the arctic char (*Salvelinus alpinus*), or the same species as arctic char (Armstrong and Morrow 1980). Today, there are two subspecies recognized in Alaska—a northern and a southern form. Only the southern Dolly Varden is found throughout Southeast. The two forms differ both genetically (the southern fish have 82 chromosomes, four more than the northern variety) and morphologically (the southern fish have fewer vertebrae than the northern fish). Both varieties have ocean-run and resident freshwater types. The southern variety lives thoughout Southeast Alaska up through the Gulf of Alaska and to the southern side of the Alaska Peninsula, Kodiak Island, and the Aleutian Islands (Alaska Department of Fish and Game 2014c).

The Dolly Varden in Southeast Alaska may grow up to 10 lbs (4.5 kg) and about 28 in (71 cm) long. They seldom live more than eight to ten years and spend their first five to six years maturing. In Southeast, Dolly Varden can be found in a wide variety of habitats, including lakes of all sizes with and without access to the sea; tiny, isolated ponds; large rivers; small streams; sections of water both above and below barriers to anadromous fish; and even intermittent rivulets (Armstrong 1991). From at least September to May, Dolly Varden can be found in glacial lakes that fish can access from the sea, and glacial lake outlets are often used for rearing young. Some Dolly Varden are present in salt water almost year-round, although populations are highest during late spring and early summer before they begin to enter streams. Dolly Varden inhabit both offshore and inshore saltwater areas but prefer inshore.

Resident Dolly Varden, which live their entire lives in streams or small lakes and ponds, are small. They seldom grow longer than 10 in (26 cm). Those that inhabit larger lakes often grow to 12 in (30 cm) or more, but they still generally weigh less than 1 lb (0.5 kg). Sea-run Dolly Varden, fish that spend part of their lives in salt water, usually grow from 15 to 22 in (38 to 56 cm) long and weigh 1 to 3 lb (0.5 to 1.4 kg). Occasionally, large fish weighing more than 10 lb (5 kg) are hauled from large mainland rivers such as the Taku River near Juneau. The state Dolly Varden/arctic char angling record was a 27 lb (12 kg) fish caught in 2002 on the Wulik River at Kivalina, Alaska.

Unlike salmon, Dolly Varden can spawn multiple seasons, although they do not often return more than three times (Alaska Department of Fish and Game 2014c). It is thought that less than half of the fish survive to spawn a second season. They spawn from September and November, returning to the headwater streams or sometimes larger stretches of river where they hatched. A single female can lay up to 6,000 eggs in the gravel bed (redd) she prepares (Alaska Department of Fish and Game 2014c). Dolly Varden are selective when choosing sites to spawn, concentrating in areas near stream headwaters rather than scattering in pairs throughout a stream.

Rearing areas are also especially important for the young of sea-run Dolly Varden. The eggs hatch within four to five months. The hatchlings hide in the gravel for another month, living off the remaining yolk sack. The alevins emerge from the gravel in May, and juveniles remain on the stream for two to four years (Armstrong 1970). During this period, before fish leave the streams as smolt, they appear to use a variety of habitats and can be found in most accessible portions of the streams (Armstrong and Morrow 1980). Young-of-the-year are found in small pools and in eddies along stream banks where the flow is reduced (Blackett 1968). In early summer, they can also be found in very small rivulets with depths of 0.5 to 1.5 in (1 to 3 cm) and widths less than 3 ft (1 m) (Armstrong and Elliott 1972).

At first, juvenile Dolly Varden stay close to the shore, feeding along the bottom on insects and larvae. After their first year of life, the juveniles use a variety of habitats ranging from still to moving water, gravel to muddy substrate, and dense vegetation to open water with no vegetation (Heiser 1966). Favored habitats appear to be undercut bank areas along the stream (Armstrong and Elliott 1972). As they grow bigger, they shift to deeper waters where they add small fish, salmon eggs, and crustaceans to their diet (Alaska Department of Fish and Game 2014c).

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After several years, the young fish reach a length of about 5 in (13 cm) and the next stage of their lives begin. Their bodies change color to silver and their physiology changes to adapt to life in saltwater. Dollies mainly head out to sea in May or June, although a portion of them move in September or October (Alaska Department of Fish and Game 2008a). They feed voraciously over the summer, growing rapidly, then return to freshwater to spawn for the first time in the fall (Alaska Department of Fish and Game 2014c).

In Southeast Alaska, after spawning, adult Dolly Varden migrate to freshwater lakes where they overwinter, perhaps from as far as 100 mi (160 km) away (Armstrong and Morrow 1980). Their migrations are more complicated than those of salmon. The Dollies often go out to sea to feed in the summer, traveling along the coastline, occasionally moving up into freshwater to feed. If a Dolly Varden hatched in a stream system with a lake, it returns to that lake for the winter. If not, it seeks out a lake where it can overwinter.

In the spring, as the Dollies head to the sea, they opportunistically feed on salmon fry, mainly pinks. Once in the ocean, they range from coastal waters to open ocean, eating amphipods, juvenile salmon, sand lance, and other small fish. Dolly Varden may also follow salmon into rivers to feed on salmon eggs (Alaska Department of Fish and Game 2008a;2014c). Generally, they seem to scavenge drifting salmon eggs that would not hatch (Alaska Department of Fish and Game 2014c).

Large amounts of Dolly Varden were historically caught as bycatch from commercial salmon harvest, sometimes as much as 190,000 lb (86,000 kg), but the amount has dropped in recent years (Alaska Department of Fish and Game 2014c).

The role of Dolly Varden in the food web of Southeast has not been well studied. The species may be important in the diet of Bald Eagles (*Haliaeetus leucocephalus*), river otters (*Lutra canadensis*), black and brown bears (*Ursus americanus* and *Ursus arctos*, respectively), mink (*Neovison vison*), harbor seals (*Phoca vitulina*), and Steller sea lions (*Eumetopias jubatas*). In addition, belted kingfishers (*Megaceryle alcyon*) have been observed bringing young Dolly Varden to their nestlings. Young sea-run Dolly Varden in coastal streams during the first two to four years of their lives are consumed by American dippers (*Cinclus mexicanus*), mergansers (*Mergus spp.*), and great blue herons (*Ardea herodias*).

For nearly two decades, from 1921 to 1939, there was a bounty of up to five cents for a Dolly tail. Because they feed on juvenile fish of other species, the idea was to boost salmon populations by decimating the Dolly Varden. People submitted nearly 6 million tails. The program halted abruptly when closer examination revealed that of the 20,000 tails submitted in 1939, more than half were actually from silver salmon (Alaska Department of Fish and Game 2008a;2014c). Research has since shown that the Dollies are not avid enough predators to affect salmon populations (Alaska Department of Fish and Game 2008a).

To the contrary, Dolly Varden may benefit salmon because in lakes they feed heavily on freshwater snails (Armstrong 1965), which are intermediate hosts of a parasite that infects the eyes of silver and red salmon young and eventually causes blindness. By controlling the population of these snails, the Dolly Varden may help reduce prevalance of the parasite and its impact on juvenile salmon (Armstrong 1991). Another possible benefit is that Dolly Varden compete for space with cutthroat trout in lakes (Andrusak and Northcote 1971). Because cutthroat trout prey heavily on sockeye in lakes (Armstrong 1971), this competition for space may play a role in reducing overall predation of the salmon young in lakes.

CONSERVATION ISSUES

Threats to local populations include urbanization, barriers to migration, fishing, mining, timber harvest, and climate change (Alaska Department of Fish and Game 2014c).

Because Dolly Varden are not as abundant as they appear to be in Southeast, they could be more easily overharvested than other species of fish. Their habit of moving from one freshwater system to another means that many of the fish seen in one stream at one time could be the same fish seen in another stream. Successful management of Dolly Varden depends on recognition of their complex migration patterns (Armstrong 1984).

Bob Armstrong

Young Dolly Varden mixed with cutthroat trout and silver salmon.

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Overharvest by sport fishermen has caused severe declines of Dolly Varden in some areas of Alaska. Over the last several decades, ADFG has instituted and removed various local limits on sportfishing, mainly in the Juneau area and Chilkoot River drainage. Based on strong declines in sportfish catch, in 1978 the allowable limit dropped to five fish per day in the Juneau area. In 1980, the agency lowered the limit to only two per day. These limits were reinforced by seasonal closures in freshwater from September through May and in nearshore ocean waters in April and May. By 1983, most of the seasonal limits were removed, except for a few specific locations. Mendenhall and Auke lakes are catch-and-release only. More recently, limits in the Chilkoot River were dropped from ten fish to two fish in 1994; further research merited raising the limit to four fish in 2003.

Although its effects have not been well studied, environmental degradation certainly has reduced the numbers of Dolly Varden in Southeast. Clearcut logging, stream channelization, and urban development have all caused obvious damage to streams where Dolly Varden live. Fortunately, Dolly Varden are widespread in the region and occur in almost all fresh waters capable of supporting fish; therefore, the current risk of widespread loss of populations is low.

Because numerous populations migrate to a relatively few lakes and larger rivers for the winter, harm to these overwintering areas could result in extensive loss of Dolly Varden. Identification and protection of Dolly Varden overwintering lakes and rivers is important to maintaining their populations in Southeast. Identification of many of these areas could be easy if one considers that any lake with access to and from the sea would be important to Dolly Varden. Lake Eva and Windfall Lake are two such major overwintering lakes which are identified for protection by the T77 proposal (see the Human Uses chapter).

Further study could reveal populations of Dolly Varden that might warrant special consideration. In particular, special consideration may be warranted for populations in isolated ponds or springs and some stream-resident populations that have been isolated from other populations for decades. Also, sea-run Dolly Varden exhibit strong homing tendencies for spawning, and some of these populations may reveal characteristics quite different from those of other sea-run populations.

Three considerations seem most important for conserving healthy populations of Dolly Varden in Southeast:

- Recognizing the complex nature of Dolly Varden migration patterns in management decisions
- Realizing that land-use activities that harm one stream, or overharvest in a single stream, could affect Dolly Varden populations in other systems
- Paying particular attention to the protection and preservation of major Dolly Varden wintering areas.

MAPPING METHODS

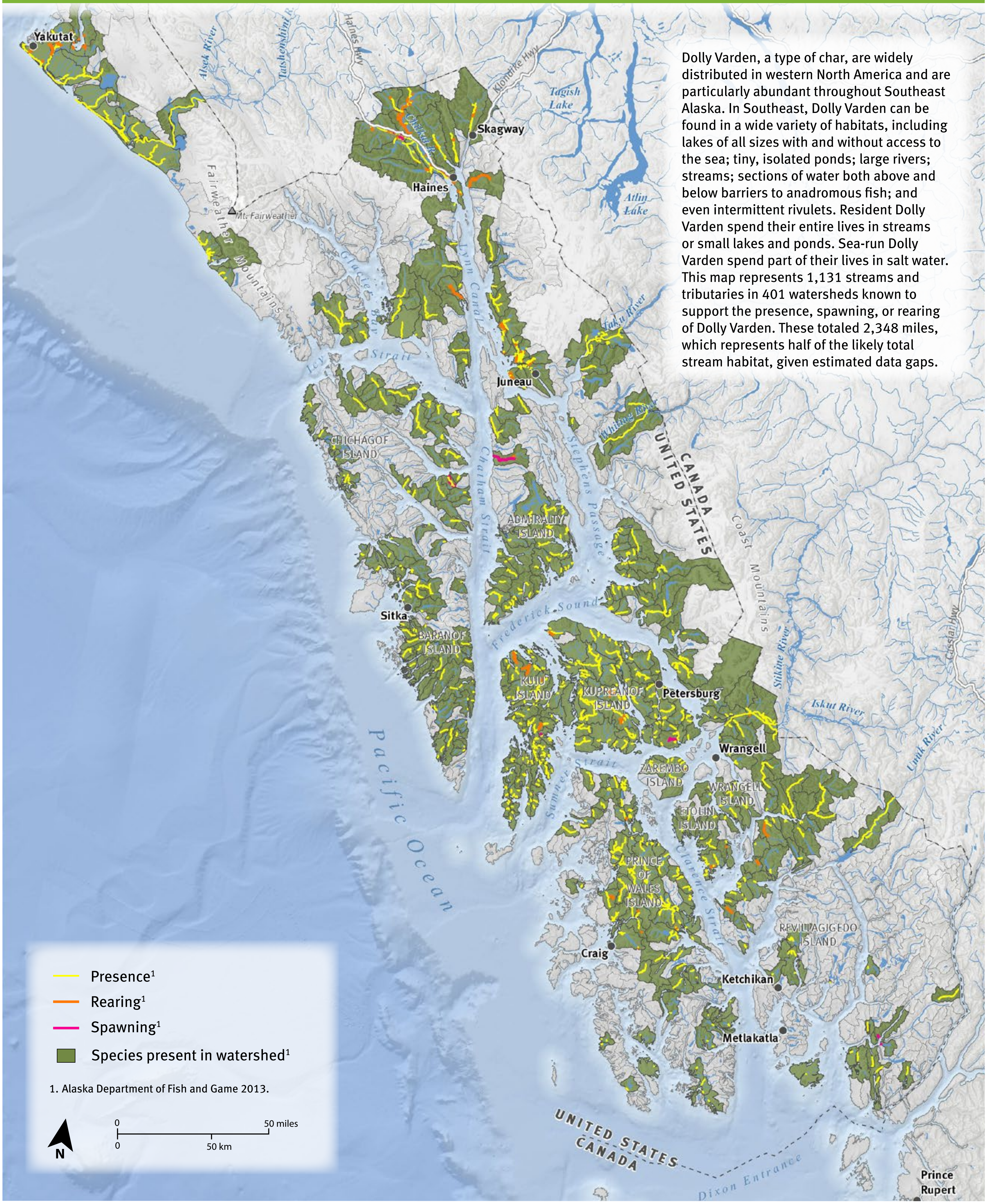
This map represents 1,131 streams and tributaries in 401 watersheds known to support the presence, spawning, or rearing of Dolly Varden (Alaska Department of Fish and Game 2013). These totaled 2,348 mi (3,779 km), which is likely only 50% of the model-estimated anadromous stream length (see Anadromous Fish Habitat methods section).

MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)

Dolly Varden

Dolly Varden, a type of char, are widely distributed in western North America and are particularly abundant throughout Southeast Alaska. In Southeast, Dolly Varden can be found in a wide variety of habitats, including lakes of all sizes with and without access to the sea; tiny, isolated ponds; large rivers; streams; sections of water both above and below barriers to anadromous fish; and even intermittent rivulets. Resident Dolly Varden spend their entire lives in streams or small lakes and ponds. Sea-run Dolly Varden spend part of their lives in salt water. This map represents 1,131 streams and tributaries in 401 watersheds known to support the presence, spawning, or rearing of Dolly Varden. These totaled 2,348 miles, which represents half of the likely total stream habitat, given estimated data gaps.



Map 4.9: Dolly Varden

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COASTAL CUTTHROAT TROUT

Bob Armstrong and Marge Osborn
Revised by Nils Warnock and Ben Sullender

There are 14 subspecies of cutthroat trout (*Oncorhynchus clarkii*) in North America. Coastal cutthroat trout (*O. clarkii clarkii*) occur in coastal streams and lakes from Prince William Sound in Alaska to the Eel River in California (Behnke 1979). These cutthroat trout are highly prized sport fish that can be found in streams and lakes throughout Southeast Alaska, where some populations are anadromous (sea-run) and others are permanent residents in freshwater (Bangs and Harding 2008, Harding 2013). Sea-run cutthroat are generally uniform silver with numerous black spots and lake residents can be golden-yellow with numerous black spots. Sea-run cutthroat can weigh from 1 to 2 lb (0.5 to 0.9 kg) and some lake residents weigh up to 6 lb (2.7 kg). These fish can live to be over 15 years old (Roger Harding, ADFG, personal communication 2015). Usually cutthroat trout have a distinct red or orange streak on the underside of the lower jaw (hence its name), although the streak may be absent or inconspicuous in fish in the sea or fresh from the sea. A cutthroat is best distinguished from a rainbow trout by the presence of a patch of small teeth behind its tongue between the gills (Mecklenburg et al. 2002).

Southeast has many streams, rivers, and lakes with good cutthroat habitat (Bangs and Harding 2008, Harding and Coyle 2011). More than 200 lakes and associated stream systems are home to the resident coastal cutthroat trout and nearly 100 streams are known to contain runs of anadromous cutthroat trout (Armstrong 1996). Small streams harboring resident populations of cutthroat trout are widespread, although the exact number of these systems is unknown.

Sea-run cutthroat are usually associated with lakes and a few larger, slow-moving rivers. Most of these anadromous populations are found south of Frederick Sound in Southeast (Armstrong 1996). Each year, the fish go to sea in May and June and return to freshwater in September and October.

Resident cutthroat trout are found in most landlocked lakes at lower elevations in Southeast. Large, trophy-sized cutthroat may be found in a few of these systems. Some lake-resident cutthroat trout feed on small landlocked sockeye kokanee salmon (*Oncorhynchus nerka*). Resident cutthroat typically live longer than sea-run individuals (Alaska Department of Fish and Game 2008b). Other resident cutthroat have adapted to live in small streams by spawning at an early age and growing to only a few inches long.

Cutthroat trout are of particular conservation concern, as abundance in Southeast is relatively low (Harding and Coyle 2011); they can be vulnerable to depletion through overharvest, and they have a wide range of sizes and ages at maturity, making management difficult (Harding 2013). To compound these factors, cutthroat are very sensitive to habitat alteration, as indicated by the major declines in *O. clarkii* populations in the Lower 48 states as a result of anthropogenic activities (Hilderbrand 2003, Colyer et al. 2005).

Smaller streams in Southeast may be especially important as spawning and rearing areas for cutthroat (Bryant et al. 2009). In a study of the coastal cutthroat trout in British Columbia, Hartman and Gill (1968) found that large streams, with drainage areas of more than 50 mi^2 (130 km^2), were occupied predominantly by steelhead/rainbow trout. Small streams, with drainage areas of less than 5 mi^2 (13 km^2), were occupied predominantly by cutthroat. Where both species occurred, the predominant species was cutthroat in the small tributaries and headwaters and steelhead in the lower reaches of the main stream (see also Johnston 1981).

Anadromous cutthroat trout may also utilize different watersheds to provide spawning, feeding, and overwintering habitat. Cutthroat tagged at Petersburg Creek were recaptured by sport fishers in a total of 14 streams in the Petersburg area from 0.5 to 44 mi (0.8 to 71 km) away from the initial capture site (Jones 1977). Tagged cutthroat tended to follow the shorelines on their migrations and were reluctant to cross large open bodies of water. This behavior could mean that spawning fish home to specific tributaries and non-maturing fish do not always return to a home stream on a feeding run or when seeking overwintering habitat (Johnston 1981).

Numbers of cutthroat trout have been counted or estimated in various systems across Southeast known as good for cutthroat fishing (Bangs and Harding 2008, Harding and Coyle 2011).

There are only two populations of anadromous cutthroat in Southeast that have been adequately sampled for trend data, both using streams near urbanized areas around Juneau. At Auke and Jordan creeks, numbers of sea-run trout have declined (Bangs and Harding 2008, Harding and Coyle 2011), likely because of urbanization resulting in reduced water and habitat quality (e.g. see Host and Neal 2004).

Perhaps the largest population of lake-bound cutthroat in Southeast occurs on Admiralty Island at Hasselborg Lake with an estimated 10,839 trout in 1991 (Laker 1994, cited in Bangs and Harding 2008). At Turner Lake near the Taku River, ADFG estimated a population of 1,526 resident cutthroat trout. Other lakes checked for resident cutthroat in Southeast included Jims Lake (2,816), Mirror Lake (5,633), Harvey Lake

Bob Armstrong

Cutthroat trout.

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John Schoen

Honker Divide on Prince of Wales Island is a popular fishing area for coastal cutthroat trout and other anadromous species.

(669), and Virginia Lake (5,631) (Jones et al. 1990, see more recent data in Bangs and Harding 2008, Harding and Coyle 2011). Several of these estimates reflect the number of cutthroat within the 4 to 16 in (100 to 400 mm) size range, the size sampled by the gear used.

Trend data on populations of freshwater cutthroat in Southeast are known for two lakes: Baranof and Auke lakes, both of which appear to be stable but highly variable (Bangs and Harding 2008). Abundance of stream-resident cutthroat is largely unknown but expected to be quite small.

Because of concerns about overfishing, state management of cutthroat in Southeast changed significantly in 1994 when the ADFG published new regulations with more restrictive bait, bag, and size limits, depending on whether areas were determined to be high or low use by anglers (Harding and Coyle 2011, Harding 2013). In most areas of Southeast, sport fishers have a bag limit of two trout (Bangs and Harding 2008).

Surveyed anglers said that the opportunity to catch trophy-size cutthroat trout is important to them, and ADFG's research shows that cutthroat do not reach trophy size for about 12 years (Alaska Department of Fish and Game 2012b). Thirteen lakes in Southeast have been designated as trophy cutthroat lakes and are under special management designations designed to maintain large cutthroat trout. The sport fish regulations covering these waters allow one cutthroat per day and in possession, 25 in (64 cm) or more. One lake, Turner, allows only catch-and-release fishing for cutthroat trout. The trophy cutthroat lakes are Distin, Hasselborg, and Jims lakes, as well as Lake Guerin—all on Admiralty Island; Turner Lake on the mainland near the Taku River; Eagle Lake off West Behm Canal; and Ella, Humpback, Manzanita, Orchard, Patching, Wilson, and Reflection lakes in the Ketchikan area. These lakes are known to have produced cutthroat trout greater than 3 lbs (1.4 kg) or 20 in (51 cm) (Alaska Department of Fish and Game 2012b).

Florence Lake and Hasselborg Lake are two of the most popular lakes in Southeast for fly-in fishing for cutthroat trout. Access to both lakes is mostly by small plane from Juneau or Sitka. Florence and Hasselborg lakes are designated "High Quality" or "Important" watersheds by both the ADFG and the USFS. The number of reported visitor days to these lakes nearly doubled during a 15-year period to more than 4,000 at Florence Lake and 3,000 at Hasselborg Lake as of 1991 (Jones et al. 1992). Following clearcutting at Florence Lake, the number of anglers declined (Harding 2013).

In the Petersburg/Wrangell area, only Eagle Lake off West Behm Canal has been designated a trophy cutthroat trout lake. In the Ketchikan area, the trophy cutthroat trout lakes are Ella, Humpback, Manzanita, Orchard, Patching, Wilson, and Reflection lakes.

In 2000, the Federal Subsistence Board liberalized the subsistence take of cutthroat and rainbow trout to a daily bag limit of six trout, with some exceptions (Bangs and Harding 2008). Statewide, numbers of cutthroat caught by sport fishers vary among years (1993 to 2003), from 30,825 to 75,067; most of these trout are caught in Southeast. At the same time, because of state restrictions imposed in 1994 and overall declines in cutthroat populations, harvest rates of cutthroat have decreased significantly (Bangs and Harding 2008, Harding and Coyle 2011). For the few years with data, the federal subsistence fishery in Southeast reports very low harvest rates (0 to 25 fish per year) (Bangs and Harding 2008).

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CONSERVATION ISSUES

The role of cutthroat trout in the food web of Southeast has not yet been widely studied, but because of the year-round presence of the species in lakes and streams, cutthroat likely provide food for American dippers (*Cinclus mexicanus*), mink (*Neovison vison*), river otters (*Lutra canadensis*), and fish-eating birds such as belted kingfishers (*Ceryle alcyon*), common mergansers (*Mergus spp.*), and great blue herons (*Ardea herodius*).

Within North America, the coastal cutthroat trout is the most abundant of the cutthroat trout subspecies (Behnke 1979, Johnston 1981), but serious declines in numbers have been reported since 1960, at least among anadromous populations. The reasons cited for these declines include loss of stream habitat from logging and forest road building, mines, oil spills, hydroelectric projects, over-fishing, and, in more populated regions, increased urbanization (Trotter 1989, Bangs and Harding 2008).

Populations of various subspecies of cutthroat trout have been considerably diminished in the Lower 48 (Colyer et al. 2005). Of the 13 subspecies of interior cutthroat trout, two are extinct and most of the rest occur at only a small fraction of their original distribution and abundance (Behnke 1991). Some of these subspecies are now listed as threatened in Nevada, California, and Colorado, and many western states have adopted wild fish management policies and management plans tailored to promote recovery of cutthroat trout subspecies (Trotter 1991).

Anadromous populations of coastal cutthroat trout outside of Alaska have declined sharply through time, and many are now listed as at risk. The declines have been attributed to anthropogenic factors such as landscape alteration from logging and urbanization, conscription of habitat for rearing millions of stocked salmon and steelhead in places that historically did not support them, and over-exploitation by anglers (Trotter 1991, Hilderbrand 2003). Indiscriminate mixing of various subspecies of cutthroat trout and hybridization with rainbow trout from hatcheries also appear to have been a major cause of the rapid decline of native subspecies in the Lower 48 (Behnke 1979).

Because anadromous cutthroat spend three to four years maturing in fresh water, these fish are particularly susceptible to habitat alteration from logging (Armstrong 1971, Giger 1972), and some populations of cutthroat trout have even been extirpated from small tributaries as a result of logging operations (Wustenberg 1953) Large woody debris creates productive habitat for salmonids by forming pools, meanders, secondary channels, and undercut banks (Bisson et al. 1987), and as the debris decomposes or is transported downstream, it is gradually replaced with new material from the riparian, or streamside, zone. This natural regeneration of salmonid habitat within forested streams is precluded by clearcut logging, which removes all streamside vegetation and depletes potential new debris for the stream channel (Crispin et al. 1993).

Because sunlight increases water temperature and stream productivity, canopy removal may initially trigger a rise in salmonid population size and biomass. However, the loss of debris eventually leads to habitat changes undesirable for salmonids, as loss of cover may reduce over-winter survival (Lowry 1966), increased siltation impairs spawning and rearing habitat (Bustard and Narver 1975). Over time, usually several decades, trout populations fall to well below pre-logging levels unless provisions are made for the addition of new, large woody structures to streams (Trotter 1989). Habitat preferred by rearing cutthroat is not as diverse as that of other salmonids and is usually limited within a given system. Alteration of this preferred habitat because of land-use activities could seriously affect the cutthroat population.

Beyond habitat degradation and impacts associated with logging, cutthroat trout are also especially vulnerable to insecticides (Whitney and Spindler 1959, Cope 1961), which may indicate they are sensitive to other pollutants as well. In a study on the effects of forest insecticide spray on salmon streams in Southeast, Reed (1963) found DDT and DDE in cutthroat from all four streams sampled.

Cutthroat trout may be susceptible to contracting viruses from stocked hatchery fish. The Turner Lake sockeye stocking project, for example, was canceled in May 1990 because of concerns related to the potential for introduction of Infectious Hematopoietic Necrosis Virus (IHNV). There was concern for both the kokanee and cutthroat trout in Turner Lake because both species are IHNV susceptible (Jones et al. 1990).

Mining in Southeast may also be impacting cutthroat. Cutthroat numbers in Tributary Creek on Admiralty Island, downstream from the underground polymetallic Hecla Mine, fell between 1981 and 2011 in all three reaches of the creek where numbers were estimated (Kanouse 2011).

In light of current knowledge about coastal cutthroat trout in Southeast, the following actions merit consideration:

- Maintaining the genetic purity of Southeast cutthroats, which are among the few pure stocks remaining in the United States
- Protecting the small headwater streams important for cutthroat spawning and rearing
- Taking into account the special sensitivity of cutthroat to pollutants whenever spraying of herbicides or insecticides or creation of by-products from mining are being considered
- Recognizing and learning more about the dependency of specific cutthroat stocks on different watersheds for spawning
- Protecting the Trophy Fish Waters identified by the ADFG and the High Quality and Important watersheds designated by USFS.

After a 10-year study of anadromous cutthroat trout in Southeast, Jones (1976) recommended:

- Establishing selected cutthroat systems in Southeast as roadless, dispersed recreation, or natural areas
- Giving special consideration to identified cutthroat spawning and rearing areas during road-building and logging operations.

Finally, predicted alterations based on climate change could negatively impact cutthroats in Southeast (Bryant 2009).

MAPPING METHODS

This map represents 674 streams and tributaries in 225 watersheds known to support the presence, spawning, or rearing of cutthroat trout (Alaska Department of Fish and Game 2013). These totaled 1,417 mi (2,281 km), which is likely only 50% of the model-estimated anadromous stream length (see Anadromous Fish Habitat methods section).

This map shows high-use cutthroat trout waters within Southeast Alaska. "These high-use waters are defined as areas with either developed access (road or trail from road), a USFS recreational cabin, and/or intensive fisheries, i.e., 'high-use'. Twenty-one lakes and six drainages including the Juneau roadside waters are classified into this category across Southeast Alaska" (Alaska Department of Fish and Game 2012a).

Also shown are the 13 trophy cutthroat trout lakes in Southeast. These are lakes "that have produced cutthroat trout that qualified for entry in the [ADFG] Trophy Fish Program... 12 of these lakes are managed with a minimum size limit of 25 inches, with only 1 per day/1 in possession and no bait allowed; Turner Lake is managed as a catch-and-release only lake with no bait allowed" (Alaska Department of Fish and Game 2012b).

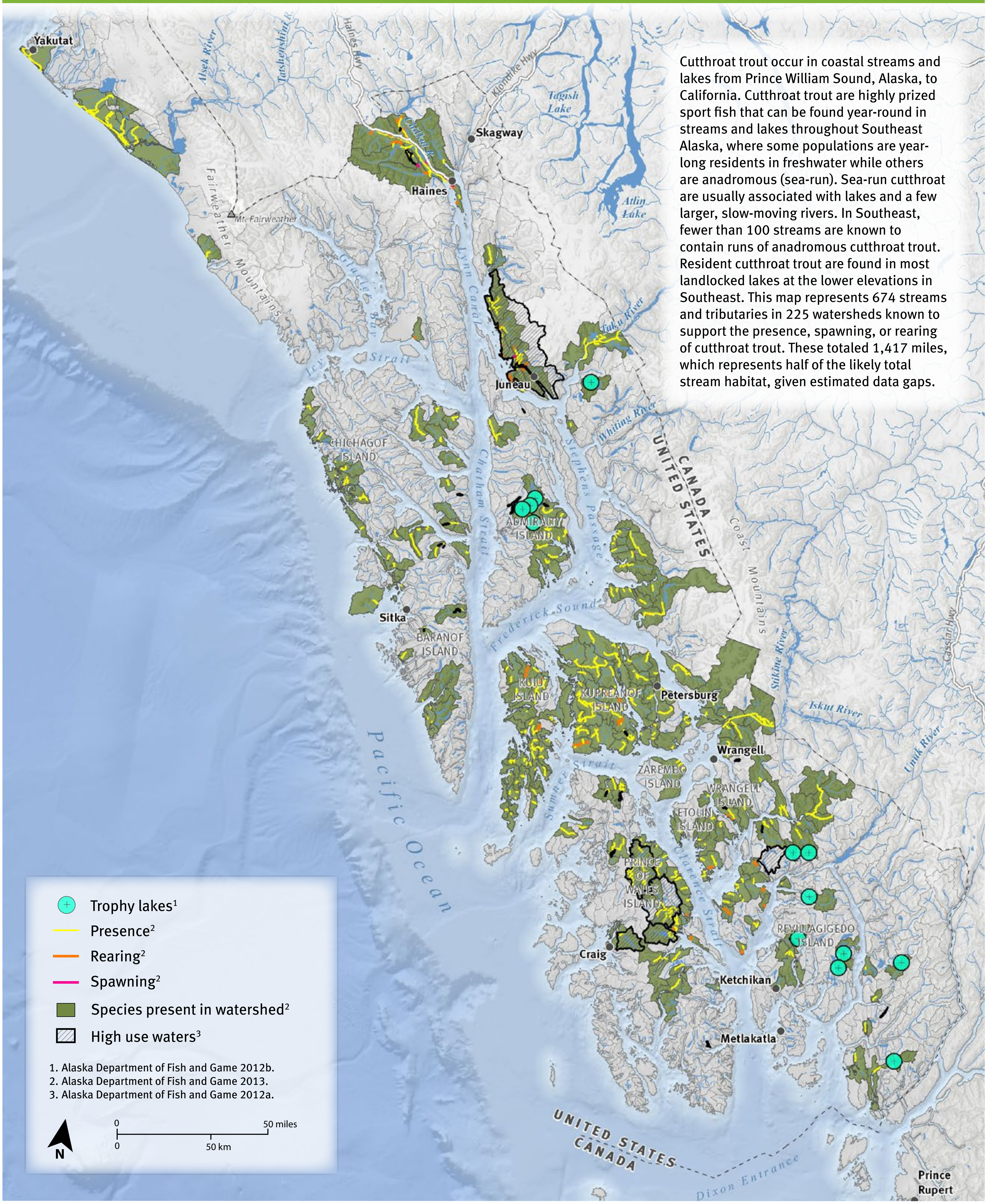
MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)
- High use cutthroat waters: Alaska Department of Fish and Game (2012a)
- Trophy lakes: Alaska Department of Fish and Game (2012b).

Coastal Cutthroat Trout

Audubon ALASKA

Cutthroat trout occur in coastal streams and lakes from Prince William Sound, Alaska, to California. Cutthroat trout are highly prized sport fish that can be found year-round in streams and lakes throughout Southeast Alaska, where some populations are year-long residents in freshwater while others are anadromous (sea-run). Sea-run cutthroat are usually associated with lakes and a few larger, slow-moving rivers. In Southeast, fewer than 100 streams are known to contain runs of anadromous cutthroat trout. Resident cutthroat trout are found in most landlocked lakes at the lower elevations in Southeast. This map represents 674 streams and tributaries in 225 watersheds known to support the presence, spawning, or rearing of cutthroat trout. These totaled 1,417 miles, which represents half of the likely total stream habitat, given estimated data gaps.

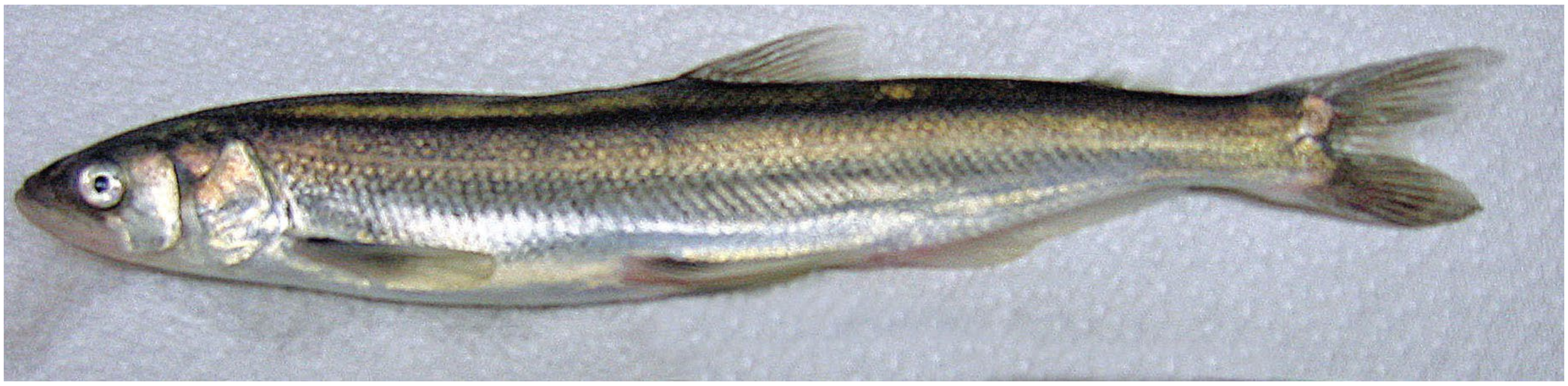


Map 4.10: Coastal Cutthroat Trout

MAP ON PAGE 102

EULACHON (HOOLIGAN)

Bob Armstrong and Marge Osborn
Revised by Nils Warnock



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Eulachon (hooligan).

Eulachon, also called hooligan (*Thaleichthys pacificus*), are small slender fishes up to 25 cm (10 in) long that belong to the smelt family (*Osmeridae*). Eulachon occur only on the northwest coast of North America, from northern California to southwestern Alaska (Moody 2008). These anadromous fishes spend most of their lives in the ocean (Clarke et al. 2007). At maturity, eulachon migrate into certain mainland rivers of Southeast (typically glacier fed) for spawning, usually during April and May (but sometimes in the fall). Features distinguishing eulachon from other smelt in Alaska are obvious circular grooves on their gill covers and dorsal fins that begin well behind the pelvic fins (Mecklenburg et al. 2002).

Eulachon are notable for their high concentration of oils (mostly mono-unsaturated fatty acids such as oleic acid). Samples of eulachon obtained from February to June in the Gulf of Alaska contained 18 to 20% oil, a value higher than that for other common forage fishes, such as sand lance (*Ammodytes hexapterus*) (3 to 6%) or capelin (*Mallotus villosus*) (2 to 10%), during the same time frame (Payne et al. 1999).

For native communities in the Pacific Northwest and Southeast Alaska, eulachon have long been important food fish, sometimes referred to as "salvation fish" due to their early arrival in the spring when they provide fresh food and oil after long winters (Stewart 1977 cited in Alaska Department of Fish and Game 2003). Commercially, the eulachon has been of relatively little importance; therefore, less is known about this species than other fishes such as salmon. The role of eulachon as food for many animals, including some of conservation significance such as Steller sea lions (*Eumetopias jubatus*), is prompting greater interest in understanding the biology and ecology of this small fish (Womble et al. 2005, Willson et al. 2006).

Because of abundance and ease of capture during spawning runs, eulachon are common forage fish for Bald Eagles (*Haliaeetus leucocephalus*), harbor seals (*Phoca vitulina*), Steller sea lions, gulls, and other animals (Drew and Lepp 1996, Marston et al. 2002, Womble 2003, Womble et al. 2005). Eulachon have a very high resource value, as they provide a higher amount of energy than other forage fish such as Pacific herring (*Clupea barengus*), Pacific sand lance, capelin, and walleye pollock (*Theragra chalcogramma*) (Perez 1994, Payne et al. 1999, Kuhnlein 2000). In addition, they are available to animals that feed on them during a season when energy costs for animals are high and when food sources, such as spawning salmon, are not available.

Other animals that feed on eulachon, include fish (spiny dogfish [*Squalus acanthias*], sablefish [*Anoplopoma fimbria*], arrowtooth flounder [*Atheresthes stomias*], salmon (*Oncorhynchus spp.*), Dolly Varden (*Salvelinus malma*), Pacific halibut [*Hippoglossus stenolepis*], and Pacific cod [*Gadus macrocephalus*]); marine birds (harlequin ducks [*Histrionicus histrionicus*], pigeon guillemots [*Cepphus columba*], common murres [*Uria aalge*], mergansers [*Mergus spp.*], cormorants [*Phalacrocorax spp.*], and gulls) (Scott 1973); marine mammals (baleen whales, orcas [*Orcinus Orca*], dolphins, pinnipeds) (Kajimura et al. 1980, Speckman and Piatt 2000, Huntington 2002) ; and terrestrial mammals (brown bears [*Ursus actos*], wolves [*Canis lupus*]).

Throughout their range, eulachon runs tend to be erratic, appearing in some years but not others, and only rarely in some river systems (Willson et al. 2006, Ormseth and Vollenweider 2007). In the ocean, eulachon appear to live near the bottom, on the shelf, usually at moderate depths of about 60 to 650 ft (20 to 500 m), but they may occur at depths greater than 2,000 ft (610 m) (Allen and Smith 1988, Eulachon Research Council 2000, Hay and McCarter 2000). In the Gulf of Alaska, eulachon have been captured in trawl samples as deep as 1,640 ft (500 m), with considerable variation among portions of the Gulf (Mueter and Norcross 2002). In northern Southeast, they have often been captured in trawl samples in the coastal fjords (Carlson et al. 1977).

Eulachon spawn only in certain mainland rivers in Southeast (Willson et al. 2006, Moody 2008). Spawning rivers may be turbid or clear, but all are thought to have spring high-water periods caused by heavy rains, characteristic of rivers draining large snowpacks or glaciers (Hay and McCarter 2000). In many rivers, spawning is more or less limited to the part of the river influenced by tides (Lewis et al. 2002). In the Berners Bay system, the greatest abundance of eulachon was observed in tidally influenced areas, but some fish ascended well beyond the tidal influence. Eulachon are reported to go as far as 50 mi (80 km) up the Susitna River in Southcentral Alaska (Barrett et al. 1984, Vincent-Lang and Queral 1984), possibly because of a low gradient (Lewis et al. 2002). Eulachon once ascended more than 100 mi (160 km) in the Columbia River system in the Pacific Northwest. Some evidence indicates that water velocity can limit upstream movements (Lewis et al. 2002)

Spawning substrates can range from silt, sand, or gravel to cobble and detritus (Smith and Saalfeld 1955, Barrett et al. 1984, Vincent-Lang and Queral 1984), but sand appears to be most common (Langer et al. 1977, Lewis et al. 2002). Egg survival of eulachon is greatly influenced by salinity. Exposure to salt water can be lethal (Farara 1996). Major temperature changes can also affect survival (Lewis et al. 2002).

Recent biological data suggests that eulachon populations are geographically structured, contrary to early studies which indicated that eulachon in general constitute a single evolutionarily significant unit throughout their entire range (McLean et al. 1999). Eulachon stocks in individual rivers may differ in characteristics such as size and spawning times (Hay and McCarter 2000), and there is significant genetic variation among different populations in the Columbia River and the Cook Inlet of Alaska, so eulachon management plans should be

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Barbara and Jack Donancy

Eulachon (hooligan).

delineated by river drainage rather than one range-wide unit (Beacham et al. 2005). Further work in Alaska recommends that northern Alaskan populations (Yakutat Forelands, Prince William Sound, and Cook Inlet) of eulachon be managed separately from southern Alaskan populations (upper Lynn Canal, Berners Bay, Stikine Strait, and Behm Canal) since they are demographically independent (Flannery et al. 2009, Flannery et al. 2013).

Population estimates of eulachon in Southeast rivers are generally lacking, but the species is often observed in tremendous numbers in certain rivers, where large congregations of birds and mammals feed on them (for example, in the Alsek, Stikine, and Chilkat rivers and in Berners Bay). Eulachon have been abundant enough in Southeast to support small commercial harvests. Commercial harvests have occurred in the Stikine, Unuk and Chickamin, and Bradfield river systems, at least in some years (Alaska Department of Fish and Game 2000, Ormseth and Vollenweider 2007), while in other years no fish have been harvested, and sometimes the runs appear to have failed completely (Miller and Moffit 1999, Walker 2001) or greatly declined (Ormseth and Vollenweider 2007).

Eulachon also support subsistence and personal use fisheries in the Chilkat and Chilkoot rivers near Haines (Mills 1982, Magdanz 1988, Betts 1994, Reeves 2001), the Berners Bay system near Juneau (Mary Willson, ecologist, personal communication 2004) and the Situk near Yakutat (Alaska Department of Fish and Game 2014d). Alaska Natives traditionally harvested eulachon to be eaten fresh, smoked or dried, or rendered into oil as a dietary supplement or condiment (Alaska Department of Fish and Game 2003, Willson et al. 2006, Moody 2008). According to Betts (1994), the contemporary eulachon subsistence fishery in Southeast is conducted primarily by the Chilkat (Jilka'at) and Chilkoot (Lkoot) Tlingits of Klukwan and Haines, with locations of fishing and processing organized by clan affiliation. The name "eulachon" comes from the Chinook Indian word ulakan, which means "candlefish" and refers to the unusually large amount of oil in the fish.

CONSERVATION ISSUES

Considering their oil content and food value, their early run timing (before salmon arrival), and the number and variety of animals that feed on them, eulachon can be considered one of the most important forage fish in Southeast.

There are a variety of threats to eulachon, some of which are relevant to the Tongass, including climate change, timber harvest and related activities, dredging and habitat alteration in spawning areas, pollution of spawning rivers, targeted commercial fisheries, and by-catch in offshore trawl fisheries (Hay and McCarter 2000).

Eulachon are especially important to Steller sea lions in Southeast. Seasonal pulses of high-energy food resources are critical to the reproductive success of Steller sea lions (Womble 2003), as energy demands are high for sea lions during spring when females are pregnant and lactating as well as when males are preparing for extended fasting prior to the breeding season. Many sea lions concentrate during the eulachon runs in Berners Bay (Womble 2003) and in Dry Bay near Yakutat (Catterson and Lucey 2002). Because Steller sea lions are listed as a threatened species under the US Endangered Species Act, eulachon conservation is particularly important.

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In some instances, eulachon appear to be extremely important in the diet of Bald Eagles (Drew and Lepp 1996). Almost 2,000 eagles are attracted to the Stikine Delta spring run of eulachon. In addition, an estimated 1,000 Bald Eagles concentrate in Berners Bay in the spring to feed on eulachon (Mary Willson, ecologist, personal communication 2004).

In the last 20 years, especially since the mid-1990s, nearly all eulachon spawning runs—from California to Southeast Alaska—have declined (Hay and McCarter 2000). Federal agency biologists determined that the southern populations (those spawning in rivers from south of the Nass River in British Columbia, Canada, down to and including the Mad River in California) were discrete from northern populations of eulachon (Department of Commerce 2009). In March 2010, the National Marine Fisheries Service listed the southern population of eulachon as threatened under the Endangered Species Act. The eulachon has been recommended by some scientists for listing as an indicator species in the North Pacific (Hay et al. 1997) . Nevertheless, although runs there have collapsed in some areas, there are no special designations for eulachon in Southeast Alaska (Ormseth et al. 2008).

Eulachon are sensitive to pollutants in their spawning rivers. The accumulation of pollutants occurs even though the fish do not feed in freshwater and remain there only a few weeks (Rogers et al. 1990, Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife 2001). For example, eulachon returning to the lower Fraser River contained contaminants from wood-treatment processes (Rogers et al. 1990), and apparently acquired them after river entry (Birtwell et al. 1988, Rogers et al. 1990). Industrial effluent into the Kitimat River has spoiled eulachon that would otherwise be edible (Pedersen et al. 1995, Mikkelson et al. 1996), and Nass River eulachon acquired detectable levels of metals derived from mine tailings (Futer and Nassichuk 1983).

Four major eulachon spawning areas in Southeast are at risk from proposed mining activities. In the Taku River, proposed reopening of the Tulsequah Mine could affect water quality. As noted by the Environmental Mining Council of British Columbia:

Re-opening this old acid and heavy metal polluting mine will also involve siting a new tailings pond in the floodplain of the Tulsequah River. While the new mine plan calls for clean-up of the old mine waste, it will introduce new toxic waste problems to the watershed (Environmental Mining Council of British Columbia 2004).

Berners Bay eulachon may be impacted by developments at the Kensington Gold Mine. Current concerns center on the newly constructed tailings facility in Lower Slate Lake or pollution from increased barge and ferry traffic (Bluemink 2004). The Stikine and Unuk watersheds also have several mines proposed or under development across the Canadian border, which will have likely downstream effects on Eulachon spawing habitat.

Three considerations seem to be most important for conserving healthy populations of eulachon in Southeast:

- Providing special attention and protection for all systems supporting eulachon, because the number of systems supporting eulachon are relatively few and these fish are an important forage resource
- Mitigating the potential of activities such as mining, other industrial development, and urban development to pollute the waters that eulachon use, because eulachon easily accumulate pollutants and pass them up the food chain
- Recognizing the traditional value of eulachon to the Native people of Southeast and supporting both eulachon habitat and harvest access.

MAPPING METHODS

This map represents 88 streams and tributaries in 33 watersheds known to support the presence, spawning, or rearing of eulachon (Alaska Department of Fish and Game 2013). These totaled 373 mi (601 km), which is likely only 50% of the model-estimated anadromous stream length (see Anadromous Fish Habitat methods section). The map also shows most environmentally sensitive areas (MESAs) for eulachon designated by ADFG.

MAP DATA SOURCES

- Anadromous streams: Alaska Department of Fish and Game (2013)
- Most environmentally sensitive areas: Alaska Department of Fish and Game Habitat and Restoration Division (2000).

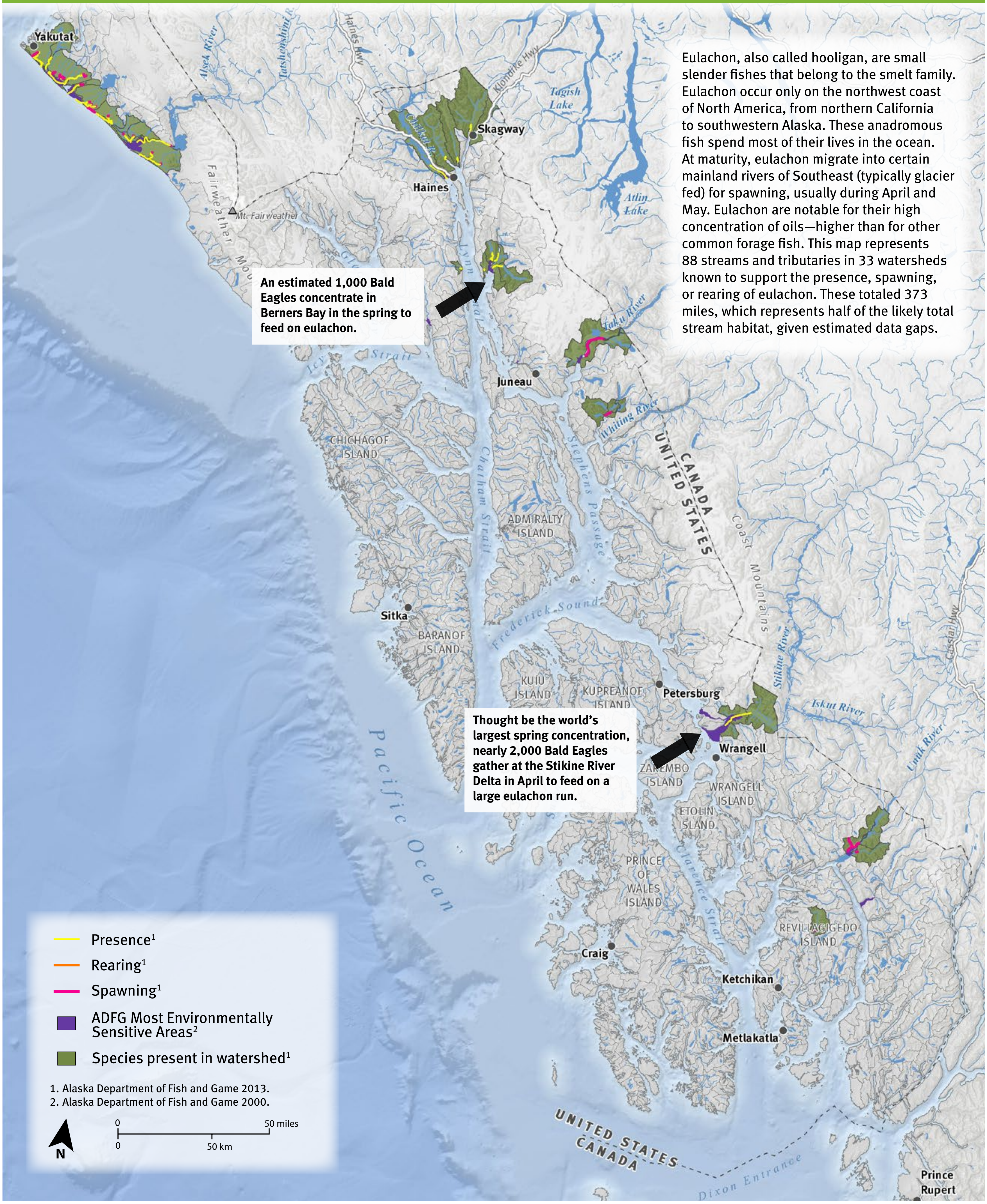
The Stikine River has a large run of eulachon each spring.

John Schoen

Eulachon (Hooligan)

Audubon ALASKA

Eulachon, also called hooligan, are small slender fishes that belong to the smelt family. Eulachon occur only on the northwest coast of North America, from northern California to southwestern Alaska. These anadromous fish spend most of their lives in the ocean. At maturity, eulachon migrate into certain mainland rivers of Southeast (typically glacier fed) for spawning, usually during April and May. Eulachon are notable for their high concentration of oils—higher than for other common forage fish. This map represents 88 streams and tributaries in 33 watersheds known to support the presence, spawning, or rearing of eulachon. These totaled 373 miles, which represents half of the likely total stream habitat, given estimated data gaps.



Map 4.11: Eulachon (Hooligan)

REFERENCES

ADFG Chinook Salmon Research Team. 2013. Chinook salmon stock assessment and research plan, 2013. Alaska Department of Fish and Game, Special Publication No. 13-01, Anchorage.

Alaska Department of Fish and Game. 1994. Catalog of waters important for spawning, rearing or migration of anadromous fishes.

______. 2000. Unuk, Chickamin, Bradfield, and Stikine Rivers 2000 Smelt Fishery News Release. Juneau, AK.

______. 2002. Alaska's Wild Salmon. Alaska Department of Fish and Game, Juneau, AK. Accessed online at http://www.adfg.alaska.gov/static-sf/statewide/aquatic_ed/adfgTeacherGuide/home.html.

______. 2003. Customary and traditional use worksheet: Eulachon smelt in the Bradfield, Chickamin, Klahini, Unuk and Stikine Rivers of Southeast Alaska. *In* Briefing Materials Prepared for the Alaska Board of Fisheries Meeting, Sitka, Jan. 20-29. Alaska Department of Fish and Game, Division of Subsistence, Alaska Department of Fish and Game, Alaska Board of Fisheries, Juneau, AK.

______. 2008a. Alaska Wildlife Notebook Series. Alaska Deptartment of Fish and Game, Juneau, AK.

______. 2008b. Cutthroat Trout Fact Sheet. Anchorage, AK.

______. 2012a. High Use Cuttroat Trout Waters. Alaska EPSCoR and GINA Alaska Science Catalog, Juneau, AK. Accessed online at http://alaska.portal.gina.alaska.edu/catalogs/9425-trophy-cutthroat-trout-lakes.

______. 2012b. Trophy Cuttroat Trout Lakes. Alaska EPSCoR and GINA Alaska Science Catalog, Juneau, AK. Accessed online at http://alaska.portal.gina.alaska.edu/catalogs/9425-trophy-cutthroat-trout-lakes.

______. 2013. Anadromous Waters Catalog. Accessed online at http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=data.GIS.

______. 2014a. 2014 Bristol Bay Salmon Season Summary. Alaska Department of Fish and Game, Dillingham, AK.

______. 2014b. Chinook Salmon (*Oncorhynchus tshawytscha*) Species Profile. Accessed online 2014 at http://www.adfg.alaska.gov/index.cfm?adfg=chinook.main.

______. 2014c. Dolly Varden (*Salvelinus malma*). Alaska Department of Fish and Game, Accessed online June 12 2014 at http://www.adfg.alaska.gov/index.cfm?adfg=dollyvarden.main.

______. 2014d. Eulachon (*Thaleichthys pacificus*) Species Profile. Accessed online 2014 at http://www.adfg.alaska.gov/index.cfm?adfg=eulachon.main.

______. 2014e. Southeast Alaska Sport Fishing Regulations Summary. Juneau, AK.

______. 2014f. Steelhead/Rainbow Trout (*Onchorhynchus mykiss*). Alaska Department of Fish and Game, Juneau, AK. Accessed online December 2014 at http://www.adfg.alaska.gov/index.cfm?adfg=steelhead.main.

______. 2014g. Steelhead/Rainbow Trout (*Oncorhynchus mykiss*) Species Profile. Accessed online 2014 at http://www.adfg.alaska.gov/index.cfm?adfg=steelhead.main.

______. 2015a. Alaska Commercial Salmon Harvests and Exvessel Values Database. Anchorage, AK. Accessed online at http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisherySalmon.exvesselquery.

______. 2015b. Chinook Salmon Research Initiative. Accessed online 2015 at http://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main.

Alaska Department of Fish and Game Habitat and Restoration Division. 2000. Oil Spill Contingency Planning: Most Environmentally Sensitive Areas (MESA) Along the Coast of Alaska, Volume II. ADFG, Anchorage, AK.

Albert, D. M. and J. W. Schoen. 2007. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Andrusak, H. and T. Northcote. 1971. Segregation between adult cutthroat trout (*Salmo clarki*) and Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes. *Journal of the Fisheries Research Board of Canada* 28:1259-1268.

Armstrong, R. 1965. Some Feeding Habits of the Anadromous Dolly Varden (*Salvelinus malma*) in Southeast. Alaska Department of Fish and Game, Juneau, AK.

______. 1971. Age, food and migration of sea-run cutthroat trout, *Salmo clarki*, at Eva Lake, Southeastern Alaska. *Transactions of the American Fisheries Society* 100:302-306.

______. 1984. Migration of anadromous Dolly Varden charr in Southeastern Alaska—a manager's nightmare., In *Biology of the arctic charr. Proceedings of the International Symposium on Arctic Charr, Winnipeg, Manitoba, May 1981.* L. Johnson and B. Burns eds. University of Manitoba Press, Winnipeg.

______. 1991. Dolly Varden char, In *Trout: the wildlife series*. J. Stolz and J. Schnell eds., pp. 266-272. Stackpole Books, Harrisburg, Pennsylvania.

Armstrong, R. and S. Elliott. 1972. A study of Dolly Varden in Alaska. Federal Aid in Fish Restoration, Annual Progress Report, 1971-1972, Project F-9-4-13:1-34. Alaska Department of Fish and Game, Juneau, AK.

Armstrong, R. and J. Morrow. 1980. The Dolly Varden charr, *Salvelinus malma*, In *Charrs: Salmonid Fishes of the Genus Salvelinus*. E. K. Balon ed., pp. 99-140. Dr. W. Junk Publishers, The Hague, Netherlands.

Armstrong, R. H. 1970. Age, food, and migration of sea-run cutthroat trout, *Salmo clarki*, at Eva Lake, Southeastern Alaska. *Transactions of the American Fisheries Society* 100:302-306.

Armstrong, R. H. 1996. *Alaska's Fish: A Guide to Selected Species*. Alaska Northwest Books Portland, Oregon.

Armstrong, R. H., and Marge Hermans. 2004. Southeast Alaska's Natural World.

Bailey, M. M., K. A. Lachapelle, and M. T. Kinnison. 2010. Ontogenetic selection on hatchery salmon in the wild: natural selection on artificial phenotypes. *Evolutionary Applications* 3:340-351.

Baker, T. T., A. C. Wertheimer, R. D. Burkett, R. Dunlap, D. M. Eggers, E. I. Fritts, A. J. Gharrett, R. A. Holmes, and R. L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. *Fisheries* 21:6-18.

Bangs, P. and R. Harding. 2008. The status and management of coastal cutthroat trout in Alaska, In *The 2005 Coastal Cutthroat Trout Symposium*. 2008, Fort Worden State Park, Port Townsend, Washington, USA.

Barrett, B. M., F. M. Thompson, and S. N. Wick. 1984. *Adult Anadromous Fish Investigations, May-October 1983*. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, AK.

Beacham, T. D., D. E. Hay, and K. D. Le. 2005. Population structure and stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt, in the Pacific Northwest. *Marine Biotechnology* 7:363-372.

Beamish, R. J. and D. R. Bouillon. 1993. Pacific salmon production trends in relation to climate. *Canadian Journal of Fisheries and Aquatic Sciences* 50:1002-1016.

Behnke, R. J. 1979. The Native Trouts of the Genus *Salmo* of Western North America. US Fish and Wildlife Service, Lakewood, Colorado.

Behnke, R. J. 1991. Endangered species, In *The Wildlife Series: Trout*. J. J. Stolz and J. Schnell ed., pp. 338-340. Stackpole Books, Harrisburg, Pennsylvania.

Betts, M. F. 1994. The Subsistence Hooligan Fishery of the Chilkat and Chilkoot Rivers. 213. Division of Subsistence, Alaska Department of Fish and Game, Juneau, AK.

Birtwell, I., C. Levings, J. Macdonald, and I. Rogers. 1988. A review of fish habitat issues in the Fraser River system. *Water Pollution Research Journal of Canada. Burlington ON* 23:1-30.

Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: Past, present, and future, In *Streamside Management: Forestry and Fishery Interactions*. E. O. Salo and T. W. Cundy eds., pp. 143-190. University of Washington, Seattle, Washington.

Blackett, R. 1968. Spawning Behavior, Fecundity and Early Life History of Anadromous Dolly Varden *Salvelinus malma* (Walbaum) in Southeastern Alaska. Alaska Department of Fish and Game, Juneau, AK.

Bluemink, E. 2004. Most at hearing push for mine in Berners Bay. Alaska Journal of Commerce, Anchorage, AK.

Bryant, M. 2009. Global climate change and potential effects on Pacific salmonids in freshwater ecosystems of southeast Alaska. *Climatic Change* 95:169-193.

Bryant, M., M. Lukey, J. McDonell, R. Gubernick, and R. Aho. 2009. Seasonal movement of Dolly Varden and cutthroat trout with respect to stream discharge in a second-order stream in southeast Alaska. *North American Journal of Fisheries Management* 29:1728-1742.

Bryant, M. D. and F. H. Everest. 1998. Management and condition of watersheds in Southeast Alaska: The persistence of anadromous salmon. *Northwest Science* 72:249-267.

Burgner, R. L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*), *In Pacific salmon life histories*. C. Groot and L. Margolis eds., pp. 3-117. UBC Press.

Bustard, D. R. and D. W. Narver. 1975. Preferences of juvenile coho salmon (*Oncorhynchus kisutch*) and cutthroat trout (*Salmo clarki*) relative to simulated alteration of winter habitat. *Journal of the Fisheries Board of Canada* 32:681-687.

Candy, J. R. and T. D. Beacham. 2000. Patterns of homing and straying in southern British Columbia coded-wire tagged chinook salmon (*Oncorhynchus tshawytscha*) populations. *Fisheries Research* 47:41-56.

Carlson, H. R., R. E. Haight, and K. J. Krieger. 1977. Species Composition and Relative Abundance of Demersal Marine Life in Waters of Southeastern Alaska, 1969-77. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center,

Catterson, N. and B. Lucey. 2002. Seasonal abundance of Steller sea lions at Dry Bay, Alaska. US Forest Service Tongass National Forest Yakutat Ranger District, Yakutat, AK.

Cederholm, C. J., M. D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. *Fisheries* 24:6-15.

Clarke, A., A. Lewis, K. Telmer, and J. Shrimpton. 2007. Life history and age at maturity of an anadromous smelt, the eulachon *Thaleichthys pacificus* (Richardson). *Journal of Fish Biology* 71:1479-1493.

Colyer, W. T., J. L. Kershner, and R. H. Hilderbrand. 2005. Movements of fluvial Bonneville cutthroat trout in the Thomas Fork of the Bear River, Idaho-Wyoming. *North American Journal of Fisheries Management* 25:954-963.

Conrad, S. and W. Davidson. 2013. Overview of The 2012 Southeast Alaska and Yakutat Commercial, Personal Use, and Subsistence Salmon Fisheries. Management Report No. 13-03. Alaska Dept of Fish and Game, Divisions of Sport Fish and Commercial Fisheries, Anchorage.

Conrad, S. and D. Gray. 2014. Overview of the 2013 Southeast Alaska and Yakutat Commercial, Personal Use, and Subsistence Salmon Fisheries. No. 14-28. Alaska Department of Fish and Game, Division of Sport and Commercial Fisheries, Anchorage.

Cope, O. B. 1961. Effects of DDT spraying for spruce budworm on fish in the Yellowstone River system. *Transactions of the American Fisheries Society* 90:239-251.

COSEWIC. 2012. COSEWIC assessment and status report on the Bull Trout *Salvelinus confluentus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Canada.

Crispin, V., R. House, and D. Roberts. 1993. Changes in instream habitat, large woody debris, and salmon habitat after the restructuring of a coastal Oregon stream. *North American Journal of Fisheries Management* 13:96-102.

Department of Commerce. 2009. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of Eulachon. 74:48. Federal Register, Code of Federal Regulations, Part 223.

Drake, D. C. and R. J. Naiman. 2007. Reconstruction of Pacific salmon abundance from riparian tree-ring growth. *Ecological Applications* 17:1523-1542.

Drew, L. and G. Lepp. 1996. A feast fit for eagles. *National Wildlife* 34:46-49.

Dunlap, R. 1997. Summary of the 1997 Fish Habitat Risk Assessment Panel. Appendix 1. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Edwards, R. T., D. D'Amore, E. Norberg, and F. Biles. 2013. Riparian ecology, climate change, and management in North Pacific Coastal Rainforests, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 43-72. University of Washington Press, Seattle, WA.

Environmental Mining Council of British Columbia. 2004. British Columbia Network. Accessed online at www.bcen.bc.

Farara, D. 1996. The Toxicity of Pulp Mill Effluent on Eulachon Eggs and Larvae in the Kitimat River. Eurocan Pulp Mills Ltd, Kitimat, B.C.

Flannery, B. G., R. E. Spangler, B. L. Norcross, C. J. Lewis, and J. K. Wenburg. 2013. Microsatellite analysis of population structure in Alaska Eulachon with application to mixed-stock analysis. *Transactions of the American Fisheries Society* 142:1036-1048.

Flannery, B. G., J. K. Wenburg, C. J. Lewis, B. L. Norcross, and R. E. Spangler. 2009. Genetic Population Structure in Alaska Eulachon. Alaska Fisheries, US Fish and Wildlife Service, Anchorage, AK.

Francis, R. C. and S. R. Hare. 1994. Decadal-scale regime shifts in the large marine ecosystems of the north-east Pacific: A case for historical science. *Fisheries Oceanography* 3:279-291.

Futer, P. and M. Nassichuk. 1983. Metals in Eulachons from the Nass River and Crabs from Alice Arm, BC. Fisheries and Oceans Canada, Vancouver, BC, Canada.

Gharrett, A. and W. Smoker. 1993. Genetic components in life history traits contribute to population structure, In *Genetic conservation of salmonid fishes*. pp. 197-202. Springer.

Giger, R. D. 1972. Ecology and Management of Coastal Cutthroat Trout in Oregon. Oregon State Game Commission, Research Division, Corvallis, Oregon.

Guthrie, C. 1994. *Preliminary report on the genetic diversity of sockeye salmon populations from southeast Alaska and northern British Columbia*. Alaska Fisheries Science Center, National Marine Fisheries Service, US Department of Commerce.

Guthrie III, C., H. Nguyen, and J. Guyon. 2012. Genetic Stock Composition Analysis of Chinook Salmon Bycatch Samples from the 2010 Bering Sea Trawl Fisheries.

Hale, S. S., McMahon, T.E. , and Nelson, P.C. . 1985. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chum Salmon. 82 (10.108). US Fish and Wildlife Service.

Halupka, K. C., M. D. Bryant, M. F. Willson, and F. H. Everest. 2000. Biological Characteristics and Population Status of Anadromous Salmon in Southeast Alaska. USDA Forest Service, Pacific Northwest Research Station.

Hansen, A. J. 1987. Regulation of bald eagle reproductive rates in Southeast Alaska. *Ecology*:1387-1392.

Hard, J. J. and W. R. Heard. 1999. Analysis of straying variation in Alaskan hatchery chinook salmon (*Oncorhynchus tshawytscha*) following transplantation. *Canadian Journal of Fisheries and Aquatic Sciences* 56:578-589.

Harding, R. and D. Jones. 1992. Peterson Creek and lake system steelhead evaluation, 1991. Alaska Department of Fish and Game Fishery Data Series 92-46. Alaska Department of Fish and Game, Juneau, AK.

______. 1993. Karta River steelhead: 1992 escapement and creel survey studies. Alaska Department of Fish and Game Fishery Data Series 93-30. Alaska Department of Fish and Game, Juneau, AK.

Harding, R. D. 2013. Coastal Cutthroat Trout Maturity Studies in Southeast Alaska, 1997-1998. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, Anchorage, Alaska.

Harding, R. D. and C. L. Coyle. 2011. Southeast Alaska Steelhead, Trout, and Dolly Varden Management. Alaska Department of Fish and Game, Juneau, AK.

Hartman, G. and C. Gill. 1968. Distributions of juvenile steelhead and cutthroat trout (*Salmo gairdneri* and *S. clarki clarki*) within streams in southwestern British Columbia. *Journal of the Fisheries Board of Canada* 25:33-48.

Hay, D., J. Boutillier, M. Joyce, and G. Langford. 1997. The eulachon (*Thaleichthys pacificus*) as an indicator species in the North Pacific. In Proceedings of Forage Fishes in Marine Ecosystems, Wakefield Fisheries Symposium. Alaska Sea Grant College Program AK-SG-97-01.

Hay, D. and P. McCarter. 2000. Status of the Eulachon *Thaleichthys pacificus* in Canada. Canadian Stock Assessment Secretariat, Ottawa, Canada.

Healey, M. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*), In *Pacific salmon life histories*. C. Groot, and L. Margolis ed., pp. 313-393. UBC Press, Vancouver, BC, Canada.

Heard, W., R. Burkett, F. Thrower, and S. McGee. 1995. A review of chinook salmon resources in Southeast Alaska and development of an enhancement program designed for minimal hatchery-wild stock interaction. *American Fisheries Society* 15:21-37.

Heard, W. R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*). *Pacific salmon life histories*:119-230.

Heard, W. R. 2002. Alaska Salmon Enhancement: A Successful Program for Hatchery and Wild Stocks. National Oceanic and Atmospheric Administration, Juneau, AK.

Heifetz, J., S. W. Johnson, K. V. Koski, and M. L. Murphy. 1989. Migration timing, size, and salinity tolerance of sea-type sockeye salmon (*Oncorhynchus nerka*) in an Alaska estuary. *Canadian Journal of Fisheries and Aquatic Sciences* 46:633-637.

Heiser, D. 1966. Age and growth of anadromous Dolly Varden char *Salvelinus malma* (Walbaum) in Eva Creek, Baranof Island, Southeastern Alaska. Research Report 5:1-29. Alaska Department of Fish and Game, Juneau, AK.

Hilderbrand, R. H. 2003. The roles of carrying capacity, immigration, and population synchrony on persistence of stream-resident cutthroat trout. *Biological Conservation* 110:257-266.

Hofmeister, K. 1994. Southeast Alaska winter air temperature cycle and its relationship to pink salmon harvest. In Northeast Pacific pink and chum salmon workshop. University of Alaska, Fairbanks, Alaska.

Host, R. H. and E. G. Neal. 2004. Baseline Characteristics of Jordan Creek, Juneau, Alaska. 2331-1258.

Huntington, H. P. 2002. Traditional Knowledge of the Ecology of Belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. *Marine Fisheries Review* 62:134-140.

Jennings, S. R., D. R. Neuman, and P. S. Blicker. 2008. Acid Mine Drainage and Effects on Fish Health and Ecology: A Review. Bozeman, MT.

Johnson, S., J. Thedinga, and K. Koski. 1992. Life history of juvenile ocean-type chinook salmon (*Oncorhynchus tshawytscha*) in the Situk River, Alaska. *Canadian Journal of Fisheries and Aquatic Sciences* 49:2621-2629.

Johnston, J. 1981. Life histories of anadromous cutthroat with emphasis on migratory behavior. In Salmon and Trout Migratory Behavior Symposium. University of Washington, Seattle, WA.

Jones, D. E. 1976. A study of cutthroat-steelhead in Southeast., *In Sport Fish Investigations of Alaska, Study AFS-42.* Alaska Department of Fish and Game ed.

______. 1977. Life history of sea-run cutthroat trout, In *Federal Aid in Fish Restoration, Study AFS-42.* Alaska Department of Fish and Game ed., pp. 78-105.

Jones, J. D., R. Harding, and A. E. Bingham. 1990. Cutthroat Trout Studies: Turner/Florence Lakes, Alaska, During 1989. ADFG, Anchorage, AK.

Jones, J. D., R. P. Marshall, and R. D. Harding. 1992. Cutthroat Trout Studies at Florence and Hasselborg Lakes, Southeast Alaska, 1991. Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, AK.

Kajimura, H., C. H. Fiscus, and R. K. Stroud. 1980. Food of the Pacific White-sided Dolphin, *Lagenorhynchus obliquidens*, Dall's Porpoise, *Phocoenoides dalli*, and Northern Fur Seal, *Callorhinus ursinus*, Off California and Washington. With Appendices on Size and Food of Dall's Porpoise from Alaskan Waters. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, WA.

Kanouse, K. M. 2011. Tributary Creek Fish Population Estimates. Alaska Department of Fish and Game, Division of Habitat, Douglas, AK.

Kline Jr, T. C., J. J. Goering, O. A. Mathisen, P. H. Poe, P. L. Parker, and R. S. Scalan. 1993. Recycling of elements transported upstream by runs of Pacific salmon: II. δ15N and δ13C evidence in the Kvichak River watershed, Bristol Bay, southwestern Alaska. *Canadian Journal of Fisheries and Aquatic Sciences* 50:2350-2365.

Kuhnlein, H. V. 2000. The joys and pains of sampling and analysis of traditional food of indigenous peoples. *Journal of Food Composition and Analysis* 13:649-658.

Laker, M. W. 1994. Evaluation of Models and Assumptions for Closed Population Abundance Estimators from from Cutthroat Trout Mark-recapture Data. thesis, University of Alaska Fairbanks, Fairbanks, AK.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. Biology of the Nass River eulachon (*Thaleichthys pacificus*). Fisheries Field Directorate, Pacific Region, Vancouver, B. C., Canada.

Larson, L. 1990. Statistics for selected sport fisheries on the Anchor River, Alaska, during 1989 with emphasis on Dolly Varden char. Alaska Department of Fish and Game Fishery Data Series 90-57. Alaska Department of Fish and Game, Juneau, AK.

Lewis, A., M. McGurk, and M. Galesloot. 2002. Alcan's Kemano River Eulachon (*Thaleichthys pacificus*) Monitoring Program 1988-1998. Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, BC, Canada.

Lowry, G. R. 1966. Production and food of cutthroat trout in three Oregon coastal streams. *The Journal of Wildlife Management* 30:754-767.

Magdanz, J. S. 1988. Harvest and Exchange of Eulachon from the Chilkat and Chilkoot Rivers, Alaska. Alaska Department of Fish and Game, Juneau, AK.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102:187-223.

Marston, B. H., M. F. Willson, and S. M. Gende. 2002. Predator aggregations during eulachon *Thaleichthys pacificus* spawning runs. *Marine Ecology. Progress Series* 231:229-236.

McLean, J. E., D. Hay, and E. B. Taylor. 1999. Marine population structure in an anadromous fish: Life-history influences patterns of mitochondrial DNA variation in the eulachon, *Thaleichthys pacificus*. *Molecular Ecology* 8:S143-S158.

Meacham, C. P. and J. H. Clark. 1994. Pacific salmon management—the view from Alaska. *Alaska Fisheries Research Bulletin* 1:76-80.

Mecklenberg, C., T. Mecklenburg, and L. K. Thorsteinson. 2002. *Fishes of Alaska*. American Fisheries Society, Bethesda, Maryland.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. *Fishes of Alaska*. American Fisheries Society, Bethesda, MD.

Mikkelson, P., J. Paasivirta, I. Rogers, and M. Ikonomou. 1996. Studies on eulachon tainting problem: Analyses of tainting and toxic aromatic pollutants, In *Environmental Fate and Effects of Pulp and Paper Mill Effluents*. M. R. Servos ed., pp. 327-333. St. Lucie Press Delray Beach, Florida.

Miller, M. and S. Moffit. 1999. Assessment of Copper River eulachon (*Thaleichthys pacificus*) commercial harvest: project operational plan. Alaska Department of Fish and Game Commercial Fisheries Division,

Mills, D. D. 1982. Historical and Contemporary Fishing for Salmon and Eulachon at Klukwan: An Interim Report. Alaska Department of Fish and Game, Division of Subsistence, Juneau, AK.

Moody, M. F. 2008. Eulachon Past and Present. Master's thesis, The University of British Columbia, Vancouver, Canada.

Mortensen, D., A. Wertheimer, C. Taylor, and J. Landingham. 2000. The relation between early marine growth of pink salmon, *Oncorhynchus gorbuscha*, and marine water temperature, secondary production, and survival to adulthood. *Fishery Bulletin* 98.

Mote, P., E. Parson, A. Hamlet, W. Keeton, D. Lettenmaier, N. Mantua, E. Miles, D. Peterson, D. Peterson, R. Slaughter, and A. Snover. 2003. Preparing for climatic change: The water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45-88.

Motyka, R. J., S. O'Neel, C. L. Connor, and K. A. Echelmeyer. 2002. Twentieth century thinning of Mendenhall Glacier, Alaska, and its relationship to climate, lake calving, and glacier run-off. *Global and Planetary Change* 35:93-112.

Mueter, F. J. and B. L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. *Fishery Bulletin* 100:559-581.

Murphy, M. 1995. Forestry impacts on freshwater habitat of anadromous salmonids in the Pacific Northwest and Alaska: Requirements for protection and restoration. National Oceanic and Atmospheric Administration Coastal Ocean Program Decision Analysis Series No. 7. NOAA Coastal Ocean Office, Silver Spring, MD.

Murphy, M. L., K. Koski, J. M. Lorenz, and J. F. Thedinga. 1997. Downstream migrations of juvenile Pacific salmon (*Oncorhynchus* spp.) in a glacial transboundary river. *Canadian Journal of Fisheries and Aquatic Sciences* 54:2837-2846.

National Marine Fisheries Service. 2013. 2013 Report of the Secretary of Commerce to the Congress of the United States concerning U.S. actions taken on foreign large-scale high seas driftnet fishing.

NOAA. 2014. FishWatch U.S. Seafood Facts. Website. Accessed online June 4 2014 at http://www.fishwatch.gov/seafood_profiles/species/salmon/species_pages/pink_salmon.htm.

Noll, C., N. V. Varnavskaya, E. A. Matzak, S. L. Hawkins, V. V. Midanaya, O. N. Katugin, C. Russell, N. M. Kinas, C. Guthrie, and H. Mayama. 2001. Analysis of contemporary genetic structure of even-broodyear populations of Asian and western Alaskan pink salmon, *Oncorhynchus gorbuscha*. *Fishery Bulletin* 99:123-138.

Ormseth, O. A., L. Conners, M. Guttormsen, and J. Vollenweider. 2008. Forage Fishes in the Gulf of Alaska. National Marine Fisheries Service, Alaska Fisheries Science Center, Accessed online at http://www.afsc.noaa.gov/REFM/docs/2008/GOAforage.pdf.

Ormseth, O. A. and J. Vollenweider. 2007. Appendix 2: Forage fishes in the Gulf of Alaska. NMFS Alaska Fisheries Science Center, Anchorage, AK.

Orsi, J. A. and H. W. Jaenicke. 1996. *Oncorhynchus tshawytscha*. *Fishery Bulletin* 94:482-497.

Pahlke, K. A. 2009. Escapements of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2007. Alaska Department of Fish and Game, Anchorage, AK.

Paustian, S. J., K. Anderson, D. Blanchet, S. Brady, M. Cropley, J. Edgington, J. Fryxell, G. Johnejack, D. Kelliher, M. Kuehn, S. Maki, R. Olson, J. Seesz, and M. Wolanek. 1992. A Channel Type Users Guide for the Tongass National Forest, Southeast Alaska. US Forest Service, Juneau, AK.

Payne, S. A., B. A. Johnson, and R. S. Otto. 1999. Proximate composition of some north-eastern Pacific forage fish species. *Fisheries Oceanography* 8:159-177.

Pedersen, R., U. N. Orr, and D. E. Hay. 1995. Distribution and Preliminary Stock Assessment (1993) of the Eulachon *Thaleichthys pacificus* in the Lower Kitimat River, British Columbia. 2330. Fisheries and Oceans Canada, B.C., Canada.

Perez, M. A. 1994. Calorimetry measurements of energy value of some Alaskan fishes and squids. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA.

Reed, R. J. 1963. Results of Preliminary Watershed Surveys Conducted in 1961 and 1962 for Studies on Effects of Forest Insecticide Spray on Salmon Streams in Southeastern Alaska. US Fish and Wildlife Service, Bureau of Commercial Fisheries, Juneau, AK.

Reeves, K. 2001. Harvest along the Chilkoot. *Alaskan Southeaster* June:45-46.

Rennert, K. J., G. Roe, J. Putkonen, and C. M. Bitz. 2009. Soil thermal and ecological impacts of rain on snow events in the circumpolar Arctic. *Journal of Climate* 22:2302-2315.

Rice, S. D., R. E. Thomas, and A. Moles. 1994. Physiological and growth differences in three stocks of underyearling sockeye salmon (*Oncorhynchus nerka*) on early entry into seawater. *Canadian Journal of Fisheries and Aquatic Sciences* 51:974-980.

Rogers, I. H., I. K. Birtwell, and G. M. Kruzynski. 1990. The Pacific eulachon (*Thaleichthys pacificus*) as a pollution indicator organism in the Fraser River estuary, Vancouver, British Columbia. *Science of the Total Environment* 97-98:713-727.

Royce, W. F. 1989. Managing Alaska's salmon fisheries for a prosperous future. *Fisheries* 14:8-13.

Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. *Nature* 465:609-613.

Schoen, J. W. and E. Dovichin eds. 2007. *The Coastal Forests and Mountains Ecoregion of Southeastern Alaska and the Tongass National Forest: A Conservation Assessment and Resource Synthesis*. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Scott, J. M. 1973. Resource Allocation in Four Syntopic Species of Marine Diving Birds. PhD thesis, Oregon State University.

Service, R. F. 2015. Meager snows spell trouble ahead for salmon. *Science* 348:268-269.

Shanley, C. S. and D. M. Albert. 2014. Climate change sensitivity index for Pacific salmon habitat in Southeast Alaska. *PLoS ONE* 9:e104799.

Smith, W. E. and R. W. Saalfeld. 1955. Studies on Columbia River smelt, *Thaleichthys pacificus* (Richardson). *Fisheries Research Papers* 1:2-23.

Southeast Alaska Conservation Council. 2014. Transboundary Mines and Rivers. Southeast Alaska Conservation Council, Juneau, AK. Accessed online January 2014 at http://seacc.org/mining/transboundary-mines.

Speckman, S. G. and J. F. Piatt. 2000. Historic and current use of lower Cook Inlet, Alaska, by belugas, *Delphinapterus leucas*. *Marine Fisheries Review* 62:22-26.

Stewart, H. 1977. *Indian Fishing: Early Methods on the Northwest Coast*. University of Washington Press, Seattle, WA.

Thedinga, J. F. 1993. Potential effects of flooding from Russell Fiord on salmonids and habitat in the Situk River, Alaska. Auke Bay Laboratory, Alaska Fisheries Science Center,

Thedinga, J. F., S. W. Johnson, and K. Koski. 1998. Age and Marine Survival of Ocean-Type Chinook Salmon *Oncorhynchus tshawytscha* from the Situk River, Alaska. *Alaska Fishery Research Bulletin* 5.

Trotter, P. C. 1989. Coastal cutthroat trout: A life history compendium. *Transactions of the American Fisheries Society* 118:463-473.

Trotter, P. C. 1991. Cutthroat trout, *In The Wildlife Series: Trout*. J. Stolz and J. Schnell eds., pp. 236-265. Stackpole Books, Harrisburg, Pennsylvania.

USEPA. 2014. An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska. EPA 910-R-14-001, Region 10, Seattle, WA.

Vincent-Lang, D. and I. Queral. 1984. Eulachon spawning in the lower Susitna River, In *Aquatic Habitat and Instream Flow Investigations, May-October 1983*. C. C. Estes and D. S. Vincent-Lang eds., pp. 1-32. Alaska Department of Fish and Game, Anchorage, AK.

Walker, S. 2001. 2000 Eulachon Summary Memorandum January 19. Alaska Department of Fish and Game, Ketchikan, AK.

Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. 2001. Washington and Oregon Eulachon Management Plan. Washington Department of Fish and Wildlife, Olympia, WA.

Whitney, A. N. and J. C. Spindler. 1959. Effects of Kraft paper wastes on a Montana stream. *Transactions of the American Fisheries Society* 88.

Willson, M. 2007. Anadromous salmon in southeastern Alaska: Harvest, evolution, and biodiversity, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Willson, M. F., R. Armstrong, K. Koski, and M. Hermans. 2006. Eulachon: A Review of Biology and an Annotated Bibliography. Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Juneau, AK.

Willson, M. F., S. M. Gende, and B. H. Marston. 1998. Fishes and the forest. *BioScience*:455-462.

Willson, M. F. and K. C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. *Conservation Biology* 9:489-497.

Womble, J. N. 2003. Seasonal Distribution of Steller Sea Lions (*Eumetopias jubatus*) in Relation to High-quality Ephemeral Prey Species in Southeastern Alaska. MS thesis, University of Alaska Fairbanks, Fairbanks, AK.

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2005. Distribution of Steller sea lions *Eumetopias jubatus* in relation to spring-spawning fish in SE Alaska. *Marine Ecology Progress Series* 294:271-282.

Wustenberg, D. W. 1953. A Preliminary Survey of the Influences of Controlled Logging on a Trout Stream in the HJ Andrews Experimental Forest, Oregon. Master's thesis.

John Schoen

BIRDS

The landscape and seascape of Southeast Alaska offer a combination of habitats that bring in a great diversity of birds, exhibited by a virtual walk from the ocean to the mountaintops. Beginning in the Gulf of Alaska, pelagic seabirds such as Northern Fulmars, auklets, and storm-petrels fish the waters offshore of the island archipelago. Moving nearer to shore, murrelets dive for small forage fish, scoters swim to the shallow bottom for mussels, and several species of gulls pick fish and zooplankton from the top of the water column. Along the thousands of miles of shore are rocky cliffs hosting raucous gatherings of colonial nesters such as puffins, kittiwakes, cormorants, and murres, totaling over 1 million birds. Preferring the coastline, there are nesting oystercatchers, foraging crows, and migrating Surfbirds. Moving inland a bit, in the estuaries are Sandhill Cranes and tens of thousands of sandpipers making their way to northern Alaska. Bald Eagles can be found in great numbers where the forest edge meets the water, their preferred nesting habitat. Stepping just inside the forest, Ruby-crowned Kinglets, Winter Wrens, and Varied Thrushes are singing boldly. Further along where a stream runs through the forest, an American Dipper is foraging, and a group of Harlequin Ducks swims by, as well as a mother merganser trailing a group of chicks. In the interior muskegs there are Mallards, goldeneyes, and Rusty Blackbirds. Somewhere among the trees of the upland forest there are Northern Saw-Whet Owls, Northern Goshawks, Spruce Grouse, and Olive-sided Flycatchers to be found. Even farther up the mountainside is alpine habitat that hosts migrating longspurs, Horned Larks, and Gray-crowned Rosy Finches.

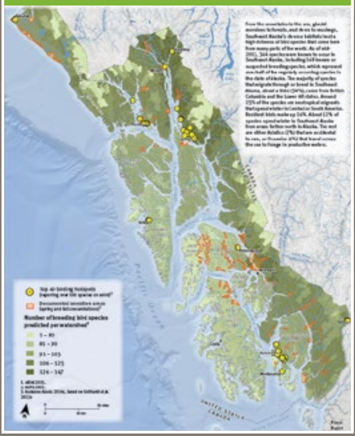
Including casual and accidental sightings, Southeast Alaska hosts about 70% of the species known to occur in Alaska, or about 40% of the bird species found in North America. These birds are keying in on the abundance of foraging and breeding opportunities, whether migrating to northern Alaska to nest, or arriving in Southeast for the season. About one-third of the species that migrate through or breed in Southeast Alaska come from British Columbia and the Lower 48 states. Around one-quarter of the species winter in Central or South America. Year-long residents are just under one-fifth of Southeast Alaska's birds. Just over one-tenth of species spend winter in Southeast Alaska from areas farther north in Alaska. The rest are either Asiatics that are accidental to rare, or Oceanics that travel across the sea to forage in productive waters.

~ Melanie Smith

Milo Burcham

BIRDS MAPS INDEX

Breeding Bird Species Richness

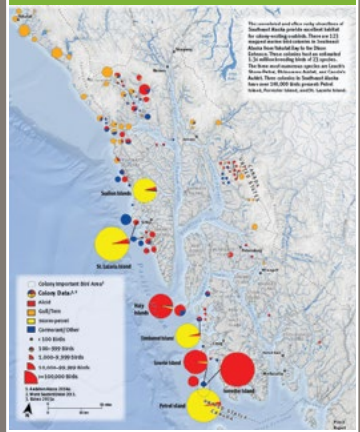


MAP 5.1 / PAGE 113

Important Bird Areas (IBAs)

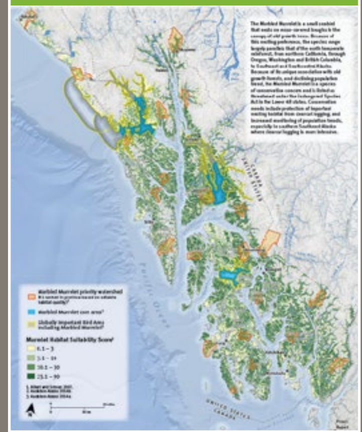
MAP 5.2 / PAGE 116

Marine Bird Colonies



MAP 5.3 / PAGE 119

Marbled Murrelet



MAP 5.4 / PAGE 122

Kittlitz's Murrelet

MAP 5.5 / PAGE 125

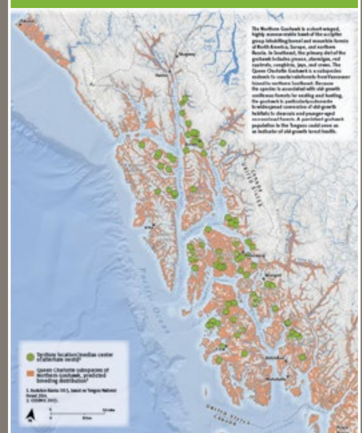
Shorebirds

MAP 5.6 / PAGE 128

Prince of Wales Spruce Grouse

MAP 5.7 / PAGE 131

Queen Charlotte Goshawk



MAP 5.8 / PAGE 134

Bald Eagle

MAP 5.9 / PAGE 137

MAP ON PAGE 113

BIRD SPECIES RICHNESS

Melanie Smith, Nils Warnock, and Iain Stenhouse

From the mountains to the sea, glacial moraines to forests, and rivers to muskegs, Southeast Alaska's diverse habitats host a high richness of bird species that come here from many parts of the world. The majority of species that migrate through or breed in Southeast Alaska, about a third (34%), come from British Columbia and the Lower 48 states. Around 25% of the species are neotropical migrants that spend winter in Central or South America. Resident birds make up 16%. About 12% of species spend winter in Southeast from areas farther north in Alaska. The rest are either Asiatics (7%) that are accidental to rare, or Oceanics (6%) that travel across the sea to forage in these productive waters (Armstrong and Hermans Undated-a).

Several sources have estimated the number of bird species that migrate, breed, overwinter, or forage in Southeast Alaska. This number increases over time due to the growth in number and distribution of observers, as well as the influence of changing weather and climate, which can boost the occurrence of accidental, non-Alaskan species.

A recent US Forest Service (USFS) publication on the Birds of the Major Mainland Rivers of Southeast Alaska (Johnson et al. 2008) recorded 211 species at 11 major transboundary and coastal mainland rivers. Impressively, in those river corridors alone, 128 known or suspected breeders constitute 50% of Alaska's statewide breeding avifauna, and 80% of Southeast Alaska's breeding species. Looking region-wide, Armstrong's 6th edition Guide to the Birds of Alaska (2015) includes 168 known or suspected breeding birds in the Southeastern Region (which included Dixon Entrance through Glacier Bay but not the Yakutat Forelands). This represents 56% of the 300 regularly occurring species in Alaska (Armstrong 2015).

Perhaps the earliest estimate of total bird richness was the 1978 publication Birds of Southeast Alaska: A Checklist which stated that "a total 384 species of birds have been found in Alaska. Of these, 278 have occurred in southeastern Alaska" (USDA Forest Service Alaska Region et al. 1978). Following a great increase in the number of observers birding around the state, 35 years later we know the total richness to be much higher. Birders and citizen scientists have played a great role in the discovery and documentation of bird distribution throughout

TABLE 5-1 Species richness (including rare and accidental sightings) recorded in eBird checklists, by reporting area, through August 2015.

Reporting Area	Number Species Recorded	Number Check-lists Submitted
Juneau	314	29,351
Skagway-Hoonah-Angoon	284	7,911
Ketchikan Gateway	253	7,239
Prince of Wales-Outer Ketchikan	222	1,228
Wrangell-Petersburg	218	2,703
Sitka	205	1,766
Haines	197	1,391
Yakutat	194	301
All Combined	357	51,890

Alaska through participation in such venues as the Christmas Bird Count, eBird, and rare bird announcement lists. The 21st edition of the Checklist of Alaska Birds includes 505 substantiated species accounts from across the entire state (Gibson et al. 2015), with 364 of those occurring in the Southeastern Region (Armstrong 2015).

Based on eBird records, the Juneau area boasts the greatest species richness, and importantly the greatest number of observers reporting bird sightings. More than 29,000 eBird checklists for the Juneau reporting area have identified 314 species, including sightings of rare and accidental birds (eBird 2015) (see Table 5-1). Combined with data from the other seven reporting areas in the region, as of August 2015, 357 unique species have been reported in eBird from nearly 52,000 checklists submitted for Southeast Alaska (eBird 2015). Based on the Armstrong (2015) data, and eBird records (2015), bird occurrences in Southeast include 70% of the species in Alaska, or about 40% of the species in North America (US/Canada).

Milo Burcham

The Red-throated Loon nests in wetlands throughout Alaska and is identified on the Audubon Alaska WatchList as a Red List species, indicating it is a high priority for conservation.

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TABLE 5-2 Summary of Audubon Alaska WatchList regularly occurring bird species in Southeast Alaska.

Red List	Yellow List
Red-throated Loon	Brant
Yellow-billed Loon	Queen Charlotte Goshawk
Black Scoter	Prince of Wales Spruce Grouse
American Golden-plover	Black Oystercatcher
Wandering Tattler	Short-billed Dowitcher
Surfbird	Whimbrel
Lesser Yellowlegs	Black Turnstone
Rock Sandpiper	
Dunlin	
Marbled Murrelet	
Kittlitz's Murrelet	
Aleutian Tern	
Varied Thrush	
Rusty Blackbird	
Olive-sided Flycatcher	


Milo Burcham

Rufous Hummingbirds migrate to Southeast Alaska for the summer season.

WATCHLIST SPECIES

Some of Alaska's numerous species rise to priority level for conservation based on consideration of habitat threats and population status. First published in 2002, and revised in 2005 and 2010, the Alaska WatchList is Audubon Alaska's science-based, early warning system to identify birds at risk (Kirchhoff and Padula 2010). It is a tool to focus attention and resources on vulnerable and declining bird populations across the state.

Audubon Alaska compiles the WatchList every few years by evaluating the vulnerability of each regularly occuring bird species (and select subspecies and populations) in the state. Drawing upon current data from a variety of sources, we consider four criteria: population size, population trend, range size, and percentage of the population dependent on Alaska habitats. Species and subspecies that are on the WatchList face some combination of population decline, small population size, or limited geographic range.

The list recognizes two levels of conservation concern. The Red List has the highest level of concern: species are vulnerable and currently declining, or depressed from a prior decline. The Yellow List is of somewhat lesser concern: species are vulnerable, but populations are either increasing, stable, or unknown.

Of the 22 WatchList species known to be regularly occuring in Southeast Alaska (see Table 5-2), 13 are known to breed in the region. Two of the WatchList species are loons; the Red-throated Loon (*Gavia stellata*) nests in wetlands throughout Alaska, including in Southeast (Gabrielson and Lincoln 1959), while the Yellow-billed Loon (*G. adamsii*) spends the winter foraging in marine waters in Southeast. The sole WatchList raptor, the Queen Charlotte subspecies of Northern Goshawk (*Accipiter gentilis laingi*), occurs in low densities throughout the coastal temperate rainforest of Southeast (Iverson et al. 1996a). The only gallinaceous bird on the WatchList in the region is the Prince of Wales subspecies of Spruce Grouse (*Falcipennis canadensis isleibi*). As its name indicates, it occurs only on Prince of Wales Island and nearby islands of the Alexander Archipelago (Dickerman and Gustafson 1996).

Of the shorebird species that are on the WatchList, four breed in Southeast Alaska, one is a potential breeder, and five have no records of breeding. Black Oystercatchers (*Haematopus bachmani*) are uncommon to common breeders (Armstrong 2015), laying eggs in close proximity to the tidal zone along rocky coastal areas. Lesser Yellowlegs (*Tringa falvipes*) and Short-billed Dowitchers (*Limnodromus griseus caurinus*), which rarely breed in the region, typically breed in bogs, muskegs, and other wetland timber tracts (Gabrielson and Lincoln 1959), although they can rarely be found breeding above timberline (Weeden 1960). Wandering Tattlers (*T. incana*), which are montane breeders that rarely nest in Southeast, are known to have nested in the Chilkat Pass area near Haines (Weeden 1960), near Skagway (Skagway Bird Club 2010), and potentially around Glacier Bay (Kessel and Gibson 1978). Surfbirds (*Aphriza virgata*) are rare to uncommon in Southeast Alaska during the breeding season with no known breeding records. Rock Sandpipers (*Calidris ptilocnemis ptilocnemis*), Black Turnstones (*Arenaria melanocephala*), and Dunlin (*C. alpina pacifica*) spend winter along the shores of Southeast, then head to coastal Western or Arctic Alaska for the breeding season. American Golden-Plovers (*Pluvialis dominica*) and Whimbrels (*Numenius phaeopus beringiea*) migrate through Southeast on their way to interior and northern Alaska.

There are two seabird species, both murrelets, that occur on Alaska's WatchList that breed in Southeast Alaska. Marbled Murrelets (*Brachyramphus marmoratus*) are widespread throughout the nearshore marine zone of Southeast, with nesting habitat in coastal old-growth forest (DeGange 1996). Kittlitz's Murrelets (*B. brevostris*) have a more clumped distribution, usually associated with rocky nesting habitats and silty, turbid waters near glaciers (Kissling et al. 2011).

Three final waterbird species are on the WatchList. Aleutian Terns (*Onychoprion aleuticus*) are uncommon coastal breeders in Southeast Alaska, extending from the north down to Dry Bay and Lituya Bay in Glacier Bay National Park and Preserve (Kessel and Gibson 1978). Black Scoters are uncommon marine foragers during the non-breeding season, and rare in the summer as most move north to breed near tundra lakes and ponds (Armstrong 2015). Brant (*Branta bernicla*) migrate through Southeast in spring on their way to the Arctic.

Of the landbirds on the WatchList, the Rusty Blackbird (*Euphagus carolinus*) is a formerly rare breeder in northern Southeast (Kessel and Gibson 1978, Armstrong 2015) but is not known to have nested recently (Gwen Baluss, Tongass National Forest, personal communication). Other WatchList breeding landbirds include the Olive-sided Flycatcher (*Contopus cooperi*), broadly distributed but uncommon (Kessel and Gibson 1978), usually nesting in open canopy spruce, with a preference for forest edges. More widely distributed throughout forest regions of Southeast is the Varied Thrush (*Ixoreus naevius*) (Armstrong 2015). While Varied Thrushes are not uncommon, the dense clustering of their breeding population in Southeast and the loss of mature forest habitat, especially in the Pacific Northwest, earns this species a place on the WatchList (Kirchhoff and Padula 2010).

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CONSERVATION ISSUES

Around the world, the greatest threat to bird populations is the fragmentation, degradation, and loss of habitat. Over the last century, such losses have often been driven by natural resource extraction, industrial development, and urban encroachment. These days, however, long-term, human-induced climate disruption is having additional dramatic effects on bird habitats at a global scale, especially in northern regions. Other threats to bird populations include pollution (i.e. marine oil spills and toxic contaminants), excessive harvest, introduced predators, and increased human disturbance.

In Alaska, natural ecosystems are still relatively intact and large portions of the landscape are protected in state and federal conservation units. Even in Alaska, however, there are serious concerns about future habitat loss, as natural resource development, habitat fragmentation, and other human influences intensify and expand into remote areas. Attempting to recover a species pushed to the brink of extinction is difficult, costly, and controversial. A far more effective approach is to work cooperatively with resource managers, land owners, industry, conservationists, and others to study, monitor, manage, and protect birds and their habitats before crises arise.

The wide variety of bird species that breed, forage, migrate, and winter across Alaska utilize a broad range of ecosystem types. Conservation planning for Southeast Alaska birds should therefore include representative habitats from these major ecosystem types, including old-growth forest, wetlands, riparian areas, estuaries, and alpine areas. At the regional scale, the richest areas are places where habitat diversity is high, such as the upper reaches of Lynn Canal or transboundary rivers where temperate rainforest and interior boreal influences come together. Also, recently deglaciated areas are suitable for some species otherwise only seen in interior Alaska (Gwen Baluss, Tongass National Forest, personal communication). Major transboundary river corridors, including the Chilkat, Taku, and Stikine rivers, are also hotspots of species richness and connect interior and coastal populations. The primary aims of the WatchList are to focus attention on at-risk populations and to encourage preventative action before they are in jeopardy of extinction.

Most watersheds in Southeast Alaska have not been systematically inventoried for landbird distribution and abundance; setting up a more thorough monitoring program is a first step in regional bird conservation. Conservation efforts should prioritize watersheds or biogeographic provinces where many species ranges overlap, where multiple life-history uses occur (e.g. breeding, migration, stop-over/staging, winter foraging) or places of particular importance to individual species, including Important Bird Areas (IBAs) and Western Hemispheric Shorebird Reserve Network (WHSRN) sites.

MAPPING METHODS

The Alaska Natural Heritage Program developed distribution models for each of 346 vertebrate species across Alaska. Gotthardt et al. (2013) provide details on the modeling process, including data sources and accuracy assessment. This map summarizes the results of these individual species models to show relative richness, calculated as the number of bird species predicted for each subwatershed in Southeast Alaska (HUC 12, or sixth level watershed).

There are certain limitations inherent to both observation data and the modeling process used by the Heritage Program. Because these models have much greater spatial resolution than other available continental-scale species distribution datasets, we utilized the data to depict species richness even though inaccuracy of some individual layers is known. Given these limitations, the information is most useful as a way to interpret broad ecological patterns and relationships. The results summarized on this map should be interpreted as a generalized representation of the relative level of species richness among province groups rather than exact species numbers.

Overall, these models predict 166 breeding bird species to be present in Southeast Alaska. Of these, 70 were passerines, 17 were raptors, 6 were seabirds, 15 were shorebirds, 23 were waterfowl, 21 were other waterbirds, and 14 were other birds.

Most environmentally sensitive areas (MESAs) were produced by the Alaska Department of Fish and Game (ADFG) (2001). As part of the ADFG's participation in the review of oil spill contingency plans, they identified MESAs along the Alaska coastline that could be impacted by a marine spill. ADFG states that these MESAs should not be considered a complete list of highly sensitive areas. Birding hotspots are from eBird (2015). Hotspots are public birding areas recommended by birders and approved by eBird staff. Shown here are the birding hotspot locations with 100 or more species reported through eBird checklists. These are the top 40 known birding locations in Southeast Alaska.

MAP DATA SOURCES

- Breeding bird species richness by province: Audubon Alaska (2014c) based on Gotthardt et al. (2013).
- Most environmentally sensitive areas: Alaska Department of Fish and Game Habitat and Restoration Division (2001)
- Birding hotspots: eBird (2015).

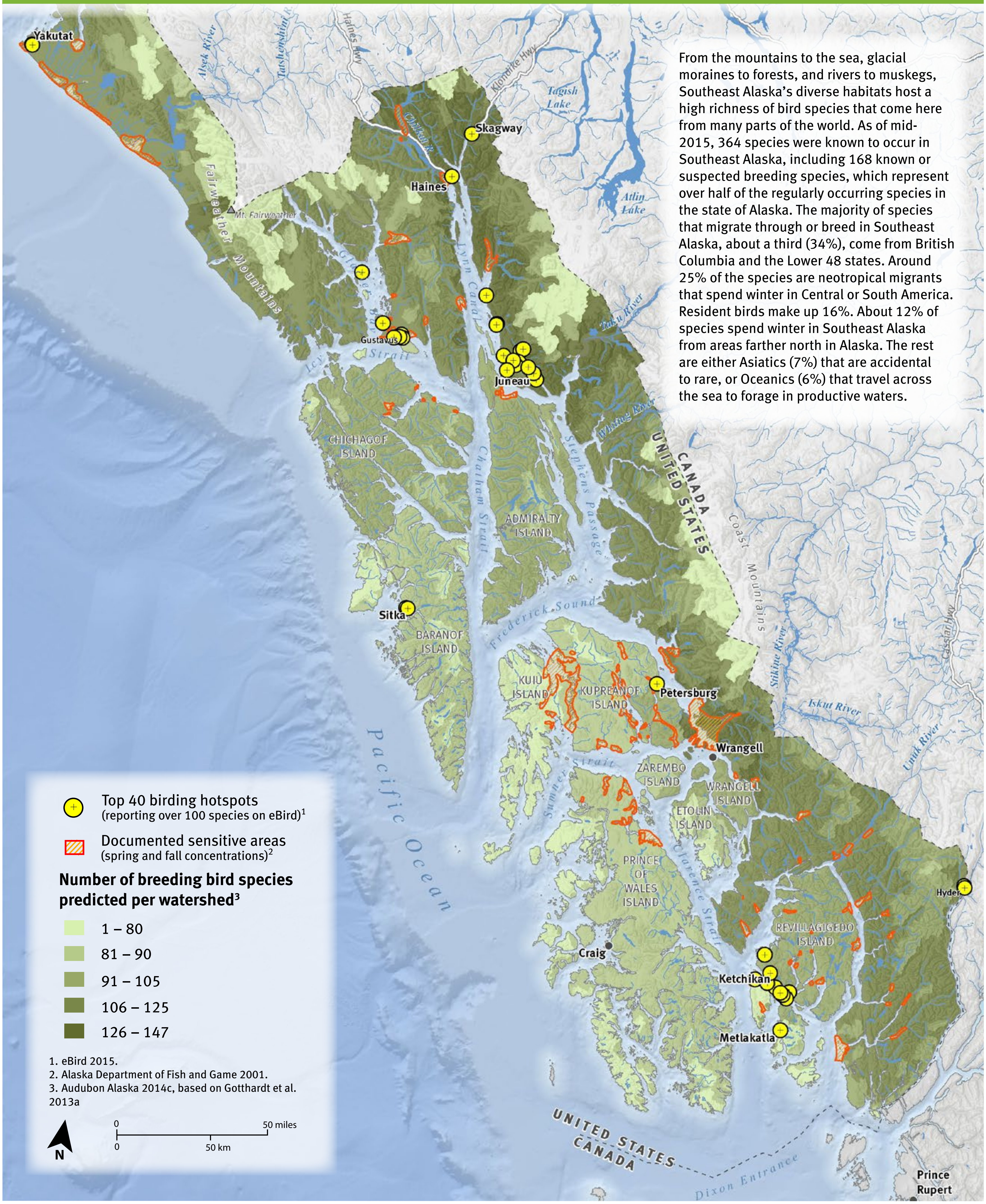
David Shaw

Red-breasted Sapsuckers breed in Southeast Alaska.

Audubon ALASKA

Breeding Bird Species Richness

From the mountains to the sea, glacial moraines to forests, and rivers to muskegs, Southeast Alaska's diverse habitats host a high richness of bird species that come here from many parts of the world. As of mid-2015, 364 species were known to occur in Southeast Alaska, including 168 known or suspected breeding species, which represent over half of the regularly occurring species in the state of Alaska. The majority of species that migrate through or breed in Southeast Alaska, about a third (34%), come from British Columbia and the Lower 48 states. Around 25% of the species are neotropical migrants that spend winter in Central or South America. Resident birds make up 16%. About 12% of species spend winter in Southeast Alaska from areas farther north in Alaska. The rest are either Asiatics (7%) that are accidental to rare, or Oceanics (6%) that travel across the sea to forage in productive waters.



Map 5.1: Breeding Bird Species Richness

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IMPORTANT BIRD AREAS (IBAS)

Melanie Smith and Beth Peluso

Effective bird conservation requires identification of locations used by bird populations for key life history events including breeding, foraging, staging, and migration. Important Bird Areas (IBAs) are based on an established program to identify these essential habitats for birds (BirdLife International 2012b, National Audubon Society 2012). IBAs are designated using a rigorous set of scientific criteria, then reviewed by local and national committees of leading bird experts convened by Audubon.

IBAs may be a few acres or thousands of acres, but they are discrete sites that stand out from the surrounding landscape. For a place to qualify as an IBA, it must either support a large concentration of birds, provide habitat for a threatened or rare species, or provide habitat for a bird with a very limited or restricted range. Once nominated and selected as an IBA, a site is then ranked as significant at either the state, continental, or global level. The majority of Alaska's IBAs are recognized at the global level for including 1% or more of the global population of seabirds, or of the North American population for waterfowl and shorebirds.

Alaska's IBAs are part of a growing global network of designated IBAs, spanning 156 countries around the world. This international effort is led worldwide by BirdLife International and in the US by the National Audubon Society. Audubon Alaska has identified 208 IBAs in the state, more than three-quarters of which are globally significant. Alaska has more globally significant IBAs than any other US state, and almost half of all globally significant IBAs identified in the US. Southeast Alaska currently has 17 IBAs identified for 34 species. Of those, 2 are state-level and 15 are globally significant. Table 5-3 describes the location, size, and significant populations present in Southeast Alaska IBAs.

CONSERVATION SUMMARY

Ever-increasing human demands on natural resources have amplified the need to identify and conserve important ecosystem functions and habitat for birds. The goal of the IBA program is to conserve birds by identifying, monitoring, and protecting critical bird habitats. Because habitat loss is the most serious threat facing bird species across North America and around the world, Audubon's IBA program is a site-based initiative to address habitat loss through community-supported conservation. Globally, thousands of IBAs and millions of acres of avian habitat have received recognition and better protection as a result of the IBA program.

Some of Alaska's IBAs are publicly owned; some are privately owned; some are swaths of marine areas. In Alaska, conservation needs range from monitoring to education to legal protections. There are no explicit restrictions on human use or development attached to IBA designations. However, IBAs can provide a starting point for establishing legal protections, and IBA information can be utilized in regional to global applications, such as environmental assessments, designing best management practices, or broad-scale integrative spatial planning.

IBAs are places that are significant to the life history of many species that live in Southeast Alaska, and should be regarded as having high conservation priority.

MAPPING METHODS

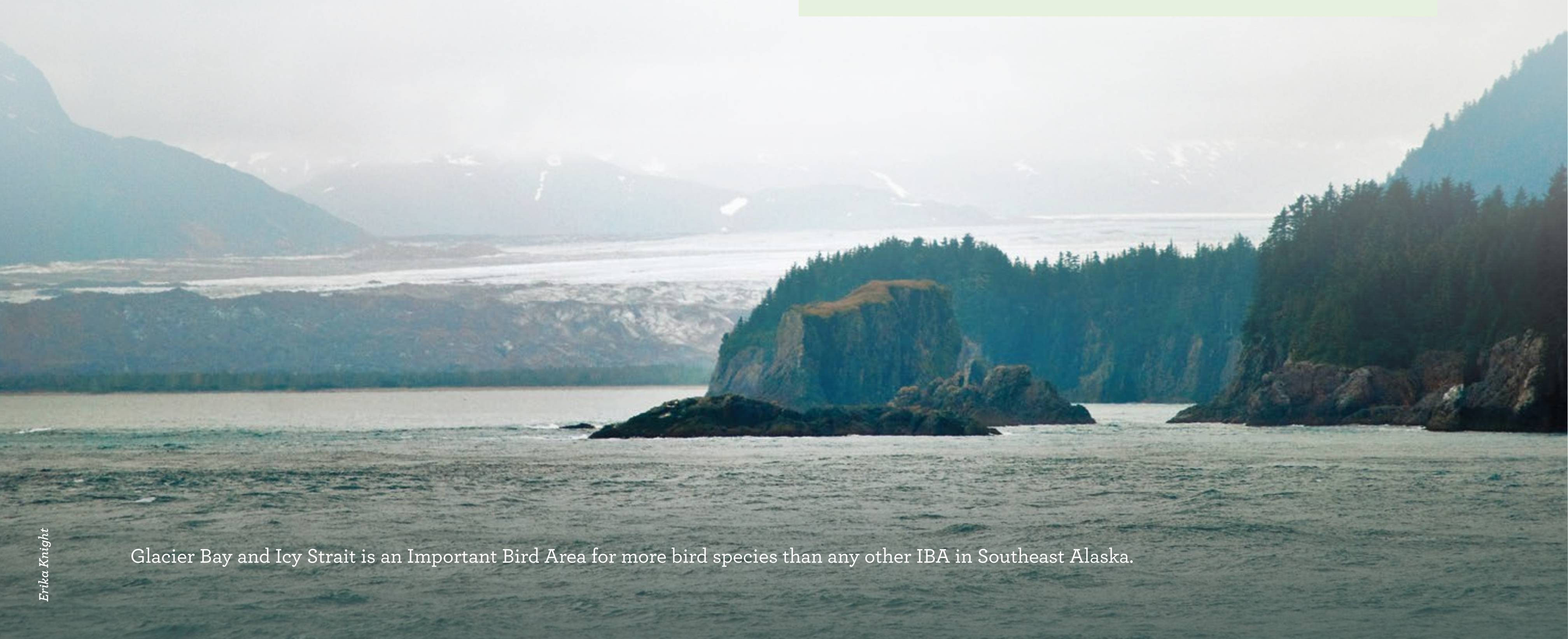
Alaska's IBA network is a compilation of areas identified using a blend of methods. At-sea IBAs were established using an extensive database of at-sea survey data spanning over 30 years (Drew and Piatt 2013). We developed a standardized and data-driven spatial method for identifying globally significant marine IBAs across Alaska. To delineate these areas we developed a six-step process: 1) spatially binning data, and accounting for unequal survey effort; 2) filtering input data for persistence of species use; 3) analyzing data to produce maps representing a gradient from low to high abundance; 4) drawing core area boundaries around major concentrations based on abundance thresholds; 5) validating the results; and 6) combining overlapping boundaries into important areas for multiple species (Smith et al. 2014b).

We identified globally significant colony IBAs by analyzing an extensive colony catalog (World Seabird Union 2011). We used spatial analysis to group nearby colonies (e.g., on adjoining cliffs or islets) together into meta-colonies, in order to identify globally significant population groups (Smith et al. 2012).

Land IBAs and coast IBAs were identified by using expert-drawn boundaries around areas of known high concentration combined with GIS analysis of aerial survey data, employing similar methods to those described above (Smith et al. 2014a).

MAP DATA SOURCES

- Important Bird Areas: Audubon Alaska (2014a), Bird Studies Canada and Nature Canada (2004-2012)



Erika Knight

Glacier Bay and Icy Strait is an Important Bird Area for more bird species than any other IBA in Southeast Alaska.

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TABLE 5-3 Summary of recognized Important Bird Areas in Southeast Alaska.

Site Name	Priority	Type	Trigger Species[1]	Acres
Berners Bay	State	Coast	*State*: Bald Eagle, Surf Scoter, Thayer's Gull	24,300
Blacksand Spit Colony	Global	Colony	*Global*: Aleutian Tern	76,428
Chilkat Bald Eagle Preserve	State	Land	*State*: Bald Eagle, Trumpeter Swan	44,783
Dixon Entrance 132W54N	Global	At-Sea	*Global*: Ancient Murrelet, Marbled Murrelet; *State*: Rhinoceros Auklet	422,070
Forrester Island Colonies	Global	Colony	*Global*: Cassin's Auklet, Fork-tailed Storm-Petrel, Leach's Storm-Petrel, Rhinoceros Auklet; *State*: Glaucous-winged Gull, Pelagic Cormorant	130,465
Frederick Sound to Duncan Canal	Global	At-Sea	*Global*: Marbled Murrelet, *State*: Bonaparte's Gull	195,099
Glacier Bay & Icy Strait	Global	At-Sea	*Global*: Barrow's Goldeneye, Black Oystercatcher, Glaucous-winged Gull, Harlequin Duck, Kittlitz's Murrelet, Marbled Murrelet, Pigeon Guillemot, Surf Scoter, White-winged Scoter; *State*: Black-legged Kittiwake, Common Goldeneye, Common Merganser, Mew Gull	890,109
Glacier Bay Outer Coast Marine	Global	At-Sea	*Global*: Kittlitz's Murrelet, Marbled Murrelet, Pelagic Cormorant, White-winged Scoter; *State*: Herring Gull	648,930
Mendenhall Wetlands	Global	Coast	*Global*: Marbled Murrelet, Surfbird, Thayer's Gull; Continental: American Golden-Plover, Canada Goose, Rock Sandpiper, Short-billed Dowitcher; *State*: Pectoral Sandpiper	4,583
Outside Islands Marine	Global	At-Sea	*Global*: Marbled Murrelet, Rhinoceros Auklet, Pelagic Cormorant; *State*: Harlequin Duck	1,525,371
Sitka Sound	Global	At-Sea	*Global*: Marbled Murrelet, Pelagic Cormorant; *State*: Glaucous-winged Gull	337,649
St. Lazaria Island Colony	Global	Colony	*Global*: Fork-tailed Storm-Petrel, Leach's Storm-Petrel; *State*: Rhinocerous Auklet	76,428
Stephens Passage	Global	At-Sea	*Global*: Marbled Murrelet, Surf Scoter, White-winged Scoter; Continental: Pigeon Guillemot; *State*: Harlequin Duck, Mew Gull	558,241
Stikine River Delta	Global	Coast	*Global*: Marbled Murrelet, Western Sandpiper; Continental: Snow Goose; *State*: Bald Eagle, Sandhill Crane	67,973
Sumner Strait	Global	At-Sea	*Global*: Bonaparte's Gull, Marbled Murrelet	190,958
Tebenkof Bay	Global	At-Sea	*Global*: Marbled Murrelet	58,160
Yakutat Bay	Global	At-Sea	*Global*: Kittlitz's Murrelet; *State*: Glaucous-winged Gull, Herring Gull	562,565

[1]Trigger species are documented population concentrations significant at the global, continental, and/or state threshold levels within the IBA boundary.

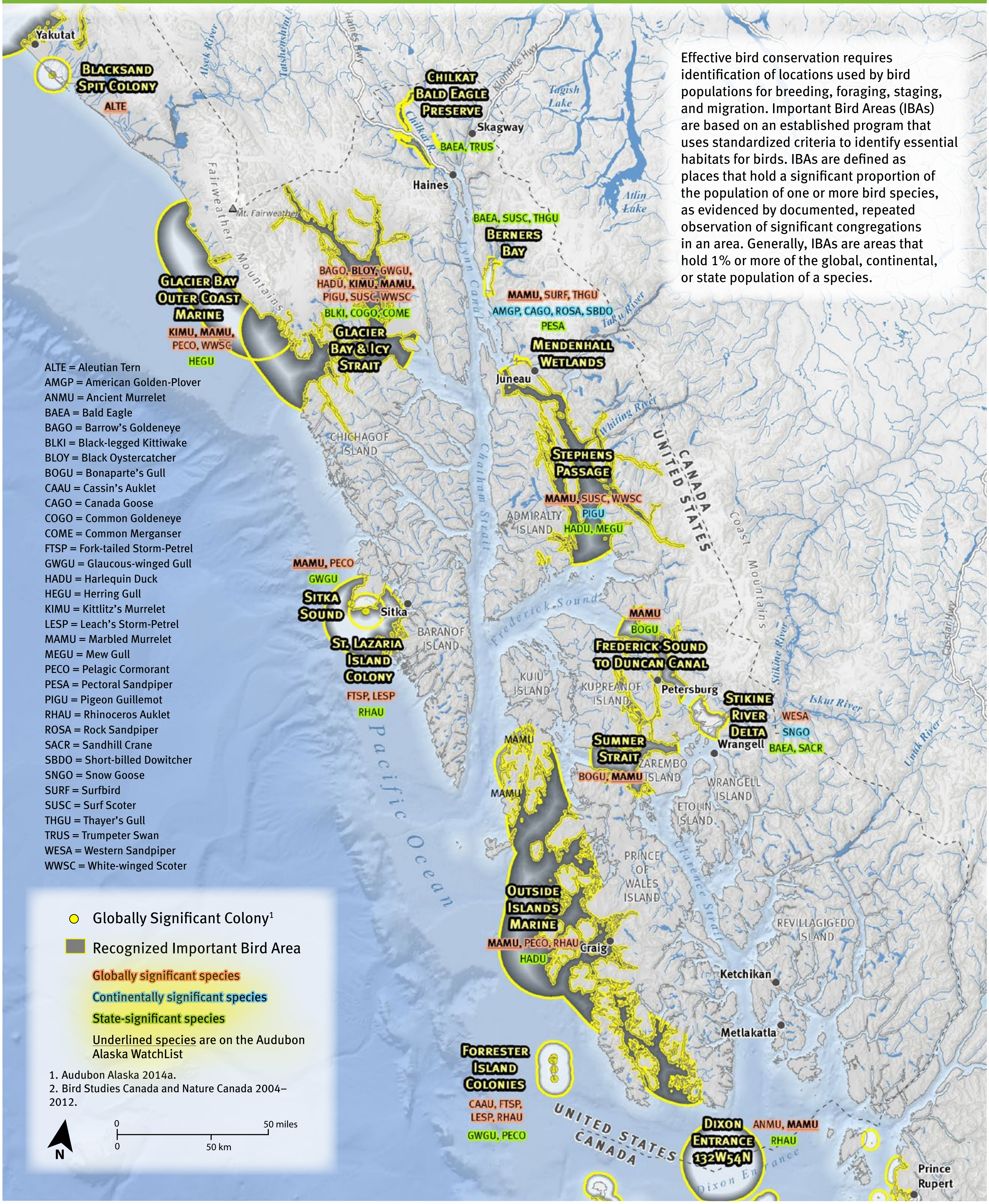
Milo Burcham

White-winged Scoters have been documented in concentrations significant at the global level in the Glacier Bay & Icy Strait IBA, Glacier Bay Outer Coast Marine IBA, and Stephens Passage IBA.

Important Bird Areas (IBAs)

Audubon ALASKA

Effective bird conservation requires identification of locations used by bird populations for breeding, foraging, staging, and migration. Important Bird Areas (IBAs) are based on an established program that uses standardized criteria to identify essential habitats for birds. IBAs are defined as places that hold a significant proportion of the population of one or more bird species, as evidenced by documented, repeated observation of significant congregations in an area. Generally, IBAs are areas that hold 1% or more of the global, continental, or state population of a species.



Map 5.2: Important Bird Areas (IBAs)

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MARINE BIRD COLONIES

Beth Peluso and Melanie Smith

The convoluted and often rocky shorelines of Southeast Alaska provide excellent habitat for colony-nesting seabirds: over 100 colonies scattered throughout the region provide nesting areas for more than 1.3 million birds (World Seabird Union 2011). Table 5-4 shows the estimated abundance and number of colonies for marine birds in the region.

The three most numerous species are Leach's Storm-Petrel (*Oceanodroma leucorhoa*), Rhinoceros Auklet (*Cerorhinca monocerata*), and Cassin's Auklet (*Ptychoramphus aleuticus*). The storm-petrels concentrate mainly in two large colonies: one on St. Lazaria Island about 20 miles from the town of Sitka, and the aptly named Petrel Island in the southern Tongass National Forest. Rhinoceros Auklets mainly nest on Forrester Island, near the northern edge of Dixon Entrance, and in another smaller colony on St. Lazaria Island. The vast majority of Cassin's Auklets in Southeast Alaska nest in colonies on the closely grouped Forrester, Petrel, and Lowrie Islands.

Colony-nesting seabird species are not evenly distributed, partly due to available habitats. Different species prefer different nesting habitats, resulting in several species sharing the same area but utilizing various niches. For example, Tufted Puffins (*Fratercula cirrhata*) usually dig burrows in soil, often at the tops of cliffs or steep slopes (Piatt and Kitaysky 2002). Common Murres (*Uria aalge*) search out ledges on craggy cliffs, preferring large, raucous colonies. On St. Lazaria Island, Common Murres further subdivide the space by selecting ledges that are wider and lower on the cliff than the similar Thick-billed Murres (*U. lomvia*), which also nest there (Ainley et al. 2002). Pigeon Guillemots (*Cepphus columba*) nest closer to the water, in lower cavities and boulder rubble, up to roughly 100 feet (30 meters) from the high water line. They tend to select small islands, and although they will nest in small colonies, pairs may nest separately from other guillemots (Ewins 1993), unlike the gregarious murres.

There are 123 mapped marine bird colonies in Southeast Alaska from Yakutat Bay to the Dixon Entrance. These colonies host an estimated 1.36 million breeding birds of 23 species. Pigeon Guillemots are present at the greatest number of colonies (64), followed by Glaucous-winged Gulls (*Larus glaucescens*) (54), Black Oystercatchers (49), Pelagic Cormorants (*Phalacrocorax pelagicus*) (29), and Arctic Terns (*Sterna paradisaea*) (28). The most abundant species are Leach's Storm-Petrels (784,000), Fork-tailed Storm-Petrels (*O. furcata*) (311,000), and Rhinoceros Auklets (110,000).

Three colonies in Southeast Alaska have over 100,000 birds present. The largest colony is located at Petrel Island with 714,000 birds estimated. Petrel Island is part of the Forrester Island Colonies IBA. Second in abundance is Forrester Island itself with 128,000 birds. In total, the Forrester Island IBA is a breeding site for 884,000 birds of 12 species at 5 colonies. Four species are present in this IBA in globally significant abundances: Leach's Storm-Petrel (577,000), Fork-tailed Storm-Petrel (111,000), Rhinoceros Auklet (108,000), and Cassin's Auklet (68,000).

The island with the third largest abundance is St. Lazaria, which is recognized as an IBA of global significance. St. Lazaria Island Colony IBA has globally significant populations of Leach's Storm-Petrel (203,000) and Fork-tailed Storm-Petrel (181,000). Blacksand Spit Colony is another colony IBA in Southeast for its significance to Aleutian Terns (*Onychoprion aleuticus*) (about 2,000 individuals).

CONSERVATION ISSUES

There are three globally significant colonies designated as IBAs in Southeast Alaska: Blacksand Spit, near Yakutat; St. Lazaria Island; and Forrester Island (Smith et al. 2012).

TABLE 5-4 Abundance of marine bird species at Southeast Alaska breeding colonies (World Seabird Union 2011).

Species	Abundance	Number of Colonies
Leach's Storm-Petrel	784,052	6
Fork-tailed Storm-Petrel	311,070	4
Rhinoceros Auklet	110,080	4
Cassin's Auklet	68,800	5
Common Murre	27,274	7
Tufted Puffin	17,725	20
Glaucous-winged Gulls	14,299	54
Black-legged Kittiwake	6,709	14
Arctic Tern	3,969	28
Pigeon Guillemot	3,812	64
Pelagic Cormorant	3,110	29
Herring Gull	2,186	7
Aleutian Tern	2,131	6
Thick-billed Murre	2,000	1
Ancient Murrelet	1,700	2
Unidentified Cormorant	1,458	2
Mew Gull	914	15
Unidentified Murre	737	1
Black Oystercatcher	379	49
Unidentified Gull	271	2
Horned Puffin	267	15
Double-crested Cormorant	228	3
Brandt's Cormorant	80	1
Northern Fulmar	30	1
Parakeet Auklet	30	1
Caspian Tern	16	1
Total	1,363,327	123

Blacksand Spit IBA supports one of the largest known nesting colonies of Aleutian Terns in the world (Yakutat Tern Festival 2011). Between 1,000–2,000 Aleutian Terns nest there, although historically the number was closer to 3,000. Although that number seems small compared to the hordes of storm-petrels, it represents a significant percentage of the world population for this species (12%) and is the largest Aleutian Tern colony in Alaska. This colony appears stable, although other populations in the state seem to be declining (Oehlers et al. 2009). The terns are ground nesters, so are very susceptible to human disturbance and may abandon eggs or chicks. The Blacksand Spit IBA is managed by the USFS, but has no special conservation status. In 2011, USFS personnel and other local sponsors teamed up to build awareness of the unique nature of this area through the now-annual Yakutat Tern Festival, which occurs in late May or early June. Protecting the Blacksand Spit nesting area from disturbance and development merits consideration, due to its importance to Aleutian Terns.

MAP ON PAGE 119

Nils Warnock

The rocky shorelines of Southeast Alaska provide habitat for colony-nesting birds such as these Common Murres on St. Lazaria Island.

St. Lazaria Island is designated Wilderness, part of the Alaska Maritime National Wildlife Refuge managed by the US Fish and Wildlife Service (USFWS). Because of the high number of burrow-nesting birds such as Rhinoceros Auklets, storm-petrels, and Tufted Puffins, the only people allowed on the island are part of a small research team. However, this volcanic island is surrounded by deep and accessible waters, and small tour boats may easily view the birds from just offshore (Alaska Department of Fish and Game 2015b).

Forrester Island IBA lies within the Alaska Maritime National Wildlife Refuge and is designated Wilderness managed by the USFWS (U.S. Fish and Wildlife Service 2013). This IBA encompases five seabird colonies, including Petrel Island, with an estimated total of more than 880,000 birds of 12 species. This is an IBA for an astonishing estimated 44,400 Cassin's Auklets, 108,000 Rhinoceros Auklets, 111,000 Fork-tailed Storm-Petrels, and 576,000 Leach's Storm-Petrels.

Conservation concerns for seabird colonies in Southeast Alaska include commercial fisheries and climate change, which may affect the availablity of forage fish.

Although some colonies with large bird populations are obvious conservation targets, others with only several hundred birds are also important, depending on the sensitivity of the species. Some species may have few breeding sites in Alaska or low population numbers. All colonies depicted on this map should be protected from human disturbance and development.

MAPPING METHODS

The North Pacific Seabird Data Portal is part of the Seabird Information Network published by the World Seabird Union. This portal contains data depicting seabird colony locations, species, and populations across Alaska. Statewide, these colonies range in size from a few individuals to several million birds. Surveyors recorded the abundance of each species present at each colony by counting the number of individuals, nests, or pairs. The database reports the best estimate made for that colony based on one or more site visits. We eliminated older (pre-1971), poor, or questionable records, resulting in a total of 1640 seabird colonies statewide (World Seabird Union 2011, Smith et al. 2012). Finally, we added an additional dataset of 23 colonies observed by the USFS (Baluss 2015a) and aggregated abundance in the same manner as above.

This map shows the proportion of birds in each of four general categories, listed here from highest to lowest proportion: alcids—Rhinoceros Auklet, Cassin's Auklet, Common Murre, Tufted Puffin, Pigeon Guillemot, Thick-billed Murre, Ancient Murrelet (*Synthliboramphus antiquus*), Unidentified Murre, Horned Puffin (*Fratercula corniculata*), and Parakeet Auklet (*Aethia psittacula*); gulls/terns—Glaucous-winged Gull, Black-legged Kittiwake (*Rissa tridactyla*), Arctic Tern, Aleutian Tern, Herring Gull (*L. argentatus*), Mew Gull (*L. canus*), Unidentified Gull, and Caspian Tern (*Hydroprogne caspia*); Storm-petrels—Leach's Storm-Petrel and Fork-tailed Storm-Petrel, and cormorants/other—Pelagic Cormorant, Unidentified Cormorant, Black Oystercatcher, Double-crested Cormorant (*P. auritus*), Brandt's Cormorant (*P. penicillatus*), and Northern Fulmar (*Fulmarus glacialis*). Sizes of the pie charts were calculated using a modified log transformation to represent the relative number of birds per colony.

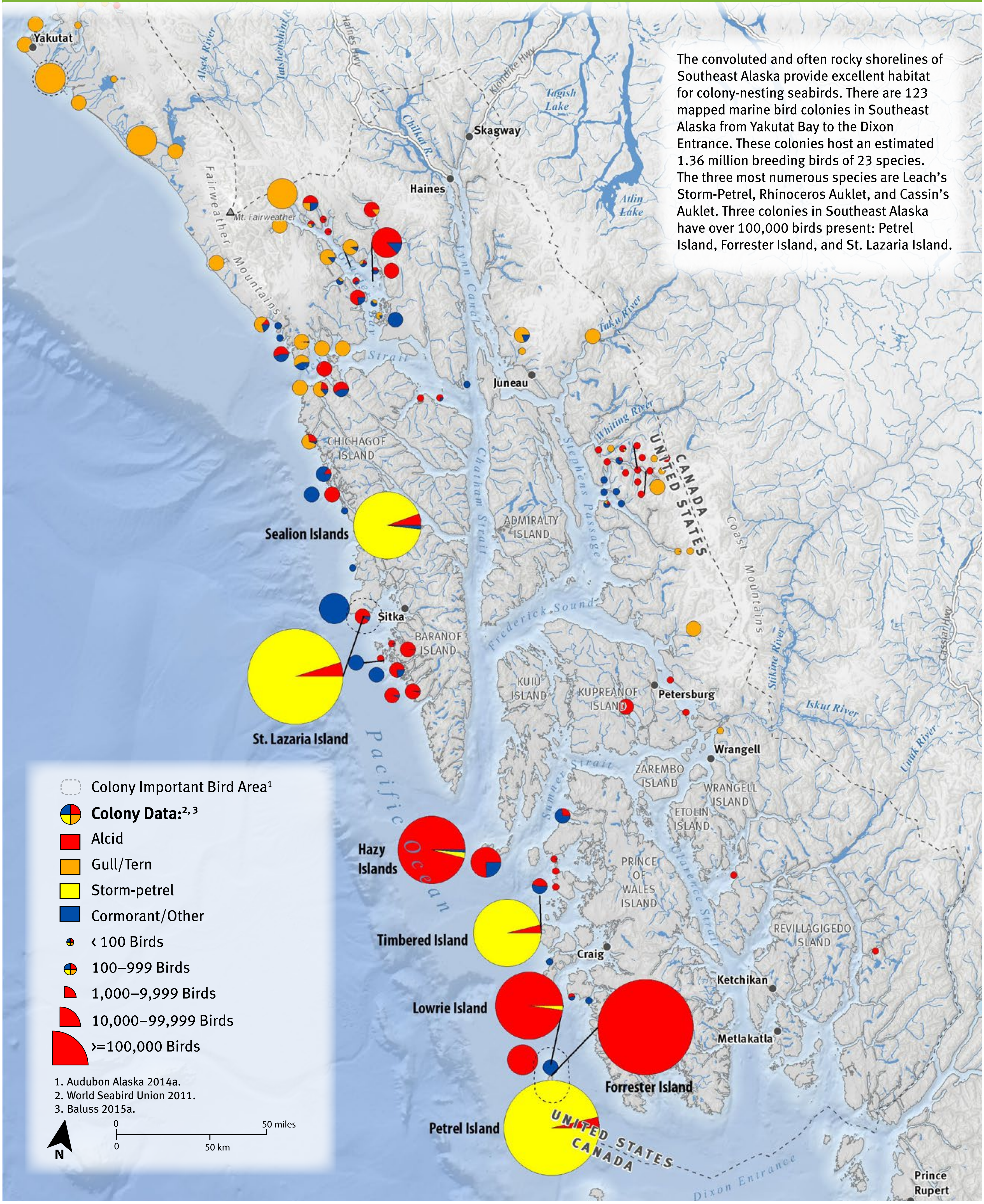
MAP DATA SOURCES

- Colonies: Audubon Alaska (2014a), based on World Seabird Union (2011); Baluss (2015a)

Audubon ALASKA

Marine Bird Colonies

The convoluted and often rocky shorelines of Southeast Alaska provide excellent habitat for colony-nesting seabirds. There are 123 mapped marine bird colonies in Southeast Alaska from Yakutat Bay to the Dixon Entrance. These colonies host an estimated 1.36 million breeding birds of 23 species. The three most numerous species are Leach's Storm-Petrel, Rhinoceros Auklet, and Cassin's Auklet. Three colonies in Southeast Alaska have over 100,000 birds present: Petrel Island, Forrester Island, and St. Lazaria Island.



Map 5.3: Marine Bird Colonies

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MARBLED MURRELET

Matt Kirchhoff

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that nests on moss-covered boughs in the canopy of old-growth trees. Because of this nesting preference, the species range largely parallels that of the north temperate rainforest, from northern California, through Oregon, Washington ,and British Columbia, to Southeast and Southcentral Alaska (Nelson 1997). The substantial loss of old-growth forest due to logging is a major contributing factor for murrelet population declines in the Lower 48 states. There, the Marbled Murrelet is listed as a threatened species under the Endangered Species Act.

In Alaska, the Marbled Murrelet is still quite abundant (Agler et al. 1998), and is by far the most common alcid seen in nearshore waters during the summer. The species center of abundance is in Southeast Alaska, with especially high numbers found in summer in the archipelago's northern straits and passages, including Icy Strait and Glacier Bay (Fair 2014). This area attracts birds from long distances for the rich foraging opportunities (Whitworth et al. 2000).

Marbled Murrelet populations in at least some areas of Southeast Alaska appear stable (Kirchhoff et al. 2010), although populations elsewhere in the species range are declining (Piatt et al. 2007, Falxa et al. 2014). The last region-wide survey estimated the Southeast Alaska population at 687,061 ± 201,162 (95% CI) in summer 1994 (Agler et al. 1998). Because of its unique association with old growth forests, and declining population trend, the Marbled Murrelet is a species of conservation concern at statewide, national, and international levels (Butcher et al. 2007, Kirchhoff and Padula 2010, BirdLife International 2012a).

Twenty years ago, areas of marine concentration in Southeast Alaska were mapped in a general way based on observations of commercial fisherman (DeGange 1996), and were believed to reflect both important marine foraging areas as well as proximity to high-quality nesting habitat. More recently, as depicted in the marine portion of the associated map, Smith et al. (2014b) utilized at-sea survey data to map and quantify nearshore abundance of Marbled Murrelets. These data were used to identify species core areas and to nominate globally significant IBAs.

The land portion of the associated map shows the distribution and quality of Marbled Murrelet nesting habitat, based on old-growth and topographic features that appear positively correlated with occupancy and nesting success in this species (Albert and Schoen 2007). Most of this understanding was derived from studies of radio-tagged birds in the Pacific Northwest and British Columbia, although recent studies in Southeast Alaska (Barbaree et al. 2014) are shedding light on inland ground nest sites in this region as well.

Because the birds nest in tall trees, and many kilometers inland, nests have been historically hard to find. The first nest was described in 1974. With the development of effective capture techniques on the water, and advent of miniaturized radio-transmitters to track birds inland, approximately 260 nests had been found in North America by 2006 (Denlinger 2006).

Most nests in the Pacific Northwest have been found within 30 km of the sea and very few farther than 50 km inland (Hamer and Nelson 1995). Marbled Murrelets generally prefer low elevation old-growth and mature coniferous forests with multi-layered canopies, on the lower two-thirds of forested slopes, with moderate gradients (Hamer and Nelson 1995). Stand canopy closure is typically low at nest sites, suggesting the birds use canopy openings for access to nest platforms. Nests in the Pacific Northwest were typically found in the largest diameter old-growth trees available in a stand (Hamer and Nelson 1995).

Milo Burcham

Marbled Murrelets often forage in pairs within a mile of the shore. Commonly, two individuals will pair up during the day; the joint effort appears to help with safety from predators and efficiency in catching prey.

In British Columbia, murrelets preferred to nest at elevations below 2625 ft (800 m) (Burger 2004). Marbled Murrelets do nest on steep slopes, and in some studies, nest success has been positively correlated with steeper slopes (Bradley 2002), which may facilitate access into and out of the canopy. Aspect does not appear to have a strong effect on the placement or success of nests in Britsh Columbia (Burger 2004) or elsewhere.

Until recently, very few nests had been described in Southeast Alaska (Quinlan and Hughes 1990). A study conducted between 2005 and 2007 in Port Snettisham on the Southeast Alaska mainland located 19 nests (Nelson and Newman 2009), of which 8 were in trees, 5 were on the ground (on cliffs), and 6 were uncertain. All were in old forests (typical of the area) and along steep cliff areas with a wide range of aspects, elevations, and distances from the coastline. Two nests were found in Canada, >50 km inland (Nelson and Newman 2009).

In Southeast Alaska, Marbled Murrelets appear to use a wider range of habitat types for nesting than in the Pacific Northwest and British Columbia. Alaska birds have access to abundant, high-quality forage fish, making long flights to relatively distant nest sites energetically feasible. Steeper topography and wetter climate in Southeast Alaska may increase availability of suitable moss nest platforms on the ground in cliffy terrain that is also well inland from shore where predation risks are reduced.

CONSERVATION ISSUES

The species is currently listed in the Lower 48 states as a threatened species under the Endangered Species Act. Populations in the Lower 48 states are declining, presumably as a result of diminishing old-growth nesting habitat and increased predation on eggs and chicks. Similar pressures exist in Southeast Alaska, although old-growth forest in Southeast Alaska is still relatively abundant, and Marbled Murrelets in Alaska may have a lesser dependence on old-growth trees for nesting than birds in the Lower 48 (Barbaree et al. 2014).

Threats to these birds include loss of old-growth nesting habitat due to logging, depredation by gulls and corvids, by-catch in nearshore drift gill nets, and declines in key forage fish species. The species marine distribution overlaps spatially with drift gillnets in local salmon fishing areas in Southeast Alaska, and mortality from by-catch can be significant (Carter et al. 1995).

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Conservation needs include protection of important nesting habitat from clearcut logging, and increased monitoring of population trends, especially in southern Southeast Alaska where clearcut logging is more intensive. Perhaps more importantly, scientists have documented crashes in prey fish populations and predict that ocean warming and acidification could cause further prey fish declines in the future. Gaining a better understanding of prey fish response to warming oceans could allow managers to better prepare for Marbled Murrelet conservation needs in a changing climate (Norris et al. 2007).

MAPPING METHODS

An interagency and university group of experts (including ADFG, Audubon, The Nature Conservancy (TNC), University of Alaska Fairbanks (UAF), USFS, and USFWS) was convened to develop and evaluate a nesting habitat capability model based on data from Alaska and British Columbia. This model was based on stand age, forest structure, slope, and distance from shoreline. Old-growth forests have the highest habitat value because they include canopy gaps that are thought to provide murrelets access to nest platforms. Large-tree old-growth was assigned higher value than medium- and small-tree old-growth because larger trees are easier to access and have larger limbs for nest platforms. Younger stands are considered not suitable because of the relatively dense, uniform canopies, lack of large-diameter branches, and limited nest platform structures. Assignment of forest structure classes was based on the USFS TIMTYPE (timber type) database.

Nesting habitat value increased with slope steepness up to 20 degrees, assuming that the upper crown of trees on such slopes is more exposed, and therefore more accessible to nesting murrelets and fledging young. The final habitat attribute is distance from shoreline: Marbled Murrelets do not nest immediately near the shore; they have been found to fly as far as 30 mi (50 km) inland to nest sites, presumably due to the increased numbers of avian predators found along the beach fringe. The murrelet model assigned a low value to beach fringe habitat, defined as from the coastline out to 984 ft (300 m), and high value beyond that distance.

The nesting habitat capability model was developed for inclusion in the 2007 Audubon-TNC Conservation Assessment. More recent analyses (Nelson and Newman 2009) have found that, in addition to the habitat predicted by this model, Marbled Murrelets also use habitat along cliff edges for nesting.

This map depicts habitat predicted by the nesting habitat capability model, as well as the top-ranked nesting habitat watershed in each biogeographic province.

TABLE 5-5 Values applied to habitat variables for the Marbled Murrelet nesting habitat suitability index model.

Variable	Habitat Type	Suitability Index
Forest Stand Age Class	<150 years	0.00
	>=150 years	1.00
Tree Size	Small POG*	0.50
	Medium POG	0.75
	Large POG	1.00
Slope	0-5	0.20
	5-10	0.40
	10-15	0.60
	15-20	0.80
	>20 degrees	1.00
Distance from shoreline	<984 feet (300m)	0.30
	>=984 feet (300m)	1.00

*POG = productive old growth

The map also includes IBA boundaries from Audubon's recent revision of IBAs statewide (Smith et al. 2014a, Smith et al. 2014b). Because IBAs often include combined core areas for multiple species, the specific core areas for Marbled Murrelets are also shown on the map. These core areas are based on Audubon's analysis of at-sea survey data (Smith et al. 2014b) and are an intermediate step toward IBA identification. Individual observations are also included to show the known distribution of the species throughout Southeast Alaska.

MAP DATA SOURCES

- Marbled Murrelet nesting habitat suitability index model: Albert and Schoen (2007)
- Marbled Murrelet marine core areas: Audubon Alaska (2014b)
- Important Bird Areas: Audubon Alaska (2014a).

Adult Marbled Murrelet on a nest in the top of an old-growth hemlock on Baranof Island.

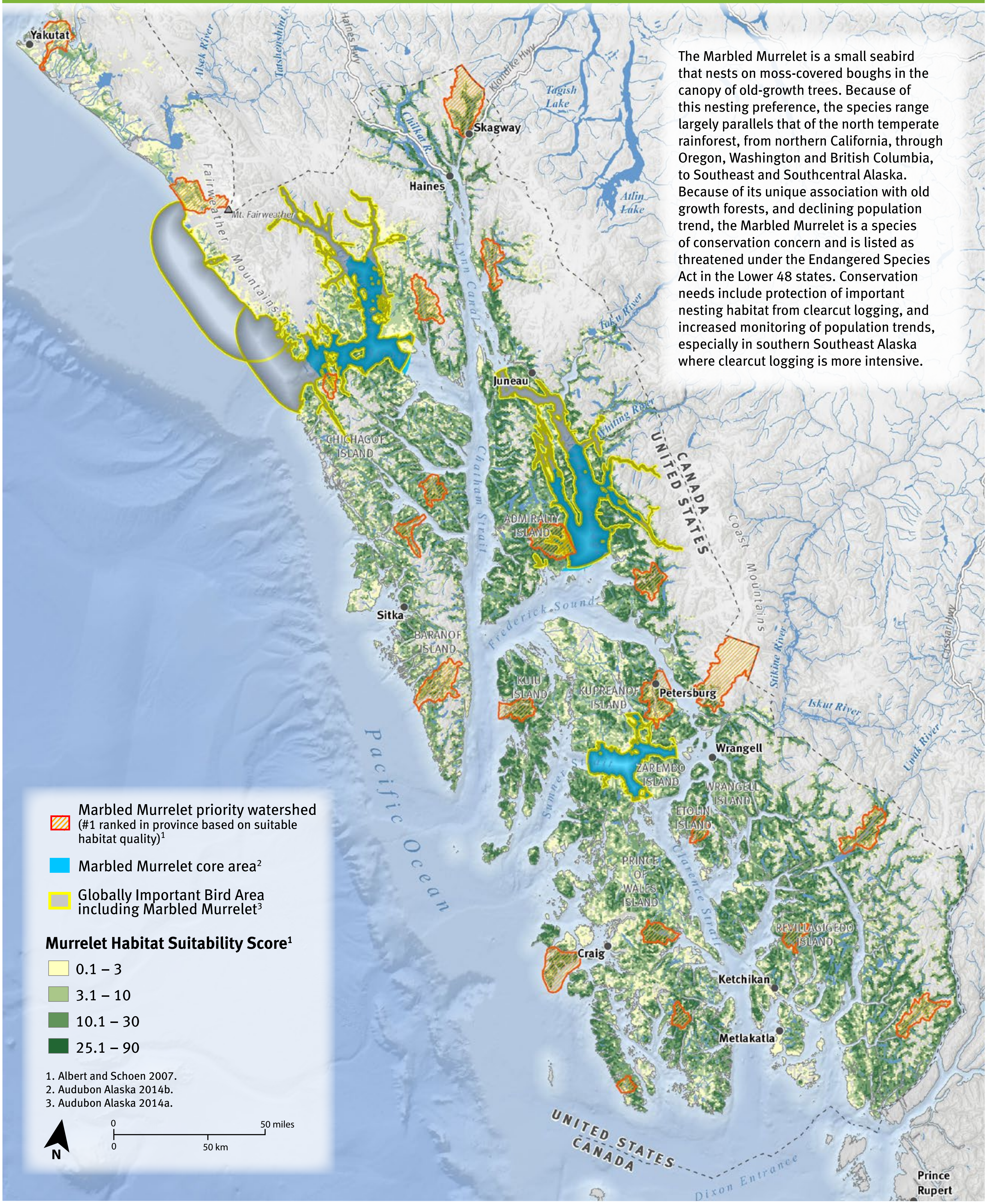
Jeff Hughes

Marbled Murrelet

Audubon ALASKA

The Nature Conservancy

The Marbled Murrelet is a small seabird that nests on moss-covered boughs in the canopy of old-growth trees. Because of this nesting preference, the species range largely parallels that of the north temperate rainforest, from northern California, through Oregon, Washington and British Columbia, to Southeast and Southcentral Alaska. Because of its unique association with old growth forests, and declining population trend, the Marbled Murrelet is a species of conservation concern and is listed as threatened under the Endangered Species Act in the Lower 48 states. Conservation needs include protection of important nesting habitat from clearcut logging, and increased monitoring of population trends, especially in southern Southeast Alaska where clearcut logging is more intensive.



Map 5.4: Marbled Murrelet

KITTLITZ'S MURRELET
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KITTLITZ'S MURRELET

Matt Kirchhoff

The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a small seabird in the auk (Alcidae) family. The family is found only in the upper latitudes of the northern hemisphere, possibly due to the advantages that cold water affords to divers who must pursue poikilothermic (cold-blooded) prey (Gaston 2004).

The global distribution of the Kittlitz's Murrelet at sea is extensive, from the Russian Far East (northern Okhotsk Sea, Bering Sea coast, and coast of the Chukchi Sea), across the Aleutians, and Gulf of Alaska, to the inshore waters of Southcentral and Southeast Alaska (Day et al. 1999, Artukhin et al. 2011). Despite a wide distribution at sea during most of the year, in the summer breeding season, many birds move into nearshore waters to nest, with the highest concentrations found in association with tidewater glaciers along the southern Alaska coastline (Day et al. 1999, Kissling et al. 2011, Kuletz et al. 2011, Piatt et al. 2011).

In Southeast Alaska, the bird is found in summer in glacially influenced waters of the northern mainland, including Tracy-Endicott Arm, Cross Sound, Yakutat Bay, and Glacier Bay (Kissling et al. 2011, Piatt et al. 2011). The largest single known population of breeding birds occurs in Glacier Bay, where surveys have reported up to 18,000 birds, representing an estimated 18 to 36% of the global population (Kirchhoff et al. 2014). Glacier Bay adjoins the Tongass National Forest, and is part of the Glacier Bay National Park and Preserve.

Our understanding of why the Kittlitz's Murrelet has evolved to prefer glaciated systems is incomplete, but part of the attraction is certainly the availability of relatively inaccessible, predator-free nesting habitat in recently deglaciated landscapes. This is especially critical to the Kittlitz's Murrelet, which, in contrast to typical seabirds, nests solitarily, laying a single egg in an exposed scrape on the ground (Day et al. 1999). Until 1999, only 19 nests of this species had been discovered (US Fish and Wildlife Service 2013). Since that time, focused research on the species has yielded over 200 nests, mostly in nonglaciated settings (Kodiak Island, Aggatu Island, Attu Island). In all areas, Kittlitz's Murrelets consistently nest in the least vegetated areas available on the landscape (US Fish and Wildlife Service 2013). These sparsely vegetated sites tend to occur at the highest elevations and on the steepest sites, and offer the greatest security from terrestrial predators.

Nesting success for this species can be low, and is a suspected cause of local population declines (e.g. Kissling et al. 2015). Because the species is relatively long-lived (assumed to be approximately 15 years), adult birds are able to make multiple nesting attempts during their lifetime. Weather conditions and marine productivity may combine to facilitate episodic breeding success in this species.

The distribution and reproductive success of seabirds, as a group, is closely tied to the productivity of their marine environment (Gaston 2004). Breeding success is highest in areas, and years, of high productivity in the ocean. There is mounting evidence that glacial systems, like those in Southeast Alaska, provide unusually high levels of dissolved organic carbon (DOC) into marine systems (Hood and Scott 2008, Hood et al. 2009). Summer-long input of nutrients, and cold, fresh water, fuels unusually high levels of productivity in some glacial estuaries (Etherington et al. 2007) and may provide cold-water refugium for important forage fish species, like capelin (*Mallotus villosus*) (Arimitsu et al. 2008) that are important to seabirds.

CONSERVATION ISSUES

The Kittlitz's Murrelet is a species of conservation concern featured on both the Audubon Alaska and National Audubon WatchLists. The International Union for Conservation of Nature and Natural Resources (IUCN) currently has the species listed as near threatened, having down-listed it in 2014 from critically endangered (BirdLife International 2014). In October 2013, the USFWS issued a 12-month finding on a petition to list the species under the Endangered Species Act. They determined listing the species as endangered or threatened was not warranted at that time (US Fish and Wildlife Service 2013).

Milo Burcham

Kittlitz's Murrelet's have a larger eye than other similar species, making them better adapted to foraging in silty water near glaciers.

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The species is of concern because of its relatively small population size (<100,000), declining trend in some areas, and because most of the world's population is associated (during summer) with glacially influenced habitats that are undergoing relatively rapid change. The number of birds counted in surveys is 33,538 (US Fish and Wildlife Service 2013), although this is a conservative estimate for the global population, given that large areas were not surveyed or incompletely surveyed. Further, the species is difficult to accurately and precisely survey (Kissling et al. 2007, Kirchhoff 2011), and differences in survey methods and designs have confounded interpretation of survey results, particularly those from early years (Day 2011, Hodges and Kirchhoff 2012, Kirchhoff et al. 2014). The total population may in fact number 48,000 to 82,000 (BirdLife International 2014). Because of these uncertainties, this is a species that should continue to be monitored closely.

Principle threats to Kittlitz's Murrelets are associated with changes in its nesting and foraging habitat, especially along the glaciated southern coast of Alaska. The loss of ice may initially benefit the species by adding suitable nest substrate and enhancing marine productivity. But the loss of ice altogether would eventually result in the disappearance of much of the bird's traditional nesting habitat (or make it very distant from water). Reduction in ice could also significantly reduce the productivity of the marine ecosystem. Other threats that may affect local populations include water pollution, disease, predation, vessel traffic, and drift-net bycatch. The USFWS (2013) concluded that no one threat was likely to have the population-level, rangewide effect sufficient to warrant listing; however, the agency acknowledged that exposure to one or more of these threats could have negative impacts on local populations.

Conservation actions in the future include continued monitoring to reveal declining population trends and identifying factors responsible for those declines. If cruise ship traffic or drift gillnet bycatch is shown to be driving declines, those activities could be regulated.

MAPPING METHODS

This map includes two different sources:

- Point data representing observed locations of Kittlitz's Murrelets from the North Pacific Pelagic Seabird Database (Drew and Piatt 2013).
- IBA boundaries from Audubon's recent revision of IBAs statewide (Smith et al. 2014a, Smith et al. 2014b). Because IBAs often include combined core areas for multiple species, the specific core areas for Kittlitz's Murrelets are also shown. These core areas are based on Audubon's analysis of at-sea survey data (Smith et al. 2014b) and are an intermediate step toward IBA identifiation.

MAP DATA SOURCES

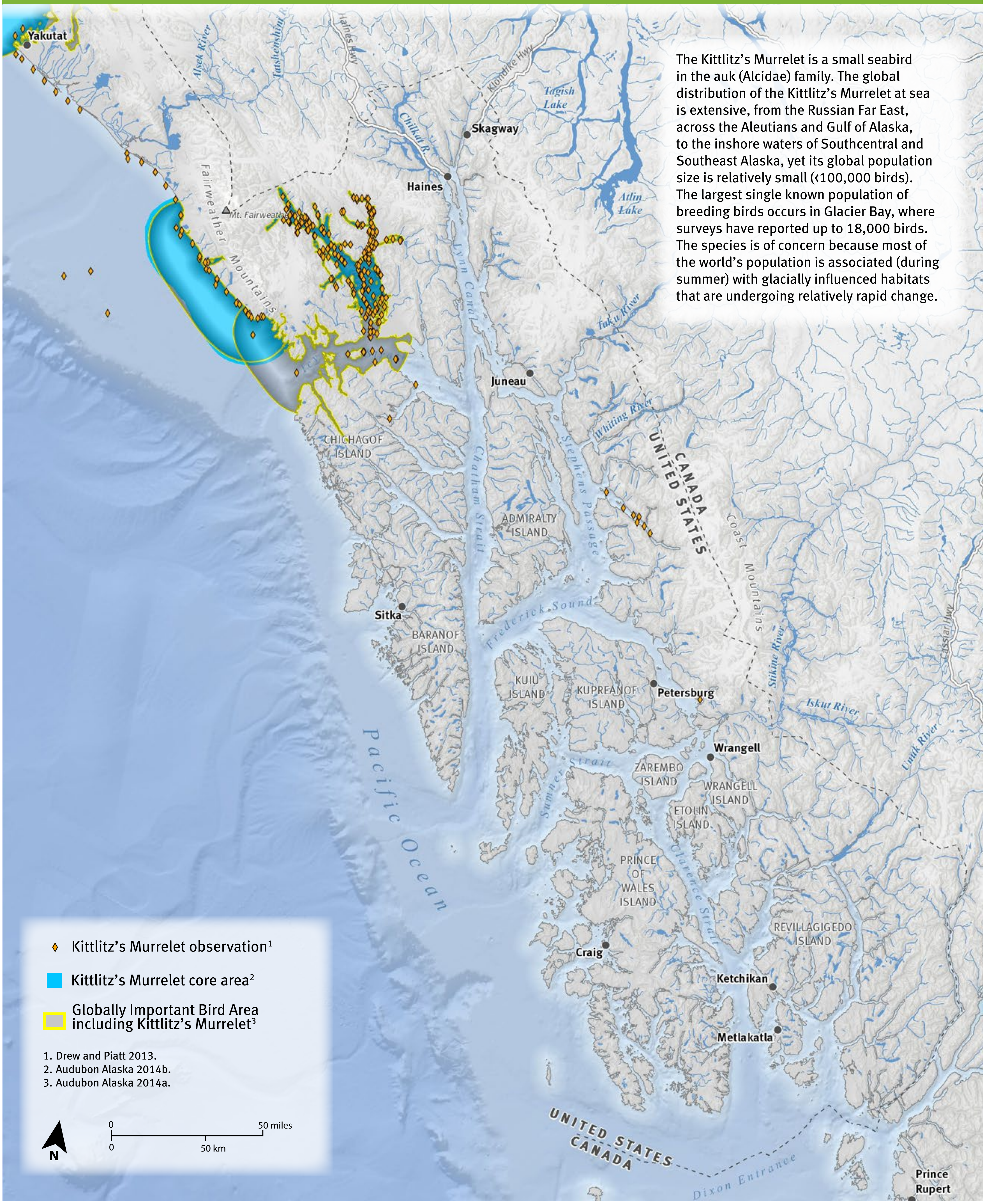
- Kittlitz's Murrelet at-sea observations: Drew and Piatt (2013)
- Kittlitz's Murrelet marine core areas: Smith et al. (2014b)
- Important Bird Areas: Smith et al. (2014a).

Milo Burcham

Audubon ALASKA

Kittlitz's Murrelet

The Kittlitz's Murrelet is a small seabird in the auk (Alcidae) family. The global distribution of the Kittlitz's Murrelet at sea is extensive, from the Russian Far East, across the Aleutians and Gulf of Alaska, to the inshore waters of Southcentral and Southeast Alaska, yet its global population size is relatively small (<100,000 birds). The largest single known population of breeding birds occurs in Glacier Bay, where surveys have reported up to 18,000 birds. The species is of concern because most of the world's population is associated (during summer) with glacially influenced habitats that are undergoing relatively rapid change.



Map 5.5: Kittlitz's Murrelet

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SHOREBIRDS

Nils Warnock and Melanie Smith

Each spring, millions of shorebirds visit Southeast Alaska. Most are migrating to northern Alaska to breed and forage in wetlands rich in algae, aquatic plants, crustaceans, mollusks, and insects (Armstrong and Hermans Undated-b). Several common species stay in Southeast Alaska to breed, including Semipalmated Plover (*Charadrius semipalmatus*), Black Oystercatcher (*Haematopus bachmani*), Greater and Lesser Yellowlegs (*Tringa melanoleuca* and *T. flavipes*), Spotted Sandpiper (*Actitis macularius*), Least Sandpiper (*Calidris minutilla*), Short-billed Dowitcher (*Limnodromus griseus*), Wilson's Snipe (*Gallinago delicata*), and Red-necked Phalarope (*Phalaropus lobatus*) (Armstrong 2015). These birds rely on high-density food resources of amphipods, worms, and small clams. Food resources are especially high in the Stikine River Delta and the Mendenhall Wetlands where studies have estimated up to 20,000 amphipods and/or hundreds of thousands of tiny worms in a single cubic meter of mud; some sandpipers can eat 30,000 amphipods per day (Armstrong and Hermans Undated-b).

Of the 45 confirmed species of shorebirds that occur in Southeast Alaska, 16 are listed as common at some point in the year (Armstrong 2015), while 11 species are considered breeders, and 2 are probable breeders. Eighteen species that have been confirmed in Southeast Alaska are listed as High Priority in the Alaska Shorebird Conservation Plan (Alaska Shorebird Group 2008), while 16 species are on Audubon Alaska's WatchList (Table 5-6). Five shorebird species that are on the Audubon Alaska WatchList breed in Southeast.

Black Oystercatcher, Greater Yellowlegs, Spotted Sandpiper, and Semipalmated Plover are fairly common breeders and widely distributed through Southeast, although with differences in breeding habitats (Heinl 2010, Armstrong 2015). The oystercatchers breed in close proximity to the tidal zone along rocky, coastal areas while the Greater Yellowlegs typically breed in bogs, muskegs, and other wetland timber tracts (Gabrielson and Lincoln 1959). Yellowlegs can also rarely be found breeding above timberline (Weeden 1960). Spotted Sandpipers and Semipalmated Plovers breed on gravel or grass along the shores of rivers, streams, and lakes (Armstrong 2015).

Southeast Alaska supports between 1,000 to 2,000 Black Oystercatchers (out of a global population of 6,900 to 10,800), with highest concentrations in and around Glacier Bay (Tessler et al. 2010). The largest concentrations of migrant shorebirds in Southeast Alaska occur at coastal estuaries, with highest numbers usually in the spring. The most abundant spring species are Western Sandpiper (*Calidris mauri*), Dunlin (*Calidris alpina*), and Short- and Long-billed Dowitchers (*L. griseus* and *L. scolopaceus*) (Andres and Browne 1998). The only common shorebird found in the region in the winter is the Rock Sandpiper (*Calidris ptilocnemis*) (Armstrong 2015), although other species like Black Turnstone (*Arenaria melanocephala*), Dunlin, Black Oystercatcher, and Surfbirds (*Aphriza virgata*) occur with regularity.

CONSERVATION ISSUES

Three sites in Southeast Alaska are known to be of particular importance to migrant shorebirds (Alaska Shorebird Group 2008). The highest numbers of migrant shorebirds occur at the Stikine River Delta. In late April to early May, Western Sandpiper numbers peak on the Stikine tidal flats at about 350,000 birds, accompanied by many thousands of other birds of up to 22 species, including Dunlin and dowitchers (Iverson and Walsh 1994, Iverson et al. 1996b, Johnson et al. 2008).

The Delta is a globally significant IBA for Western Sandpiper, and qualifies for status as a Western Hemispheric Shorebird Reserve Network (WHSRN) site, but has not been officially designated.

Not far behind in terms of numerical importance to springtime migrating shorebirds is the Yakutat Forelands, especially at the Seal Creek-Ahrnklin estuary. Andres and Browne (1998) estimated over 350,000 shorebirds, mainly Western Sandpipers, Dunlin, Least Sandpipers, and dowitchers, moved through the area during spring migration. Yakutat Forelands qualifies as a WHSRN site for high numbers of migrating Marbled Godwits (*Limosa fedoa*).

Having lower bird abundance, but of critical importance to a high number of species of shorebirds, is the Mendenhall Wetlands (Armstrong et al. 2009). Western Sandpipers are the most abundant spring migrant at Mendenhall, but the wetlands support significant numbers of other species during fall migration and in winter as well. Notably, single day counts of over 2,000 Surfbirds have occurred there (Armstrong et al. 2009). Mendenhall Wetlands is therefore a globally significant IBA, triggered by the large numbers of migrating Surfbirds; a continentally significant abundance of migrating American Golden-Plovers (*Pluvialis dominica*) and Short-billed Dowitchers, and wintering Rock Sandpipers; and state-significant numbers of migrating Pectoral Sandpipers (*Calidris melanotos*).

MAPPING METHODS

The Alaska Natural Heritage Program developed distribution models for each of 346 vertebrate species across Alaska. Gotthardt et al. (2013) provide details on the modeling process, including data sources and accuracy assessment. This map summarizes the results of these

Milo Burcham

Dunlin.

Milo Burcham

Red-necked Phalarope.

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TABLE 5-6 Shorebird species known to occur in Southeast Alaska. Birds in bold are fairly common to common at some time during the year.

Species	Special Status[8]	Breeder?	Species	Special Status[8]	Breeder?
Black-bellied Plover			Red Knot	RL, AS	
European Golden-Plover[1]			Red-necked Stint[2]		
American Golden-Plover	RL, AS		Sanderling	AS	
Pacific Golden-Plover			Semipalmated Sandpiper		
Semipalmated Plover		yes	**Western Sandpiper**	AS	
Killdeer		yes	Long-toed Stint[2]		
Black Oystercatcher	RL, AS	yes	**Least Sandpiper**		yes[9]
American Avocet[2]			White-rumped Sandpiper[5]		
Greater Yellowlegs		yes	Baird's Sandpiper		
Lesser Yellowlegs	RL, AS	yes	**Pectoral Sandpiper**		
Solitary Sandpiper	RL, AS	yes[9]	Sharp-tailed Sandpiper		
Wandering Tattler[3]	RL	yes[9]	**Rock Sandpiper**		
Spotted Sandpiper		yes	**Dunlin**	RL, AS	
Upland Sandpiper	AS		Curlew Sandpiper[7]		
Whimbrel	YL, AS		Stilt Sandpiper		
Bristle-thighed Curlew[4]	YL, AS		Buff-breasted Sandpiper[5]	RL, AS	
Long-billed Curlew[2]			Ruff[5]		
Bar-tailed Godwit[5]	RL, AS		**Short-billed Dowitcher**	RL, AS	yes
Hudsonian Godwit[6]	RL, AS	yes[9]	Long-billed Dowitcher		
Marbled Godwit	YL, AS		**Wilson's Snipe**		yes
Ruddy Turnstone			Wilson's Phalarope[5]		
Black Turnstone	YL, AS		**Red-necked Phalarope**		yes[9]
Surfbird	RL, AS		Red Phalarope		

Data from Armstrong (2015), eBird (2015), Yakutat Bird Checklist (Baluss 2015b), Andres and Browne (1998), Birds of the Chilkat Valley Checklist (Bertsch Undated), The Birds of Chilkat Pass (Weeden 1960), Birds of Juneau Alaska Checklist (Juneau Audubon Society 2007), Birds of Skagway Alaska Checklist (Skagway Bird Club 2010), Birds of Southeast Alaska Checklist (Heinl 2010), Glacier Bay Checklist (Paige and Drumheller 2012), and personal communication with USFS biologist Gwen Baluss.

[1]accidental; Ketchikan
[2]accidental; Juneau
[3]past breeding records near Haines and Skagway; currently not known to breed in the region
[4]accidental; Lituya Bay, Douglas Island
[5]casual; Juneau, Gustavus
[6]past record of breeding pair on territory in Chilkat Pass area
[7]accidental; Juneau, Gustavus
[8]Status, RL = Red List Audubon WatchList Species, YL = Yellow List Audubon WatchList Species; AS = Alaska Shorebird Conservation Plan High Priority Species
[9]rare breeder

individual species models to show relative richness, calculated as the number of breeding shorebird species predicted for each subwatershed in Southeast Alaska (HUC 12, or sixth level watershed).

There are certain limitations inherent to both observation data and the modeling process used by the Heritage Program. Because these models have much greater spatial resolution than other available continental-scale species distribution datasets, we utlized the data to depict species richness even though inaccuracy of some individual layers is known. Given these limitations, the information is most useful as a way to interpret broad ecological patterns and relationships. The results summarized on this map should be interpreted as a generalized representation of the relative level of species richness among province groups rather than exact species numbers.

There are 14 breeding shorebird species present during the breeding season in Southeast Alaska based on the predictions of these models: Baird's Sandpiper (*Calidris bairdii*), Black Oystercatcher, Greater Yellowlegs, Killdeer (*Charadrius vociferus*), Lesser Yellowlegs, Pectoral Sandpiper, Red-necked Phalarope, Sanderling (*Calidris alba*), Short-billed Dowitcher, Semipalmated Plover, Spotted Sandpiper, Surfbird, Wandering Tattler, and Wilson's Snipe.

Compared to Table 5-6, four species with predicted breeding habitat are not known to breed in Southeast Alaska: Baird's Sandpiper (predicted in a small portion of Upper Lynn Canal); Surfbird (predicted in a small portion of the Yakutat Forelands); Sanderling (predicted in areas along the coast from Juneau to Berner's Bay); and Pectoral Sandpiper (predicted in a small portion of Taku Inlet and Upper Lynn Canal). Two other species that are known to breed rarely in Southeast, Solitary and Least sandpipers, were not predicted by the Alaska Natural Heritage Program models.

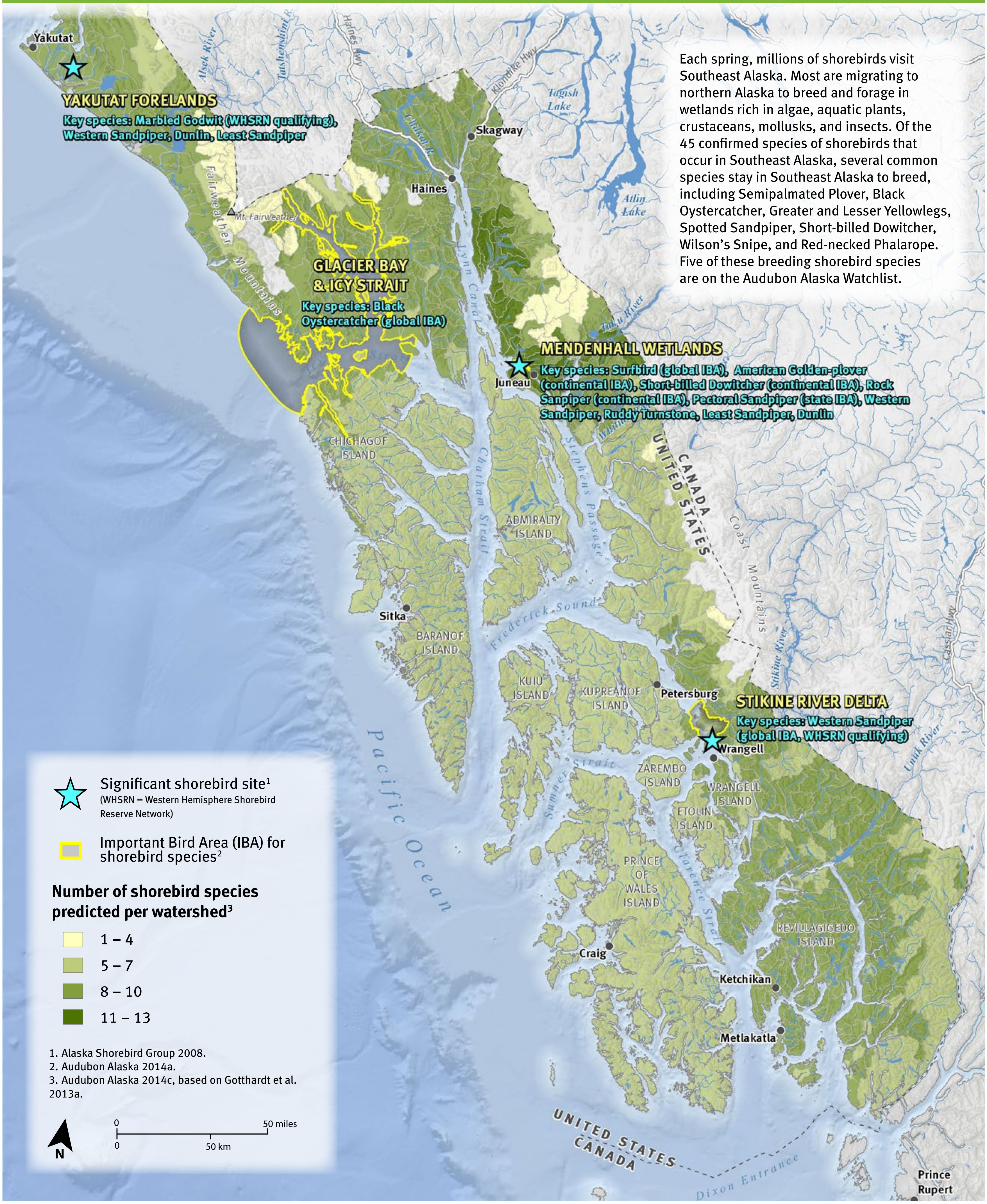
MAP DATA SOURCES

- WHSRN qualifying sites: Alaska Shorebird Group (2008)
- Important Bird Areas: Audubon Alaska (2014a)
- Shorebird species richness by watershed: Audubon Alaska (2014c) based on Gotthardt et al. (2013).

Shorebirds

Audubon ALASKA

Each spring, millions of shorebirds visit Southeast Alaska. Most are migrating to northern Alaska to breed and forage in wetlands rich in algae, aquatic plants, crustaceans, mollusks, and insects. Of the 45 confirmed species of shorebirds that occur in Southeast Alaska, several common species stay in Southeast Alaska to breed, including Semipalmated Plover, Black Oystercatcher, Greater and Lesser Yellowlegs, Spotted Sandpiper, Short-billed Dowitcher, Wilson's Snipe, and Red-necked Phalarope. Five of these breeding shorebird species are on the Audubon Alaska Watchlist.



Map 5.6: Shorebirds

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PRINCE OF WALES SPRUCE GROUSE

Beth Peluso

In Southeast Alaska, the Prince of Wales subspecies of Spruce Grouse (*Falcipennis canadensis isleibi*) is endemic to the Prince of Wales Island complex, with records on 11 islands. This is the only place in the species' range where they inhabit temperate rainforest (Kissling and Jahrsdoerfer 2010). First proposed as a subspecies in 1996 based on coloration and shape of the wings and tail (Dickerman and Gustafson 1996), a 2010 paper detailed genetic differences from the mainland subspecies (Barry and Tallmon 2010). The USFWS considers the Prince of Wales birds a subspecies. Prince of Wales Spruce Grouse are darker than other subspecies and have different markings on the tail (Kissling and Jahrsdoerfer 2010). These grouse are not long-distance fliers; because Prince of Wales and the surrounding islands are more than 3.75 mi (approx. 6 km) from the mainland, it is thought the subspecies' isolation dates back more than 10,000 years to the last ice age when glaciers made the islands accessible by bridging the mainland to the islands.

Spruce Grouse, as their name implies, feed almost exclusively on conifer needles during winter. During other seasons they broaden their diet to include berries, mushrooms, and insects. Insects make up the majority of chicks' diet for their first couple months; plants become a larger proportion of their diet by the end of their first summer. Spruce Grouse tend to forage in the lower portion of the crown of conifers, where they can watch for predators but remain mostly hidden (Boag and Schroeder 1992). Spruce Grouse grow bristles on the sides of their toes in fall and shed them in the spring. The bristles act as snowshoes on snowy ground and possibly provide traction on slippery tree branches.

A Spruce Grouse male attracts mates with a strutting display that includes raising the red combs above his eyes, raising his tail almost vertically to show off the white-tipped feathers underneath, and drooping his wings. When defending a territory from other males, the male does a display flight and loudly claps his wings together behind his back once, making a sound like a gunshot, before gliding to another tree (Kissling and Jahrsdoerfer 2010). The female chooses the nest site, which is always on the ground in a natural or created depression. The site is usually at the base of a coniferous tree providing overhead cover (Boag and Schroeder 1992).

Spruce Grouse rely on their mottled feathers as camouflage, staying still when they feel threatened. They stay motionless even when a person approaches closely. Because of this behavior, Spruce Grouse are difficult to detect and there is very little historical population information. There is no precise information on pre-logging population size for this subspecies (Kissling and Jahrsdoerfer 2010), though researchers have made a rough estimate of less than 25,000 (Kirchhoff and Padula 2010). Because of this lack of past population data, it is unknown if the population is changing or stable (Kissling and Jahrsdoerfer 2010).

Although capable of explosive take-offs and fast, short flights, these grouse are not long-distance fliers. There is no information on Prince of Wales Spruce Grouse migration, but the most closely related subspecies do migrate locally between winter and breeding habitat, preferring denser forest where there is less snow in winter (Kissling and Jahrsdoerfer 2010). Prince of Wales Spruce Grouse may follow a similar migration pattern, within the constraints of their island boundary.

Spruce Grouse prefer to walk rather than take wing when traveling, sometimes using human trails and roads. As a game species, this behavior leaves them vulnerable to hunting along roads as well as to vehicle collisions. The hunting harvest of Spruce Grouse on Prince of Wales Island is not monitored or monitored only in a limited capacity, but the USFWS does not consider overhunting a threat (Kissling and Jahrsdoerfer 2010).

Prince of Wales Spruce Grouse use a variety of habitats, such as old-growth, second-growth, and muskegs. In the breeding season, both males and females seem to prefer open-canopy scrub-forest, which offers food and cover as well as display areas for males. These habitat needs mean the birds do not depend solely on old-growth, and their use of clearcut areas shifts during different stages of forest succession. Prince of Wales Spruce Grouse are rarely seen crossing

Spruce Grouse chicks.

Milo Burcham

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young clearcuts, possibly because of the diffuculty of walking through logging debris. After about 15 to 25 years, understory vegetation is more habitable, providing berries and other foods as well as shelter for chicks. As the forest canopy gradually fills in, it blocks light used by understory vegetation and shifts to habitat that no longer meets grouse needs. These unsuitable conditions can last for more than a century (Kissling and Jahrsdoerfer 2010).

CONSERVATION ISSUES

The Prince of Wales Spruce Grouse is listed on the Yellow List of the Audubon Alaska WatchList because of small population size and limited geographic range.

Spruce Grouse are sensitive to habitat loss and predation, as, "Modern industrial forest exploitation, with its creation of open clearcuts and subsequent single-species plantations, reduces populations locally and often eliminates them entirely" (Boag and Schroeder 1992). Although the Tongass National Forest is not managed as a single-species plantation, the effect of deforestation is a concern for the Prince of Wales subspecies of Spruce Grouse. Prince of Wales Island, especially the northern end, has been heavily logged over the last 60 years. Many stands that are now in the stem-exclusion stage effectively eliminate light and understory cover and forage. These conditions are akin to the kind of concerns raised by Boag and Schroeder (1992). Managing the forest for stand structural stages that more closely mimic the natural range of variability would increase nesting, hiding, and foraging habitat for the Spruce Grouse. Nelson (2010) found that Prince of Wales Spruce Grouse prefer unharvested forest at the watershed scale, and that grouse avoid edges and prefer roads. Their preference for roads is the biggest management issue facing the grouse. Road mortality is the largest known source of death; subsequently, roads should be seasonally closed during times of the year when grouse are most vulnerable (Nelson 2010).

The USFWS determined in a 2010 assessment that the Prince of Wales Spruce Grouse did not warrant listing. In part, this assessment was based on the Tongass Land Management Plan's (TLMP) Old Growth Reserve system and wildlife management guidelines for other old-growth dependent species that would benefit the grouse (Kissling and Jahrsdoerfer 2010). At the time of the assessment, it was assumed TLMP would not be revised for 15 years; however, in 2015, a draft TLMP amendement was released that may alter how old-growth reserves are managed. It remains to be seen how changes to TLMP will affect Prince of Wales Spruce Grouse in the future. More research to develop baseline population numbers is an important next step.

Sealaska Corporation lands make up a substantial portion of the Prince of Wales Spruce Grouse habitat as well. In 2015, the USFS transferred 68,400 acres of the Tongass to Sealaska Native Corporation, in order to finalize the tribe's allotment under the Alaska Native Claims Settlement Act (Brehmer 2015). As a result, Spruce Grouse habitat may undergo greater deforestation and road pressures on these privatized lands than other areas of the forest. Future conservation of this subspecies may therefore include cooperation between the corporate landowner, federal agencies, and scientists.

MAPPING METHODS

For Prince of Wales and the surrounding islands, Prince of Wales Spruce Grouse confirmed distribution is shown in based on documented sightings and museum specimens, as reported in the USFWS's species assessment (Kissling and Jahrsdoerfer 2010).

Elsewhere, this map uses the Bayesian network model from Suring (2014) to identify high-quality summer and winter habitat. Within this model, land cover (productive old forest) was most strongly associated with high-quality habitat, followed by high canopy closure (Suring 2014). The output maps form this report were georeferenced and manually digitized by Audubon.

Note that Suring (2014) and the USFWS assessment (Kissling and Jahrsdoerfer 2010) indicate Prince of Wales Spruce Grouse habitat in different areas. The Suring analysis is based on occurrence at the scale of 4th level basins, which assumes that Spruce Grouse may occur on Kupreanof, Etolin, and Wrangell Islands. The Kissling and Jahrsdoerfer (2010) data describe these areas as unconfirmed or potential distribution.

MAP DATA SOURCES

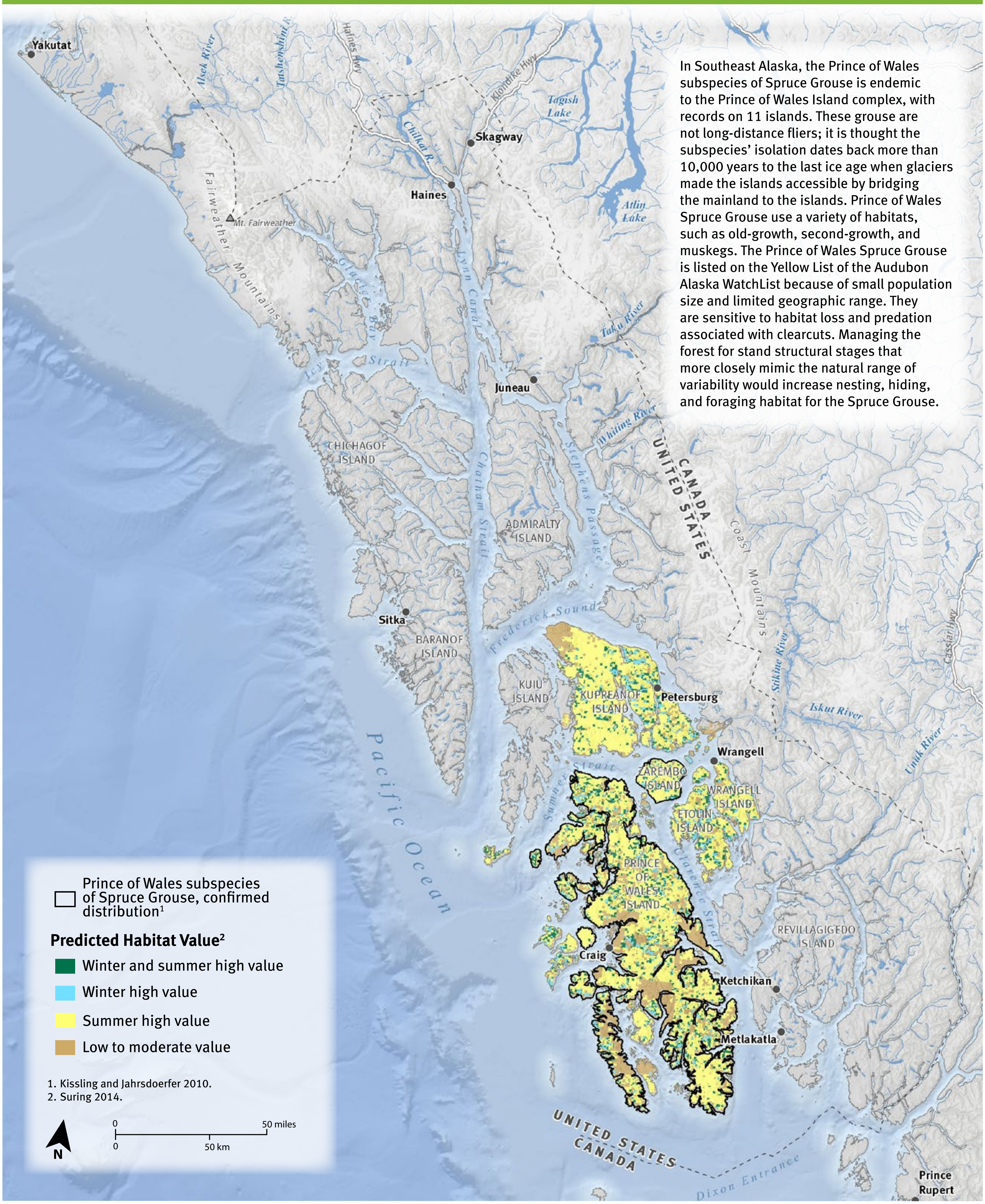
- Prince of Wales Spruce Grouse confirmed distribution: Kissling and Jahrsdoerfer (2010)
- Prince of Wales Spruce Grouse seasonal habitat quality: Suring (2014).

Nick Jans

Adult female Spruce Grouse on Prince of Wales Island.

Prince of Wales Spruce Grouse

In Southeast Alaska, the Prince of Wales subspecies of Spruce Grouse is endemic to the Prince of Wales Island complex, with records on 11 islands. These grouse are not long-distance fliers; it is thought the subspecies' isolation dates back more than 10,000 years to the last ice age when glaciers made the islands accessible by bridging the mainland to the islands. Prince of Wales Spruce Grouse use a variety of habitats, such as old-growth, second-growth, and muskegs. The Prince of Wales Spruce Grouse is listed on the Yellow List of the Audubon Alaska WatchList because of small population size and limited geographic range. They are sensitive to habitat loss and predation associated with clearcuts. Managing the forest for stand structural stages that more closely mimic the natural range of variability would increase nesting, hiding, and foraging habitat for the Spruce Grouse.



Map 5.7: Prince of Wales Spruce Grouse

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QUEEN CHARLOTTE GOSHAWK

Paul Cotter and Melanie Smith

The Northern Goshawk (*Accipiter gentilis*) is a short-winged, highly maneuverable hawk of the accipiter group inhabiting boreal and mountain forests of North America, Europe, and northern Russia. Some goshawks migrate; some are resident; and others are probably nomadic, moving more in years of low prey. The breeding and winter ranges of the goshawk overlap extensively. Short wings and a long tail make the goshawk very maneuverable and well-suited for navigating through its most common habitat of old-growth forest, where it often crashes through dense brush to capture birds and small mammals. In Southeast, the primary diet of the goshawk includes grouse, ptarmigan (*Lagopus spp.*), red squirrels (*Tamiasciurus hudsonicus*), songbirds, jays, and Northwestern Crows (*Corvus caurinus*) (Lewis et al. 2006).

The Queen Charlotte Goshawk (*A. g. laingi*), the subspecies most commonly found in Southeast Alaska, is endemic to coastal rainforests from Vancouver Island to northern Southeast (Iverson et al. 1996a, Squires and Reynolds 1997), where it is a year-round resident and an integral part of the biodiversity and natural heritage of the Tongass National Forest. The importance of the Tongass to the Queen Charlotte Goshawk becomes apparent when one considers the amount of suitable habitat found in insular (i.e., island) British Columbian forests. Generally, insular British Columbia forests have been converted to early seral stages (i.e., younger forests) more rapidly, and to a greater extent, than the old-growth forests of the Tongass (US Fish and Wildlife Service 2007). Because the species is associated with old-growth coniferous forests for nesting and hunting, the goshawk is particularly vulnerable to widespread conversion of old-growth habitats to clearcuts and younger-aged successional forests (Iverson et al. 1996a, Flatten et al. 2001, US Fish and Wildlife Service 2007, Smith 2013). A persistent goshawk population in the Tongass could serve as an indicator of old-growth forest health.

A precise quantitative population estimate for Southeast Alaska's goshawks does not yet exist. Northern Goshawks are found in low density across the Tongass from Dixon Entrance to Yakutat (Isleib and Kessel 1973, Titus et al. 1994, Iverson et al. 1996a). The most recent estimate of Queen Charlotte Goshawk abundance across their range is 300 to 700 breeding pairs (US Fish and Wildlife Service 2007), plus an unknown number of juvenile and non-breeding birds (Crocker-Bedford 1994). USFWS (2007) estimated that habitat quality has declined by 23% range-wide, and that Southeast Alaska currently holds 61% of the existing habitat value.

The 2014 USFS Northern Goshawk occurrence dataset includes locations where goshawks have been known to nest on the Tongass. Based on researchers' best judgement of which alternate nest clusters are (or were) used by the same mating pair, the dataset indicates 83 known active or inactive territories during the last 25 years. This dataset is known to be incomplete because surveyors typically discover goshawk nests during surveys when planning for timber sales, or as a follow up to an anecdotal hawk or nest sighting, thus leaving some areas of the Tongass completely uninventoried.

Northern Goshawks in Southeast have garnered the attention of government agencies, conservation organizations, and the environmental community nationwide. Kirchhoff and Padula (2010) include the Queen Charlotte subspecies on the Audubon Alaska WatchList because of its limited distribution and potential threats posed by commercial timber harvesting in breeding and nonbreeding seasons. It is a "species of greatest conservation need" in the State of Alaska's Wildlife Action Plan (Alaska Department of Fish and Game 2015a). The USFS considers the Queen Charlotte Goshawk a species of special management

Bob Armstrong

Northern Goshawk nesting in old-growth forest in Southeast Alaska.

MAP ON PAGE 134

concern in the Tongass National Forest. This results from its year-round residency, the likelihood of its habitat being affected by land management activities, its negative response to habitat fragmentation, and its characteristic role as an ecological specialist (Iverson and Rene 1997).

In the mid-1990s, the conservation status of the Queen Charlotte Goshawk was the focus of much public and legal debate. The issue centered on the vulnerability of this goshawk to large-scale timber harvesting because of its association with mature and old-growth forests across much of its range. In the mid-1990s, the USFWS was petitioned to list the Queen Charlotte goshawk as endangered. The USFWS determination that listing was not warranted was challenged in court. In 2007, after a number of years of litigation, the USFWS determined that the Alaska and British Columbia portions of the Queen Charlotte goshawk population are distinct population segments. The USFWS also determined that listing was not warranted for the Alaska population, but that listing was warranted for the British Columbia population. In 2012, the USFWS published a final rule listing the British Columbia population of goshawks as threatened (US Fish and Wildlife Service 2012). In 2000, and reaffirmed in 2013, the Canadian government listed the Queen Charlotte goshawk as threatened because of continued logging of low-elevation, old-growth coniferous forests within its range and likely population declines (COSEWIC 2013).

According to the USFS, goshawks in Southeast require mature nest trees, typically in productive old-growth forests below 1,000 ft (305 m) elevation, and large use areas (9,000 to 48,000 acres [4,050 to 12,150 ha]) of mixed habitats (Iverson et al. 1996a). Goshawks in the Tongass use large tracts of land during the entire year (Iverson et al. 1996a, Flatten et al. 2001). A nesting area, defined as the area that includes all nest sites and alternative nest sites used by a pair or an individual within its breeding home range, can be as large as 1,987 acres (804 ha) (Titus and Lewis 2000). Nesting plots generally have more hemlock, higher canopy closure, and more multistory canopy structure than randomly selected plots of old-growth forest (Iverson et al. 1996a). Smith (2013) found that goshawks prefer medium- and large-tree old growth for nest areas in Southeast Alaska. Stick and bark nests are usually placed near the trunk on large conifer limbs, low in the forest canopy. Nest size depends on the number of years in use, but in Southeast Alaska is usually about 3 ft (0.9 m) in diameter (Squires and Reynolds 1997).

Goshawks select old-growth forest habitats over younger forests and nonforested areas (Smith 2013). Movement tracking (i.e. relocations) of radio-telemetered goshawks show higher frequency of occurrence in old-growth forests with high volume and medium volume than in any other habitat type. Selection for habitats did not occur in mature sawtimber, scrub forest, forests with small-tree old-growth, nonforest, or clearcut habitats. Goshawks also use riparian and beach-fringe habitats at a higher rate compared to the availability of those habitats (Iverson et al. 1996a).

CONSERVATION ISSUES

Currently, the USFS lists the goshawk as a species of special management concern in the Tongass National Forest. Extensive logging throughout coastal British Columbia has likely contributed to the diminished number of goshawks found in the Tongass (US Fish and Wildlife Service 2007). Similar trends may also be seen in some portions of the Tongass where timber harvest has significantly reduced the abundance and distribution of productive stands of old-growth forest (Lewis et al. 2004). Habitat loss in the goshawk's already limited range (coastal British Columbia and Southeast Alaska) has increased the difficulty of maintaining abundant, well-distributed populations of Queen Charlotte Goshawks in northern coastal rainforests. The ability of goshawk populations to survive and reproduce is closely tied to the maintenance of large, undisturbed tracts of productive (large-tree) old-growth forest throughout the Tongass National Forest (Smith 2013).

The goshawk's use of large areas of the forest during the entire year makes it a landscape species. Currently, a 100-acre (40-ha) buffer around known goshawk nests is required under the Tongass Land Management Plan (TLMP) (US Forest Service 1997). Unfortunately, this policy does not adequately protect goshawks in the Tongass for two main reasons. First, unless radio telemetry is used, it is unlikely that most goshawk nests will be located. Failure to locate nests makes it impossible to accurately define a buffer centered on a nest. Second, nesting areas can be nearly 2,000 acres (800 ha) in size (Iverson et al. 1996a, Flatten et al. 2001), much bigger than buffer zones presently specified in the TLMP. Therefore, if protecting nesting areas is the primary approach to goshawk conservation, larger nesting area buffers are needed, as concluded by Flatten et al. (2001). Rather than using a nest-by-nest conservation approach, the 1997 TLMP also included old-growth reserves and wildlife standards and guidelines.

In Southeast, the loss of old-growth forest habitat is the primary threat to goshawk populations (Iverson et al. 1996a, Iverson and Rene 1997, Flatten et al. 2001). Clearcut logging removes the most valuable habitat and replaces it with habitat types avoided by goshawks (Smith 2013). Clearcutting of old-growth forest stands likely affects goshawk use of those areas for at least 100 years (Iverson et al. 1996a). Widespread logging may also have indirect effects by diminishing prey habitats and populations (Iverson et al. 1996a, Smith 2013). Thrushes, grouse, and squirrels (common forest inhabitants that may be affected by timber harvesting) contribute up to 60% of prey during the goshawk breeding season (Lewis et al. 2004). Although goshawks are considered generalist predators and possess some adaptability to fluctuations in their prey base, large-scale habitat disturbance may diminish breeding success through changes in prey availability (Lewis et al. 2004).

Timber harvest is a primary threat to nesting populations. Goshawks prefer closed canopy forests, and harvest that reduces canopies below 40% may be especially detrimental (Squires and Reynolds 1997). The Tongass National Forest may contribute only half or less of the secure habitat recommended for breeding pairs, indicating that old-growth reserves and buffers alone are not enough to sustain a viable population. Project planning in land use designations (LUDs) that allow development should consider goshawk habitat effects to increase the long-term security of choice habitats, especially in areas most heavily logged such as North Prince of Wales Island (Smith 2013). Forest management practices that maintain the most old-growth forest, especially large-tree and medium-tree old-growth stands, will provide the most direct and indirect benefits to Tongass goshawks (Smith 2013).

MAPPING METHODS

The map shows the presumed breeding range of the Queen Charlotte Goshawk. This dataset was developed by the Committee on the Status of Endangered Wildlife in Canada for their assessment and status report on the goshawk (COSEWIC 2013).

This map also shows the median centers for known Northern Goshawk territories, based on analysis of alternate nest sites coded by territory name, provided by the USFS. Note that the territory locations presented are known to be incomplete due to unequal survey effort across the region.

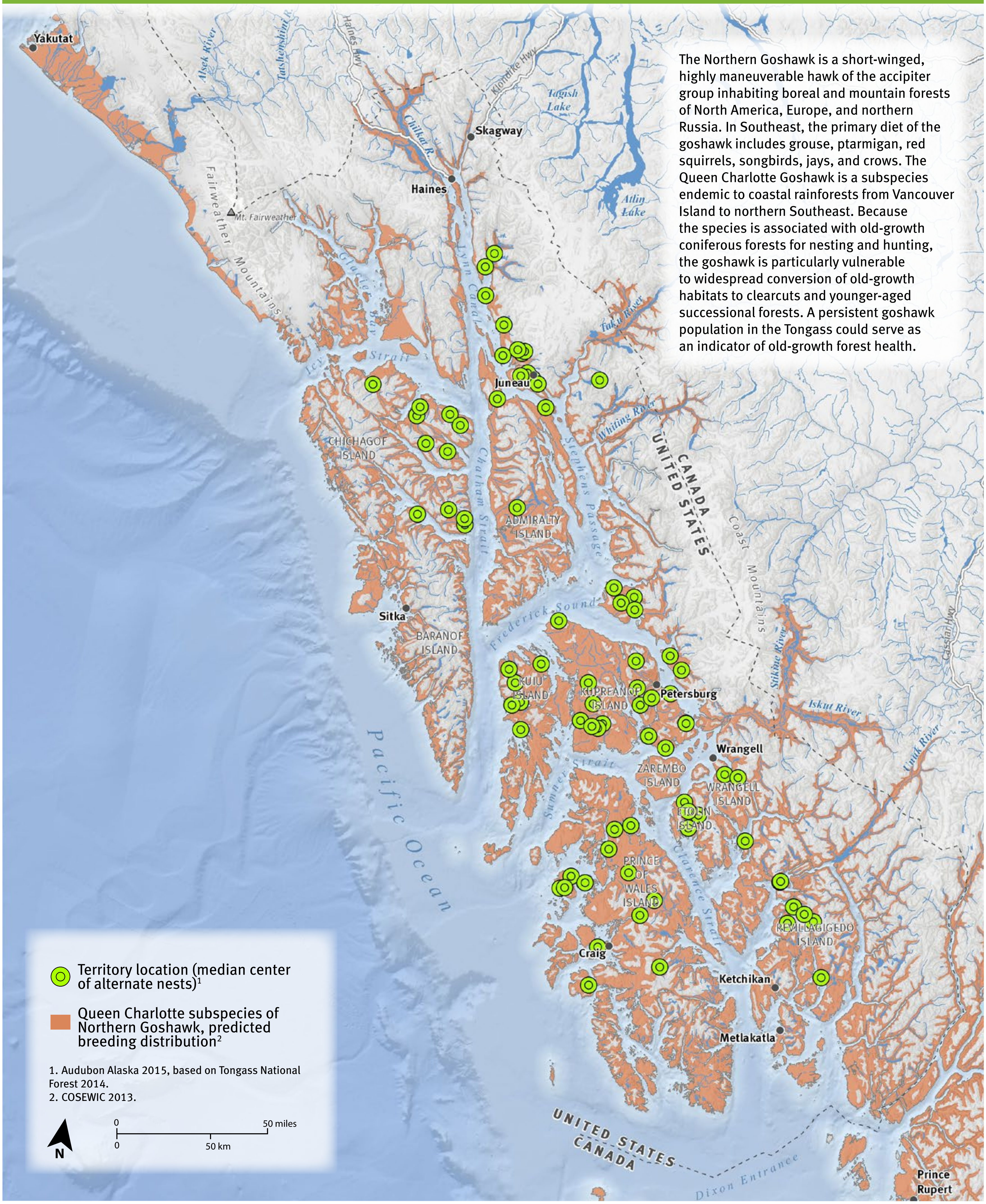
MAP DATA SOURCES

- Median territory locations: Audubon Alaska (2015), based on Tongass National Forest (2014).
- Goshawk predicted breeding distribution: COSEWIC (2013).

Queen Charlotte Goshawk

Audubon ALASKA

The Northern Goshawk is a short-winged, highly maneuverable hawk of the accipiter group inhabiting boreal and mountain forests of North America, Europe, and northern Russia. In Southeast, the primary diet of the goshawk includes grouse, ptarmigan, red squirrels, songbirds, jays, and crows. The Queen Charlotte Goshawk is a subspecies endemic to coastal rainforests from Vancouver Island to northern Southeast. Because the species is associated with old-growth coniferous forests for nesting and hunting, the goshawk is particularly vulnerable to widespread conversion of old-growth habitats to clearcuts and younger-aged successional forests. A persistent goshawk population in the Tongass could serve as an indicator of old-growth forest health.



Map 5.8: Queen Charlotte Goshawk

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BALD EAGLE

Iain Stenhouse
Revised by Kathy Wells

The Bald Eagle (*Haliaeetus leucocephalus*) is the second largest raptor in North America with a wingspan of about 7 ft (2 m), second in size only to the California Condor (*Gymnogyps californianus*). The species is found nowhere else in the world. Adult Bald Eagles weigh 8 to 14 pounds (3.6 to 6.4 kilograms); female eagles are larger and heavier than males. Powerful fliers, they can reach speeds of more than 35 mph (56 kph) during level flight and between 75 to 99 mph (121 to 159 kph) in a hunting dive. Their favorite food is fish, but they also eat carrion, other birds, ducks, and small mammals such as muskrats. They are notorious for stealing fish from Ospreys (*Pandion haliaetus*).

For most Americans, Bald Eagles are highly prized for their aesthetic value, but the species was not always so esteemed. In Alaska, a bounty was offered for much of the first half of the 1900s to reduce eagles because they were considered an unwelcome predator of salmon. Records show that approximately 80% of the Bald Eagles for which bounties were paid came from Southeast Alaska, estimated at 128,000 individuals (Robards and King 1966). The bounty system was eventually eliminated by federal legislation to protect Bald Eagles in 1952 (Robards and King 1966). Despite considerable persecution during the first half of the 20th century, Alaska, particularly Southeast, has remained a stronghold for the Bald Eagle (US Fish and Wildlife Service 2001). The favorable conditions in Alaska are largely due to (1) the remote nature of most of the state; (2) a bountiful supply of salmon and other fish that makes up a major food source for the eagles; and (3) the extent of relatively undisturbed breeding and wintering habitat (Sidle and Suring 1986).

Bald Eagle populations across the entire United States suffered drastically from persecution, pollution (particularly from the pesticide DDT), and habitat loss in the mid- to late- 1900s (Buehler 2000). Populations of the species have rebounded since then, and have generally increased throughout much of North America since the 1980s. At that time, Alaska had the highest breeding density on record for Bald Eagles in North America (Hodges and Robards 1982), and individuals from Alaska were transplanted to various areas of the contiguous United States in reintroduction projects (Nye 1986).

Southeast Alaska supports the largest breeding population of Bald Eagles in North America (Jacobson and Hodges 1999), with the majority of breeding birds remaining resident year-round. Bald Eagles have been systematically surveyed in Southeast, first in 1967, again in 1977, then about every 5 years since 1982 (US Fish and Wildlife Service 2001). These surveys, conducted by USFWS, indicate that the Bald Eagle population in Southeast has increased considerably during the time of the study, but appears to have stabilized at around 25,000 individuals (Jacobson and Hodges 1999). The most recent wintering population estimate for Bald Eagles is 44,000, which in turn is almost half of the estimated global population of 100,000 individuals (Buehler 2000).

The abundance of Bald Eagles in Southeast varies dramatically between habitat types. Clusters of islands or broken shorelines show higher densities than continuous shorelines, and the lowest densities are found along steep, unforested fiords that terminate in glaciers (King et al. 1972). Considerably lower densities are observed on islands south of Sumner Strait than more optimal island habitats, such as on Admiralty Island (King et al. 1972).

The breeding Bald Eagle population is locally dense but widely distributed across coastal Southeast (Gabrielson and Lincoln 1959). At some times of the year the birds congregate, often in very large numbers, at specific locations where there is an abundance of food (Buehler 2000). The Chilkat Valley Bald Eagle Preserve, north of the city of Haines, supports the largest concentrations of Bald Eagles on record (more than 3,500 individuals at times). In fall, the birds are attracted by late ice-free conditions and a large late-spawning run of chum salmon (*Oncorhynchus keta*) (Hansen et al. 1984). In April each year, about 2,000 eagles congregate along the Stikine River Delta. This is the second-largest known concentration of Bald Eagles, and is the highest anywhere in spring. A second spring concentration of about 1,000 eagles occurs at Berner's Bay. All three of these areas are IBAs for the Bald Eagle.

Once an endangered species in the Lower 48 states, Bald Eagles are commonly observed throughout much of Southeast Alaska and the Tongass National Forest.

John Hyde

MAP ON PAGE 137

To support their large heavy nests, Bald Eagles require tall, live mature trees with stout supporting branches. Bald Eagles generally build their nests in trees close to shore, with the average distance of nests from water only 121 ft (37 m) (Robards and Hodges 1976).

Industrial forestry has multiple potential influences on Bald Eagles, including reducing nesting habitat and perch sites, affecting salmon spawning streams, and increasing disturbance (Buehler 2000). Bald Eagles are especially sensitive to disturbance early in the breeding season, and activities associated with resource extraction, development, and recreation can result in failed or abandoned nests (Fraser et al. 1985). According to an Interagency Agreement between the USFS and USFWS, the USFS will attempt to regulate human disturbance within identified Bald Eagle use areas of the Tongass National Forest. The Forest-wide Standards and Guidelines of the TLMP prohibit timber harvest within 330 ft (100 m) of a Bald Eagle nest tree. It is not known, however, whether this buffer is adequate to provide sufficient space to prevent disruption of breeding activities and maintain nesting densities (Gende et al. 1998). If small buffer stands are left isolated, they are subject to greater windthrow, reducing their effectiveness, and do not necessarily include alternative nest or perch trees (Hodges 1982).

The Bald Eagle was specifically protected in the United States under the Bald Eagle Protection Act of 1940, which prohibited killing, harassment, or possession of eagles or parts thereof. The State of Alaska was initially exempted from the Bald Eagle Protection Act, but was finally included in 1952, after studies showed that foraging by Bald Eagles did not affect salmon numbers (US Fish and Wildlife Service 1995).

In 1973, with the introduction of the Endangered Species Act, the USFWS designated the Bald Eagle as endangered in most of the contiguous United States (except in Washington, Oregon, Minnesota, Wisconsin, and Michigan, where it was considered threatened). In 1995, the agency down-listed the Bald Eagle to threatened across the contiguous United States. In 2007, the Bald Eagle was deemed recovered and delisted. In Alaska, however, Bald Eagles were never listed under the Endangered Species Act.

CONSERVATION ISSUES

Habitat loss and disturbance associated with human activities (such as proximity of clearcut logging to nests, roads, pesticide use, lead contamination likely left behind by hunters and anglers, and resource development) are widely recognized as the greatest threats to Bald Eagle populations and many other birds of prey (US Fish and Wildlife Service 2001).

Organochlorine pesticides and other environmental contaminants pose a threat to many bird species by thinning eggshells and harming reproduction. The Bald Eagle, as a predator and scavenger that forages at the top of the food chain, is particularly susceptible to the accumulation of these pollutants (Buehler 2000). Pesticides are not known to be a major problem in Alaskan Bald Eagles, however (Wiemeyer et al. 1972, Sprunt et al. 1973). Instead, heavy metals may represent a greater threat to eagles in Alaska (US Fish and Wildlife Service 2001). For example, lethal concentrations of lead have been found in dozens of Bald Eagle carcasses in Alaska, and sublethal doses of mercury are commonly found in tissue samples of Bald Eagles from Alaska (US Fish and Wildlife Service 2001).

Bald Eagles are long-lived birds with a relatively low reproductive potential, a strategy common to most large birds of prey (Newton 1977). The species' longevity creates a considerable population lag time, such that even a major decline in productivity would take some time to appear at the population level (US Fish and Wildlife Service 2001). Currently, it is not clear whether Bald Eagle productivity in Southeast is high enough to maintain current population numbers in the region. The removal of large, old-growth trees in Southeast, particularly near saltwater shores, has clearly reduced nesting opportunities for Bald Eagles in the region. Although, to date, there has been no attempt to quantify the degree of habitat loss, the proximity of clearcuts is known to adversely affect the density of Bald Eagle nesting throughout the Tongass National Forest (Gende et al. 1998).

The most common nest sites for Bald Eagles in Southeast Alaska are in large, old-growth spruce and hemlock trees adjacent to the shoreline. However, this eagle has chosen to nest in a cottonwood.

Larger buffer zones of 656 ft (200 m) around trees with Bald Eagle nests have been recommended for areas scheduled for logging (Corr 1974), and one study suggested that buffers of at least 984 ft (300 m) are required to maintain Bald Eagle nesting densities in Southeast (Gende et al. 1998). In other regions of the country, buffer zones of 1,312 to 2,624 ft (400 to 800 m) have been recommended to better protect Bald Eagle nests from disturbance (Gende et al. 1998). In 1997, the USFS adopted a regulation to maintain a 984-ft (300-m) fringe of "mostly undisturbed" forest around beach and estuary habitat in the Tongass National Forest (US Forest Service 1997). This measure, which was designed to provide habitat for a range of wildlife species and human uses, resulted in improved protection for Bald Eagle nest and perch sites.

Bald Eagles are the national emblem of the United States, and Southeast Alaska encompasses the largest breeding density of Bald Eagles in the nation and the world. Therefore, Southeast and the Tongass National Forest play a significant role in the conservation network for the Bald Eagle in North America.

MAPPING METHODS

Point data of Bald Eagle observations from the Alaska Bald Eagle Nest Atlas, a compilation of nest surveys between 1962 and 2006. This includes point data digitized from maps and coordinates on data cards from decades of surveys, mostly in Southeast and Southcentral Alaska (Schempf 2013).

The following are IBAs designated for Bald Eagles: Berners Bay, Stikine River Delta, and Chilkat Bald Eagle Preserve. Of these, Stikine River Delta is a global IBA, and the other two sites are state-level IBAs.

Based on an extensive survey of Southeast Alaska, the USFWS determined that Bald Eagle nests are typically associated with old-growth forests and close proximity to salt water (Hodges and Robards 1982). The average distance between nests and the nearest salt water was 120 ft (37 m), and 98% of nests were within 600 ft (183 m). These two buffers were combined with old-growth land cover types (US Forest Service 2008), creating most suitable (within 121 ft [37 m], old-growth), moderately suitable (within 600 ft [183 m], old-growth), and somewhat suitable (within 600 ft [183 m]) nesting habitats.

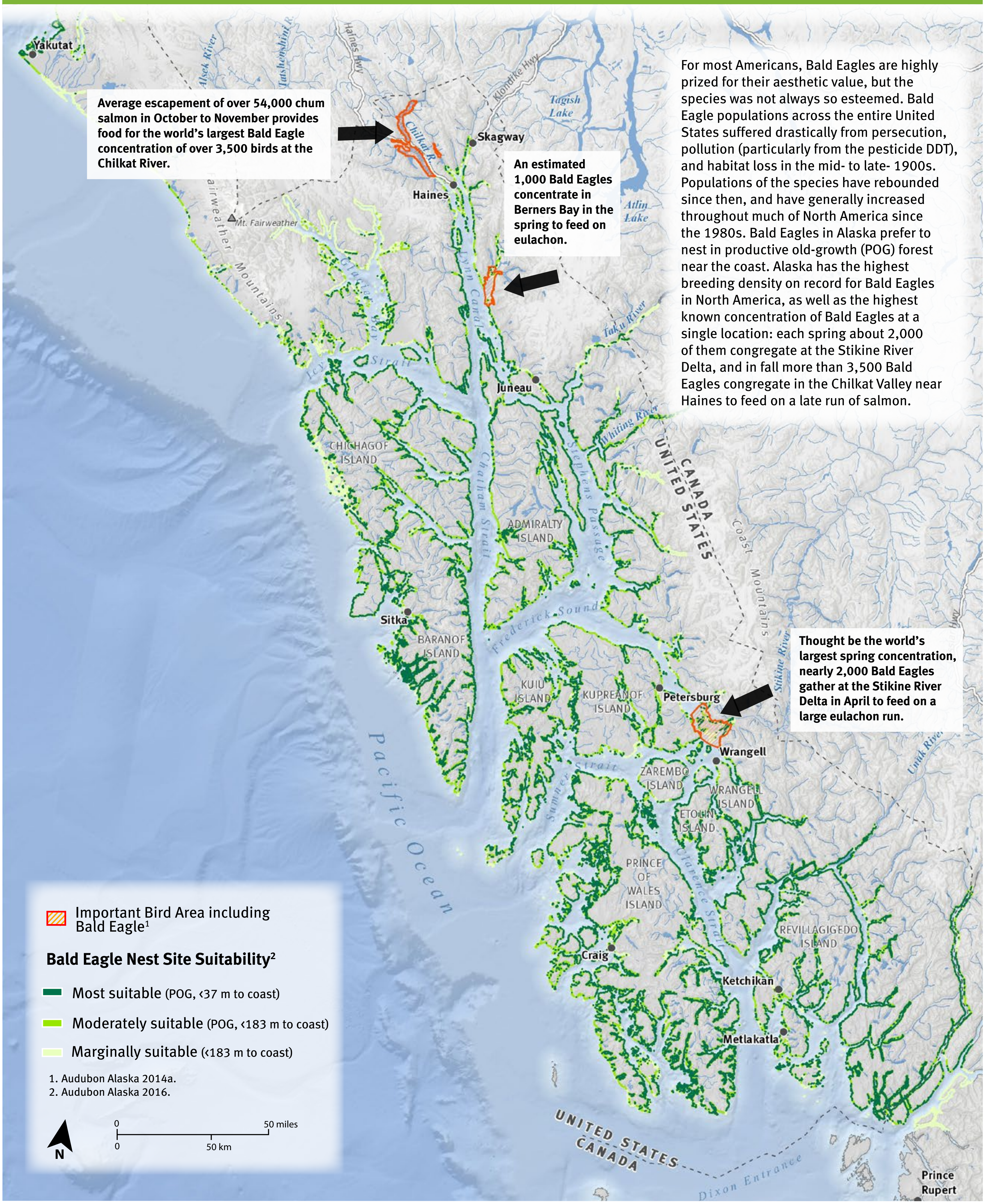
MAP DATA SOURCES

- Observation locations: Schempf (2013)
- Important Bird Area for Bald Eagles: Audubon Alaska (2014a)
- Nest site suitability: Audubon Alaska (2016).

Audubon ALASKA

Bald Eagle

For most Americans, Bald Eagles are highly prized for their aesthetic value, but the species was not always so esteemed. Bald Eagle populations across the entire United States suffered drastically from persecution, pollution (particularly from the pesticide DDT), and habitat loss in the mid- to late- 1900s. Populations of the species have rebounded since then, and have generally increased throughout much of North America since the 1980s. Bald Eagles in Alaska prefer to nest in productive old-growth (POG) forest near the coast. Alaska has the highest breeding density on record for Bald Eagles in North America, as well as the highest known concentration of Bald Eagles at a single location: each spring about 2,000 of them congregate at the Stikine River Delta, and in fall more than 3,500 Bald Eagles congregate in the Chilkat Valley near Haines to feed on a late run of salmon.



Map 5.9: Bald Eagle

REFERENCES

Agler, B. A., S. J. Kendall, and D. B. Irons. 1998. Abundance and distribution of Marbled and Kittlitz's murrelets in Southcentral and Southeast. *The Condor* 100:254-265.

Ainley, D. G., D. N. Nettleship, H. R. Carter, and A. E. Storey. 2002. Common Murre (*Uria aalge*), In *The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, New York. Accessed online at http://bna.birds.cornell.edu/bna/species/666.

Alaska Department of Fish and Game. 2015a. 2015 Alaska Wildlife Action Plan. ADFG Division of Wildlife Conservation, Juneau, AK.

______. 2015b. Sitka Wildlife Viewing: St. Lazaria Island. Accessed online 23 Jan at http://www.adfg.alaska.gov/index.cfm?adfg=southeastviewing.sitkasaintlazariaisland.

Alaska Department of Fish and Game Habitat and Restoration Division. 2001. Oil Spill Contingency Planning: Most Environmentally Sensitive Areas (MESA) Along the Coast of Alaska, Volume I. ADFG, Anchorage, AK.

Alaska Shorebird Group. 2008. Alaska Shorebird Conservation Plan, Version II. Alaska Shorebird Group, Anchorage, AK.

Albert, D. M. and J. W. Schoen. 2007. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Andres, B. A. and B. T. Browne. 1998. Spring migration of shorebirds on the Yakutat Forelands, Alaska. *The Wilson Bulletin*:326-331.

Arimitsu, M. L., J. F. Piatt, M. A. Litzow, A. A. Abookire, M. D. Romano, and M. D. Robards. 2008. Distribution and spawning dynamics of capelin (*Mallotus villosus*) in Glacier Bay, Alaska: A cold water refugium. *Fisheries Oceanography* 17:137-146.

Armstrong, R. 2015. *Guide to the Birds of Alaska, 6th Edition*. Alaska Northwest Books, Portland, OR.

Armstrong, R., R. Carstensen, M. Willson, and M. Osborn. 2009. The Mendenhall wetlands: A globally recognized Important Bird Area.

Armstrong, R. and M. Hermans. Undated-a. Frequent fliers visit Southeast, In *Southeast Alaska's Natural World*. Juneau, AK.

______. Undated-b. The shorebirds are coming!, In *Southeast Alaska's Natural World*. Juneau, AK.

Artukhin, Y., P. Vyatkin, A. Andreev, N. Konyukhov, and T. I. Van Pelt. 2011. Status of the Kittlitz's Murrelet *Brachyramphus brevirostris* in Russia. *Marine Ornithology* 39:23-33.

Audubon Alaska. 2014a. Important Bird Areas of Alaska, v3. Audubon Alaska, Anchorage, AK. Accessed online at http://databasin.org/datasets/f9e442345fb54ae28cf72f249d2c23a9.

______. 2014b. Single Species Core Areas (Basis for Identifying Important Bird Areas). Audubon Alaska, Anchorage, AK.

______. 2014c. Summary of AKGAP Predicted Species Ranges by Watershed. Audubon Alaska, Anchorage, AK.

______. 2015. Analysis of Median Central Location of Known Northern Goshawk Territories. Audubon Alaska, Anchorage, AK.

______. 2016. Bald Eagle Nest Site Suitability. Audubon Alaska, Anchorage, AK.

Baluss, G. 2015a. Report of Waterbird Mapping in Tracy Arm-Ford's Terror Wilderness Area. USFS Tongass National Forest, Juneau, AK.

______. 2015b. Yakutat Bird Checklist. Juneau Audubon Society, Juneau, AK.

Barbaree, B. A., S. K. Nelson, B. D. Dugger, D. D. Roby, H. R. Carter, D. L. Whitworth, and S. H. Newman. 2014. Nesting ecology of Marbled Murrelets at a remote mainland fjord in Southeast Alaska. *The Condor* 116:173-184.

Barry, P. and D. Tallmon. 2010. Genetic differentiation of a subspecies of spruce grouse (*Falcipennis canadensis*) in an endemism hotspot. *The Auk* 127:617-625.

Bertsch, D. Undated. Birds of the Chilkat Valley: A Checklist. Haines Visitor Bureau, Haines, AK.

Bird Studies Canada and Nature Canada. 2004-2012. Important Bird Areas of Canada Database. Bird Studies Canada, Port Rowan, Ontario. Accessed online at http://www.ibacanada.ca/explore_how.jsp?lang=en.

BirdLife International. 2012a. *Brachyramphus marmoratus.* The IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources, Cambridge, UK. Accessed online at http://www.iucnredlist.org/details/22694870/0.

______. 2012b. Important Bird Areas (IBAs). BirdLife International, Cambridge, UK. Accessed online 28 Aug at http://www.birdlife.org/action/science/sites.

______. 2014. *Brachyramphus brevirostris.* The IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources, Cambridge, UK. Accessed online at http://www.iucnredlist.org/details/22694875/0.

Boag, D. A. and M. A. Schroeder. 1992. Spruce Grouse *(Falcipennis canadensis)*, In *The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, NY. Accessed online at http://bna.birds.cornell.edu/bna/species/005.

Bradley, R. W. 2002. Breeding Ecology of Radio-marked Marbled Murrelets (*Brachyramphus marmoratus*) in Desolation Sound. MSc thesis, Simon Fraser University.

Brehmer, E. 2015. Long-awaited Sealaska land transfer completed. Alaska Journal of Commerce.

Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*), *In The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, NY. Accessed online at http://bna.birds.cornell.edu/bna/species/506.

Burger, A. E. 2004. Marbled Murrelet (*Brachyramphus marmoratus*), In *Accounts and Measures for Managing Identified Wildlife*. Ministry of Environment ed. Ministry of Environment, Victoria, BC, Canada.

Butcher, G. S., D. K. Niven, A. O. Panjabi, D. N. Pashley, and K. V. Rosenberg. 2007. WatchList. National Audubon Society, New York, NY.

Carter, H. R., M. L. McAllister, and M. Isleib. 1995. Mortality of Marbled Murrelets in gill nets in North America, In *Ecology and conservation of the Marbled Murrelet, General Technical Report (GTR)*. C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt eds. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA.

Corr, P. O. 1974. Bald eagle (*Haliaeetus leucocephalus alaskanus*) nesting related to forestry in southeastern Alaska. PhD thesis, University of Alaska Fairbanks.

COSEWIC. 2013. Assessment and Status Report on the Northern Goshawk *Accipiter gentilis laingi* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.

Crocker-Bedford, D. 1994. Conservation of the Queen Charlotte Goshawk in Southeast Alaska, In *A Proposed Strategy for Maintaining Well-distributed, Viable Populations of Wildlife Associated with Old-growth Forests in Southeast Alaska*. The Interagency Viable Population Committee for Tongass Land Management Planning, Ketchikan, AK.

Day, R. H. 2011. Evaluating Population Trends of Kittlitz's Murrelets in Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Day, R. H., K. J. Kuletz, and D. A. Nigro. 1999. Kittlitz's Murrelet *(Brachyramphus brevirostris)*, In *The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, NY. Accessed online at http://bna.birds.cornell.edu/bna/species/435.

DeGange, A. R. 1996. A Conservation Assessment for the Marbled Murrelet in Southeast Alaska. USDA Pacific Northwest Research Station, Portland, OR.

Denlinger, L. M. 2006. Alaska Seabird Information Series. US Fish and Wildlife Service, Migratory Bird Management, Nongame Program, Anchorage, AK. Accessed online at http://alaska.fws.gov/mbsp/mbm/seabirds/species.htm.

Dickerman, R. and J. Gustafson. 1996. The Prince of Wales spruce grouse: A new subspecies from southeastern Alaska. *Western Birds* 27:41-47.

Drew, G. F. and J. Piatt. 2013. North Pacific Pelagic Seabird Database (NPPSD) v2. US Geological Survey Alaska Science Center & US Fish and Wildlife Service, Anchorage, AK.

eBird. 2015. eBird: An Online Database of Bird Distribution and Abundance. eBird, Ithaca, NY. Accessed online at http://www.ebird.org.

Etherington, L. L., P. N. Hooge, E. R. Hooge, and D. F. Hill. 2007. Oceanography of Glacier Bay, Alaska: implications for biological patterns in a glacial fjord estuary. *Estuaries and Coasts* 30:927-944.

Ewins, P. J. 1993. Pigeon Guillemot (*Cepphus columba*), In *The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, New York. Accessed online at http://bna.birds.cornell.edu/bna/species/049.

Fair, J. 2014. A journey to Alaska's Tongass, where our last old-growth temperate forest meets the sea. *Audubon* 116.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S. Nelson, S. Pearson, M. Raphael, C. Strong, and R. Young. 2014. Marbled Murrelet Effectiveness Monitoring, Northwest Forest Plan: 2013 Summary Report.

Flatten, C., K. Titus, and R. Lowell. 2001. Northern Goshawk monitoring, population ecology and diet on the Tongass National Forest. Alaska Department of Fish and Game, Anchorage, AK.

Fraser, J. D., L. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in north-cental Minnesota. *The Journal of Wildlife Management* 49:585-592.

Gabrielson, I. N. and F. C. Lincoln. 1959. *The Birds of Alaska*. Stackpole Company and Wildlife Management Institute, Mechanicsville, PA and Washington, DC.

Gaston, A. J. 2004. *Seabirds: A Natural History*. Yale University Press, New Haven, CT.

Gende, S. M., M. F. Willson, B. H. Marston, M. Jacobson, and W. P. Smith. 1998. Bald eagle nesting density and success in relation to distance from clearcut logging in Southeast Alaska. *Biological Conservation* 83:121-126.

Gibson, D. D., L. DeCicco, R. Gill Jr, S. Heinl, A. Lang, T. Tobish Jr, and J. Withrow. 2015. Checklist of Alaska Birds 21st Edition. University of Alaska Museum, Fairbanks, AK.

Gotthardt, T., S. Pyare, F. Huettmann, K. Walton, M. Spathelf, K. Nesvacil, A. Baltensperger, G. Humphries, and T. Fields. 2013. Predicting the Range and Distribution of Terrestrial Vertebrate Species in Alaska, Report and Model Atlas. University of Alaska, Alaska Natural Heritage Program, Anchorage, AK.

Hamer, T. E. and S. K. Nelson. 1995. Characteristics of marbled murrelet nest trees and nesting stands. PSW-GTR-152:152. Albany, CA.

Hansen, A. J., E. L. Boeker, J. I. Hodges, and D. R. Cline. 1984. Bald Eagles of the Chilkat Valley, Alaska: Ecology, Behavior and Management. National Audubon Society, Anchorage, AK.

Heinl, S. 2010. Birds of Southeast Alaska: An Annotated List from Icy Bay South to Dixon Entrance. Alaska Geographic, Anchorage, AK.

Hodges, J., D. Groves, and B. P. Conant. 2002. Distribution and Abundance of Waterbirds Near Shore in Southeast Alaska, 1997-2002. US Fish and Wildlife Service, Juneau, AK.

Hodges, J. and F. Robards. 1982. Observations of 3,850 bald eagle nests in Southeast Alaska. In Symposium on Raptor Management and Biology in Alaska and Western Canada. US Fish and Wildlife Service, Anchorage, AK.

Hodges, J. I. 1982. Evaluation of the 100 meter protective zone for Bald Eagle nests in Southeast Alaska. US Fish and Wildlife Service, Raptor Management Studies, Juneau, AK.

Hodges, J. I. and M. D. Kirchhoff. 2012. Kittlitz's Murrelet *Brachyramphus brevirostris* population trend in Prince William Sound, Alaska: Implications of species misidentification. *Marine Ornithology* 40:117-120.

Hood, E., J. Fellman, R. G. Spencer, P. J. Hernes, R. Edwards, D. D'Amore, and D. Scott. 2009. Glaciers as a source of ancient and labile organic matter to the marine environment. *Nature* 462:1044-1047.

Hood, E. and D. Scott. 2008. Riverine organic matter and nutrients in Southeast Alaska affected by glacial coverage. *Nature Geoscience* 1:583-587.

Isleib, M. and B. Kessel. 1973. Birds of the North Gulf Coast-Prince William Sound Region, Alaska. University of Alaska. Institute of Arctic Biology, Fairbanks, AK.

Iverson, G. and B. Rene. 1997. Conceptual approaches for maintaining well-distributed, viable wildlife populations: a resource asssessment, In *Assessments of Wildlife Viability, Old-Growth Timber Volume Estimates, Forested Wetlands, and Slope Stability*. K. R. Julin ed. USDA Pacfic Northwest Research Station, Portland, OR.

Iverson, G. and P. Walsh. 1994. Avian use of the Stikine River Delta during spring, 1990-1992. Unpublished data. USDA Forest Service, Petersburg, AK.

Iverson, G. C., G. Hayward, K. Titus, E. DeGayner, R. Lowell, D. Crocker-Bedford, P. Schempf, and J. Lindell. 1996a. Conservation Assessment for the Northern Goshawk in Southeast Alaska. USDA Forest Service. General Technical Report PNW-GTR-387. Pacific Northwest Research Station, Juneau, AK.

Iverson, G. C., S. E. Warnock, R. W. Butler, M. A. Bishop, and N. Warnock. 1996b. Spring migration of western sandpipers along the Pacific coast of North America: A telemetry study. *The Condor*:10-21.

Jacobson, M. and J. Hodges. 1999. Population trend of adult bald eagles in Southeast Alaska, 1967-97. *Journal of Raptor Research* 33:295-298.

Johnson, J. A., B. A. Andres, and J. Bissonette. 2008. Birds of the Major Mainland Rivers of Southeast Alaska. General Technical Report PNW-GTR-739. USDA Forest Service Pacific Northwest Research Station, Portland, OR.

Juneau Audubon Society. 2007. Birds of Juneau, Alaska Checklist. Juneau Audubon Society, Juneau, AK.

Kessel, B. and D. D. Gibson. 1978. *Status and distribution of Alaska birds*. Cooper Ornithological Society.

King, J. G., F. C. Robards, and C. J. Lensink. 1972. Census of the bald eagle breeding population in Southeast Alaska. *The Journal of Wildlife Management*:1292-1295.

Kirchhoff, M. and V. Padula. 2010. Alaska WatchList: Highlighting Declining and Vulnerable Bird Species in Alaska. Audubon Alaska, Anchorage, AK.

Kirchhoff, M., M. Smith, and S. Wright. 2010. Abundance, population trend, and distribution of marbled murrelets and Kittlitz's murrelets in Glacier Bay National Park. Audubon Alaska, Anchorage, AK.

Kirchhoff, M. D. 2011. A review of selected surveys of the Kittlitz's Murrelet *Brachyramphus brevirostris* in Alaska: Lessons learned. *Marine Ornithology* 39:77-83.

Kirchhoff, M. D., J. R. Lindell, and J. I. Hodges. 2014. From critically endangered to least concern? A revised population trend for the Kittlitz's murrelet in Glacier Bay, Alaska. *The Condor* 116:24-34.

Kissling, M. and S. Jahrsdoerfer. 2010. Prince of Wales Spruce Grouse Species Assessment and Listing Priority Assignment Form. Region 7, Alaska.

Kissling, M. L., S. M. Gende, S. B. Lewis, and P. M. Lukacs. 2015. Reproductive performance of Kittlitz's murrelet in a glaciated landscape, Icy Bay, Alaska, USA. *The Condor* 117:237-248.

Kissling, M. L., P. M. Lukacs, S. B. Lewis, S. M. Gende, K. J. Kuletz, N. R. Hatch, S. K. Schoen, and S. Oehlers. 2011. Distribution and abundance of the Kittlitz's murrelet *Brachyramphus brevirostris* in selected areas of southeastern Alaska. *Marine Ornithology* 39:3-11.

Kissling, M. L., R. Mason, P. M. Lukacs, S. M. Gende, and S. B. Lewis. 2007. Understanding abundance patterns of a declining seabird: Implications for monitoring. *Ecological Applications* 17:2164-2174.

Kuletz, K. J., C. S. Nations, B. Manly, A. Allyn, D. B. Irons, and A. McKnight. 2011. Distribution, abundance, and population trends of the Kittlitz's murrelet *Brachyramphus brevirostris* in Prince William Sound, Alaska. *Marine Ornithology* 39:97-109.

Lewis, S. B., M. R. Fuller, and K. Titus. 2004. A comparison of 3 methods for assessing raptor diet during the breeding season. *Wildlife Society Bulletin* 32:373-385.

Lewis, S. B., K. Titus, and M. R. Fuller. 2006. Northern goshawk diet during the nesting season in Southeast Alaska. *Journal of Wildlife Management* 70:1151-1160.

National Audubon Society. 2012. Important Bird Areas Program: A Global Currency for Bird Conservation. National Audubon Society, New York, NY. Accessed online 15 Jan at http://web4.audubon.org/bird/iba/index.html.

Nelson, A. 2010. Ecology of Prince of Wales Spruce Grouse. Master's thesis, University of Alaska Fairbanks.

Nelson, S. K. 1997. Marbled murrelet *(Brachyramphus marmoratus)*, *In Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, NY. Accessed online at http://bna.birds.cornell.edu/bna/species/276.

Nelson, S. K. and S. Newman. 2009. Marbled Murrelet Activity Patterns and Health at Port Snettisham, Alaska. Alaska Department of Fish and Game, Juneau, AK.

Newton, I. 1977. Breeding strategies in birds of prey, *In Living Bird, 16th Annual Conference.*

Norris, D. R., P. Arcese, D. Preikshot, D. F. Bertram, and T. K. Kyser. 2007. Diet reconstruction and historic population dynamics in a threatened seabird. *Journal of Applied Ecology* 44:875-884.

Nye, P. E. 1986. 1986 New York state bald eagle collection report. New York State Department of Environmental Conservation Delmar, NY.

Oehlers, S., N. Catterson, S. Pyare, and M. Goldstein. 2009. Aleutian terns: Declining population and the role of the Forest Service in Alaska. USFS Alaska Region, Juneau, AK.

Paige, B. and N. Drumheller. 2012. Glacier Bay Bird Checklist. Glacier Bay National Park and Preserve, Gustavus, AK.

Piatt, J., M. Arimitsu, G. Drew, E. Madison, J. Bodkin, and M. Romano. 2011. Status and Trend of the Kittlitz's murrelet *Brachyramphus brevirostris* in Glacier Bay, Alaska. *Marine Ornithology* 39:65-75.

Piatt, J. F. and A. S. Kitaysky. 2002. Tufted puffin (*Fratercula cirrhata*), In *The Birds of North America Online*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, New York. Accessed online at http://bna.birds.cornell.edu/bna/species/708.

Piatt, J. F., K. Kuletz, A. Burger, S. Hatch, V. Friesen, T. Birt, M. Arimitsu, G. Drew, A. Harding, and K. Bixler. 2007. Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia. US Geological Survey, Washington, DC.

Quinlan, S. E. and J. H. Hughes. 1990. Location and description of a marbled murrelet tree nest site in Alaska. *The Condor* 92:1068-1073.

Robards, F. C. and J. I. Hodges. 1976. Observations from 2,760 Bald Eagle Nests in Southeast Alaska: Progress Report, 1969-1976. Department of Interior, US Fish and Wildlife Service, Eagle Management Studies, Juneau, AK.

Robards, F. C. and J. G. King. 1966. Nesting and Productivity of Bald Eagles: Southeast Alaska, 1966. US Department of the Interior, Bureau of Sport Fisheries and Wildlife, Juneau, AK.

Schempf, P. 2013. Alaska Bald Eagle Nest Atlas. U.S. Fish and Wildlife Service: Migratory Bird Management, Accessed online 27 Feb 2014 at http://www.fws.gov/alaska/mbsp/mbm/landbirds/alaskabaldeagles/.

Sidle, W. B. and L. H. Suring. 1986. Wildlife and Fisheries Habitat Management Notes: Management Indicator Species for the National Forest Lands in Alaska. US Department of Agriculture, Forest Service, Alaska Region, Juneau, AK.

Skagway Bird Club. 2010. Skagway Bird Checklist. Juneau Audubon Society, Juneau, AK.

Smith, M., N. Walker, C. Free, M. Kirchhoff, N. Warnock, A. Weinstein, T. Distler, and I. Stenhouse. 2012. Marine Important Bird Areas in Alaska: Identifying Globally Significant Sites Using Colony and At-sea Survey Data. Audubon Alaska, Anchorage, Alaska.

Smith, M., N. J. Walker, I. J. Stenhouse, C. M. Free, M. Kirchhoff, O. Romanenko, S. Senner, N. Warnock, and V. Mendenhall. 2014a. A new map of Important Bird Areas in Alaska, *In 16th Alaska Bird Conference*. Juneau, AK.

Smith, M. A., N. J. Walker, C. M. Free, M. J. Kirchhoff, G. S. Drew, N. Warnock, and I. J. Stenhouse. 2014b. Identifying marine Important Bird Areas using at-sea survey data. *Biological Conservation* 172:180-189.

Smith, W. P. 2013. Spatially explicit analysis of contributions of a regional conservation strategy toward sustaining northern goshawk habitat. *Wildlife Society Bulletin* 37:649-658.

Sprunt, A., W. Robertson Jr, S. Postupalsky, R. Hensel, C. Knoder, and F. Ligas. 1973. Comparative Productivity of Six Bald Eagle Populations. National Audubon Society, New York, NY.

Squires, J. R. and R. T. Reynolds. 1997. Northern goshawk (*Accipiter gentilis*), In *The Birds of North America*. A. Poole ed. Cornell Lab of Ornithology, Ithaca, NY. Accessed online at http://bna.birds.cornell.edu/bna/species/298.

Suring, L. H. 2014. Describing Habitat Quality for Species of Conservation Concern in Southeast Alaska, USA. USDA Forest Service Alaska Region and Tongass National Forest, Juneau, AK.

Tessler, D. F., J. A. Johnson, B. A. Andres, S. Thomas, and R. Lanctot. 2010. Black Oystercatcher (*Haematopus bachmani*) Conservation Action Plan. International Black Oystercatcher Working Group, Alaska Department of Fish and Game, US Fish and Wildlife Service, Manomet Center for Conservation Sciences, Anchorage, AK.

Titus, K., C. Flatten, and R. E. Lowell. 1994. Northern Goshawk Ecology and Habitat Relationships on the Tongass National Forest. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Titus, K. and S. B. Lewis. 2000. Northern Goshawk Monitoring, Population Ecology and Diet on the Tongass National Forest. Alaska Department of Fish and Game, Juneau, AK.

Tongass National Forest. 2014. Northern Goshawk Nesting Locations from NRIS Database. Ketchikan, AK.

U.S. Fish and Wildlife Service. 2013. Alaska Maritime Wilderness. Accessed online 23 Jan 2015 at http://www.fws.gov/refuges/whm/alaskaMaritime.html.

US Fish and Wildlife Service. 1995. Endangered and threatened wildlife and plants: Final rule to reclassify the bald eagle from endangered to threatened in all of the Lower 48 states. 60:133. Washington, DC.

______. 2001. Management Plan for Alaska Raptors: A Plan Covering All Species of Diurnal and Nocturnal Raptors that Occur in Alaska. US Fish and Wildlife Service, Juneau, AK.

______. 2007. Queen Charlotte Goshawk Status Review. Alaska Regional Office, Juneau, AK.

______. 2012. Endangered and threatened wildlife and plants: Listing the British Columbia distinct population segment of the Queen Charlotte goshawk under the Endangered Species Act. 77:148. Federal Register, Washington, DC.

______. 2013. Endangered and threatened wildlife and plants: 12-month finding on a petition to list Kittlitz's murrelet threatened or endangered. 77:168. Federal Register, Washington, DC.

US Forest Service. 1997. Tongass Land and Resource Management Plan. US Forest Service, Juneau, AK.

US Forest Service. 2008. Tongass National Forest Land and Resource Management Plan. US Forest Service, Juneau, AK.

USDA Forest Service Alaska Region, National Audubon Society Juneau Chapter, and Alaska Department of Fish and Game. 1978. Birds of Southeast Alaska: A Checklist. USDA Forest Service, Juneau, AK.

Weeden, R. B. 1960. The birds of Chilkat Pass. *British Columbia. Canadian Field-Naturalist* 74:119-129.

Whitworth, D. L., S. K. Nelson, S. H. Newman, G. B. Van Vliet, and W. P. Smith. 2000. Foraging distances of radio-marked Marbled Murrelets from inland areas in Southeast Alaska. *The Condor* 102:452-456.

Wiemeyer, S. N., B. Mulhern, F. Ligas, R. J. Hensel, J. Mathisen, F. Robards, and S. Postupalsky. 1972. Residues of organochlorine pesticides, polychlorinated biphenyls, and mercury in bald eagle eggs and changes in shell thickness, 1969 and 1970. *Pesticides Monitoring Journal* 6:50-55.

World Seabird Union. 2011. Seabird Information Network: North Pacific Seabird Data Portal. World Seabird Union, www.seabirds.net. Accessed online at http://axiom.seabirds.net/portal.php.

Yakutat Tern Festival. 2011. Terns of Alaska. Yakutat, Alaska. Accessed online 16 Jan 2015 at http://www.yakutatternfestival.org/terns_of_alaska.htm.

Milo Burcham

MAMMALS

Southeast Alaska's naturally fragmented landscape, created by its steep mountains, island archipelago, and glacial history, have greatly influenced the distribution and speciation of mammals. At multiple times in recent history, from the lengthy Pleistocene Ice Age (1.6 million to 12,000 years ago) to the very recent Little Ice Age (500 to 150 years ago), glacial ice sheets have advanced and retreated, at times covering virtually all of what is Southeast Alaska today. The physical geography and geologic history explain much of today's heterogeneous species patterns. During the most recent glacial maximum (71,000 to 12,000 years ago), sea level was lower due to much of the world's freshwater being captured in continental ice sheets. Some pockets of land that were free of both ice and seawater became strongholds for wildlife during that time. As the ice receded, these "refugia" were centers from which species dispersed and recolonized newly open areas. Some species moved east from coastal refugia while others moved west into Southeast Alaska from interior areas that are part of British Columbia. Along the way, animals encountered natural barriers such as difficult topography and wide ocean passages, which shaped dispersal patterns and affected the ability to colonize new lands. Today, brown bears live on the northern islands of Admiralty, Baranof, and Chichagof (ABC) while black bears and wolves live on the southern islands. All three species inhabit the mainland. Deer occur in higher density on the islands, and in lower density on the mainland, but have yet to colonize Glacier Bay despite the presence of suitable habitat.

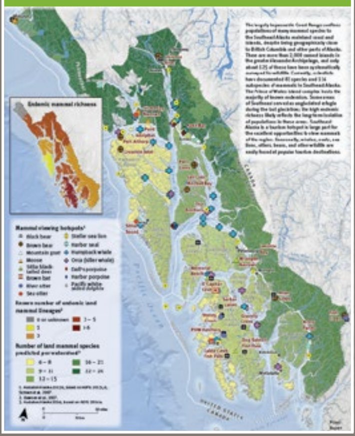
Importantly, the Alexander Archipelago is a center of endemism. The greatest number of known endemic mammal species live on Prince of Wales (POW) Island: species such as the POW flying squirrel, coastal marten, and Alexander Archipelago wolf. So far, scientists have documented 82 species and 116 subspecies of mammals, of which 24 occur only in Southeast Alaska. These mammals represent 63 genera, 28 families, and 8 orders; about 20% of the known mammal taxa are endemic (MacDonald and Cook 2007). We are likely only starting to uncover the genetic diversity that has evolved in the Alexander Archipelago. Remarkably, recent genetic studies revealed that the ABC island brown bears are descendants of polar bears that were stranded in the area during a major glacial period (550,000 to 700,000 years ago) and later hybridized with brown bears migrating from the mainland. This population represents an important component of the biodiversity of Southeast. Studies like this one continue to provide key information about the biogeographic history of this island ecosystem. Southeast Alaska, especially Glacier Bay, is a natural laboratory for studying the succession and dispersal of life following glacial retreat as plants, fish, birds, and mammals colonize new areas. Although less obvious on the human time scale, Southeast Alaska is a young landscape still breaking free from its recent glaciation. Species patterns are not yet settled and continue to evolve today.

~ Melanie Smith

David Shaw

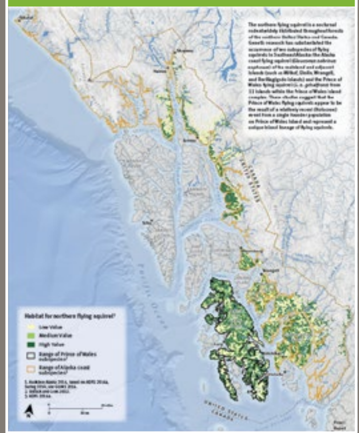
MAMMALS MAPS INDEX

Mammal Species Richness



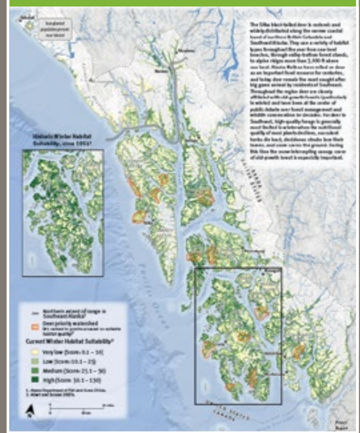
MAP 6.1 / PAGE 146

Northern Flying Squirrel



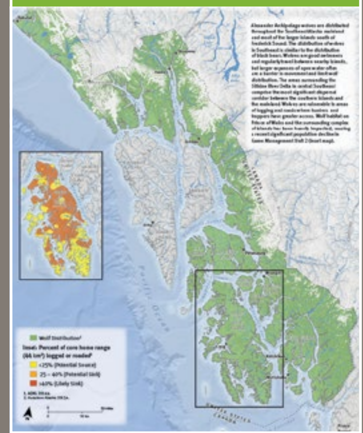
MAP 6.2 / PAGE 149

Sitka Black-tailed Deer



MAP 6.3 / PAGE 154

Alexander Archipelago Wolf



MAP 6.4 / PAGE 159

Brown Bear and Black Bear

MAP 6.5 / PAGE 167

MAP ON PAGE 146

MAMMAL SPECIES RICHNESS

Benjamin Sullender

The coastal temperate rainforests of Southeast Alaska harbor a wide variety of flora and fauna. The region's variable connectivity, both historic and current, has created striking patterns of species distribution across the landscape. Distribution patterns here are characterized in terms of richness (the number of species present in a given area) and endemism (the number of endemic species, or organisms indigeneous to a particular geographic location and occurring nowhere else).

Historically, parts of the Alexander Archipelago likely served as glacial refugia during the Wisconsin glaciation, about 20,000 years ago (Carrara et al. 2007). Sea levels were much lower at that time due to much of the world's fresh water being tied up in expansive ice caps, thus exposing parts of the continental shelf (refer to Figure 6-1). The southern tip of Baranof Island and the western sections of the Prince of Wales (POW) Island complex remained ice free and served as terrestrial habitat for continental species displaced by the expanding ice sheets (Carrara et al. 2007, Pauli et al. 2015). Long-standing populations in these refugia, coupled with sporadic re-colonization events and dispersal barriers such as steep topography, strong currents, and expanses of open water, have resulted in regionally high levels of endemism (Cook et al. 2006) and highly varied species richness (MacDonald and Cook 1996) across the archipelago. Within Southeast Alaska as a whole, the largely impassable Coast Range confines populations of many species to the mainland coast and isolated islands, despite being geographically close to British Columbia and other parts of Alaska.

Wildlife respond to the region's underlying geologic and geographic structure in patterns that emerge among biogeographic provinces. POW and the complex of surrounding island (POW Complex) hosts the majority of known endemism in the region. Because some areas of the complex likely served as a glacial refuge during the last glaciation (Carrara et al. 2007, Pauli et al. 2015), the very high endemic richness likely reflects the long-term isolation of these populations (Kondzela et al. 1994, Dickerman and Gustafson 1996).

There are more than 2,000 named islands in the greater Alexander Archipelago, and only about 125 of these have been systematically surveyed for wildlife (Dawson et al. 2007). Currently, scientists have documented 82 species and 116 subspecies of mammals in Southeast Alaska. These mammals represent 63 genera, 28 families, and 8 orders (MacDonald and Cook 2007). Of the described taxa, 24 occur only in Southeast Alaska, meaning that about 20% of the known mammal taxa (including species and subspecies) are endemic.

Old-growth forest provides important habitat for some of these endemic mammals. For example, black and brown bears (*Ursus americanus* and *U. arctos*, respectively) are associated with old-growth, particularly riparian forests with salmon (*Oncorhynchus spp.*) spawning streams (Titus and Beier 1999). Bat species (*e.g. Myotis spp.*) rely on old-growth for adequate roosting (Parker et al. 1996). Northern flying squirrels (*Glaucomys sabrinus*) display a key role in temperate old-growth rainforest ecosystems even though some research resists classification as a bona fide management indicator species for old-growth forest. (Smith et al. 2005). In addition to serving as a food source for old-growth-associated predators such as martens and owls, flying squirrels serve as a dispersal vector for mycorrhizal fungi. These fungi have a symbiotic relationship with dominant conifers, and are essential for forest development (Flaherty et al. 2010). The American marten relies on old-growth forests to find large stumps and tree hollows suitable for denning (Buskirk and Ruggiero 1994), and the endemic coastal marten in Southeast Alaska could display a similar preference. However, more research is needed to determine whether patterns for American martens are consistent with the endemic coastal marten (Dawson et al. 2007).

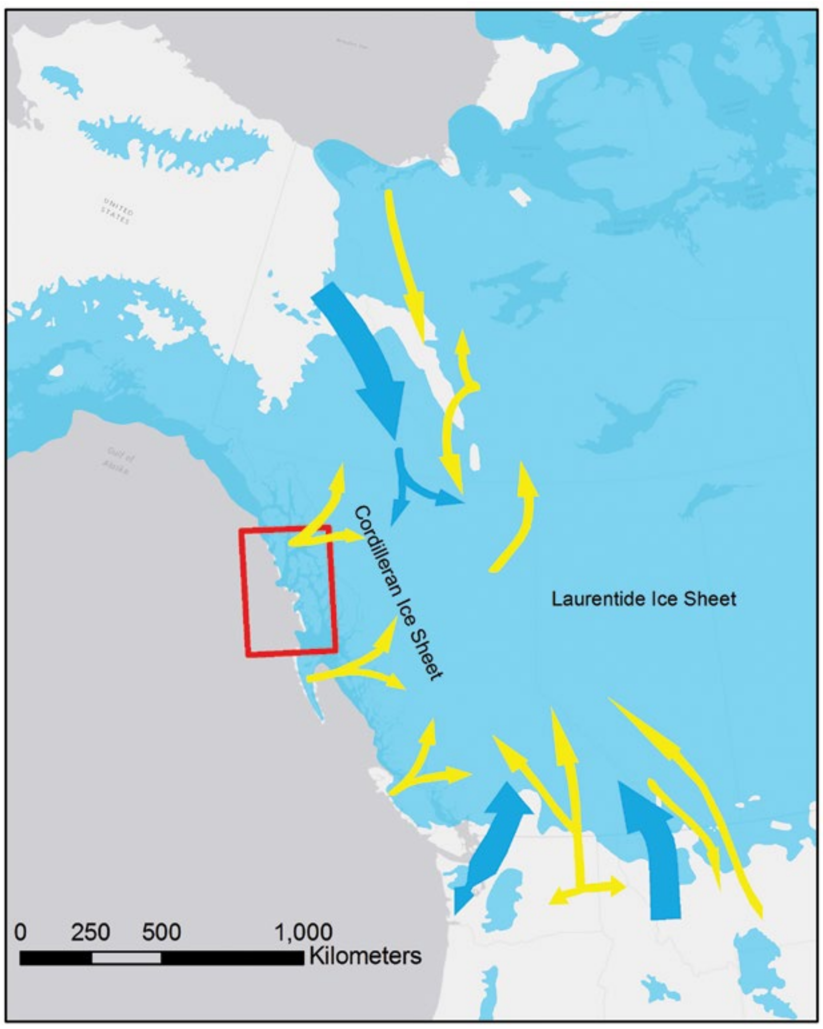
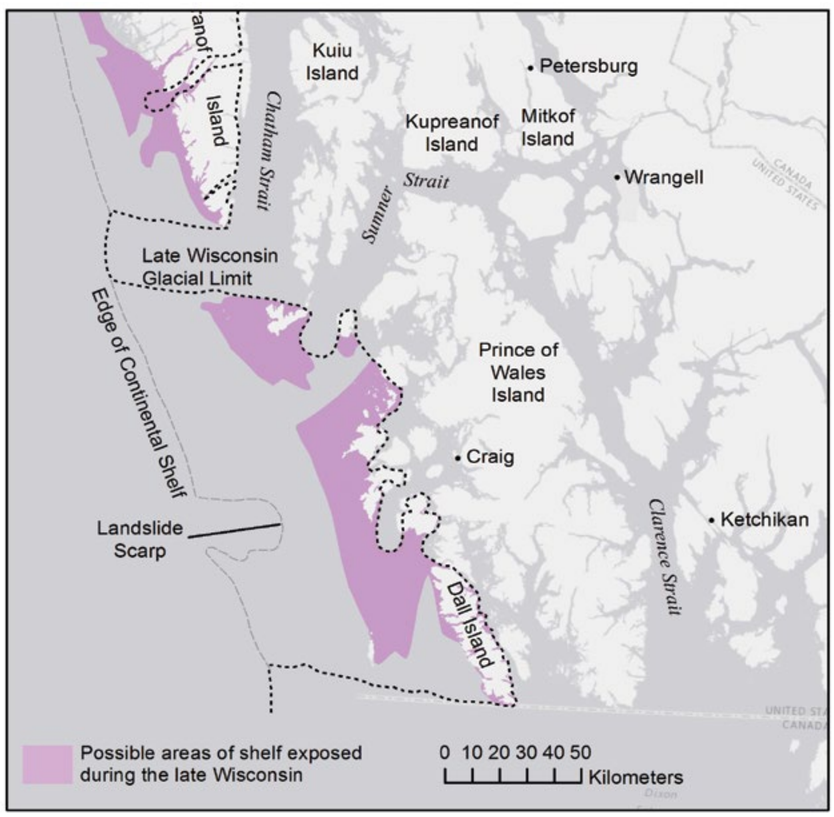


FIGURE 6-1. Extent of glacial coverage during last glacial maximum (light blue), and major (dark blue) and minor (yellow) post-glacial colonization routes (top; adapted from Shafer et al. 2010). Red box indicates approximate bounds of the bottom map, which illustrates refugia using glacial extents (dotted lines) and unglaciated abovewater areas (purple polygons; adapted from Carrara et al. 2007).



MAMMAL SPECIES RICHNESS MAP ON PAGE 146

CONSERVATION ISSUES

Despite rapidly accumulating evidence of Southeast Alaska's biological significance, scientific understanding of the region's terrestrial mammals has developed in a piecemeal fashion. Effective management plans for the region's mammal species will require a comprehensive research effort to fill in existing gaps (Smith 2005). The region is characterized by a dynamic geological history and a complex landscape of connected habitat and dispersal barriers. Such factors pose significant challenges to species management. In order to overcome these obstacles, researchers should gather genetic and species distribution data with a representative coverage from across the region's geography. Two main research needs exist: clarify the region's taxonomy; and improve the delineation of species and endemic distribution.

New and advanced phylogenetic techniques, used for measuring taxonomic distinctiveness, offer an opportunity to reassess historic morphological descriptions of new species and subspecies. However, researchers have yet to apply these methods to much of Southeast Alaska. This paucity of data has led to the widespread and erroneous perception that there are few endemic taxa at risk of extirpation (Cook and MacDonald 2001).

Genetic information must be considered alongside an island-specific understanding of species ranges, habitat associations, and demography. Although the distribution models used here are a useful first step, the input survey data is patchy and may overlook important areas simply due to a restricted sampling extent. Additional observation data will improve quantification of population structure and functional connectivity for species across land usage types, a key component of assessing population viability in this fragmented landscape (Smith and Person 2007).

For example, phylogenetic evidence suggests that the POW flying squirrel (*Glaucomys sabrinus griseifrons*) is genetically distinct from other flying squirrel populations (Bidlack and Cook 2002). But poor information about population size and habitat associations led the US Fish and Wildlife Service (USFWS) recently to reject a petition to consider this squirrel as endangered or threatened (US Fish and Wildlife Service 2012). Similar uncertainty may threaten the endemic bat subspecies *Myotis lucifugus alascensis*. Cutting-edge analyses have revealed genetic distinctiveness (Carstens and Dewey 2010, Vonhof et al. 2015), but little information is known regarding population status.

For the Alexander Archipelago wolf (*Canis lupus ligoni*), the uncertainty rests not so much with the population size, but rather in the interpretation of genetic information. The scientific community accepts estimated population trends, but a conclusive decision on genetic distinctiveness has proven fractious (Weckworth et al. 2005, Weckworth et al. 2010, Cronin et al. 2014;2015, Weckworth et al. 2015). The 2016 USFWS Endangered Species Act status review recognized the Alexander Archipelago wolf of Southeast Alaska and coastal British Columbia as a subspecies of gray wolf, and recognized the discrete population of wolves in the POW Complex. However, the Service decided that listing of the Alexander Archipelago wolf was not warranted at this time (US Fish and Wildlife Service 2016).

In two decades of management plans, the US Forest Service (USFS) has referred to the importance of managing for endemics, but has failed to operationalize these concerns. The 1997 Tongass Land Management Plan (TLMP) mentioned endemic mammals as a priority, but the agency never developed a specific research and monitoring agenda (US Forest Service 1997b). Similarly, the 2008 TLMP listed endemic terrestrial mammals as a separate standard and guideline for management, with the mandate to assess impacts "relative to the distinctiveness of the taxa, population status, degree of isolation, island size, and habitat associations" (US Forest Service 2008a). Unfortunately, achieving the mandate will prove difficult, because all of these metrics suffer from the data gaps mentioned above.

It is of paramount importance to thoroughly investigate the genetic distinctiveness and geographic associations of wildlife, particularly terrestrial mammals, within Southeast Alaska. Without investing in an understanding of Southeast Alaska's ecological baseline, managers will remain largely unaware of potential species extirpations, the erosion of endemic hotspots such as the POW Complex, and the overall ecological significance of this region.

MAPPING METHODS

The Alaska Department of Fish and Game (ADFG) developed species profiles for 201 animals that occur in Alaska (Alaska Department of Fish and Game 2016a). For each species, a description and range map was generated based on expert knowledge and modeling efforts varying by species. This map summarizes the results of these range maps to show the number of mammal species predicted to occur in each subwatershed in Southeast Alaska (HUC 12, or sixth level watershed). Overall, these models predict the presence of 30 mammal species in Southeast Alaska out of a total of 40 mapped across the state by ADFG.

Note that the number of mammal species included in this analysis (30) is much smaller than the total number that have been physically documented to occur in Southeast Alaska (82), which is, in turn, almost certainly an underestimation of actual species richness (Dawson et al. 2007). Even models of known species have insufficient data or produce non-viable results due to inaccuracy or uncertainty. Due to limitations both inherent in the observation data and stemming from the modeling process, readers should interpret the results summarized on this map as an approximate representation of the relative level of species richness among the biogeographic provinces, rather than exact species numbers. Given these constraints, the information is most useful when used as a way to interpret broad ecological patterns and relationships.

Endemic mammal species richness is illustrated in the inset map. As with the species richness data, counts of endemic species are approximate and are best interpreted as a relative index of endemism among subregions of the Alexander Archipelago.

Mammal viewing hotspots were digitized by Audubon Alaska based on the ADFG Southeast Alaska wildlife viewing guides (Alaska Department of Fish and Game and US Forest Service 2006, Alaska Department of Fish and Game 2015c;d).

TABLE 6-1 Mammal species included in species richness map (based on ADFG 2015 distribution data).

American Marten	Keen's Myotis	Northern Redbacked Vole
American Mink	Little Brown Bat	Gray Wolf
Arctic Ground Squirrel	Meadow Vole	Pacific Marten
Black Bear	Moose	Red Fox
Brown Bear	Mountain Goat	Red Squirrel
Collared Pika	Muskrat	Roosevelt Elk
Coyote	North American Beaver	Silver-haired Bat
Dall Sheep	North American Porcupine	Sitka Black-Tailed Deer
Ermine	North American River Otter	Snowshoe hare
Hoary Marmot	Northern Flying Squirrel	Wolverine

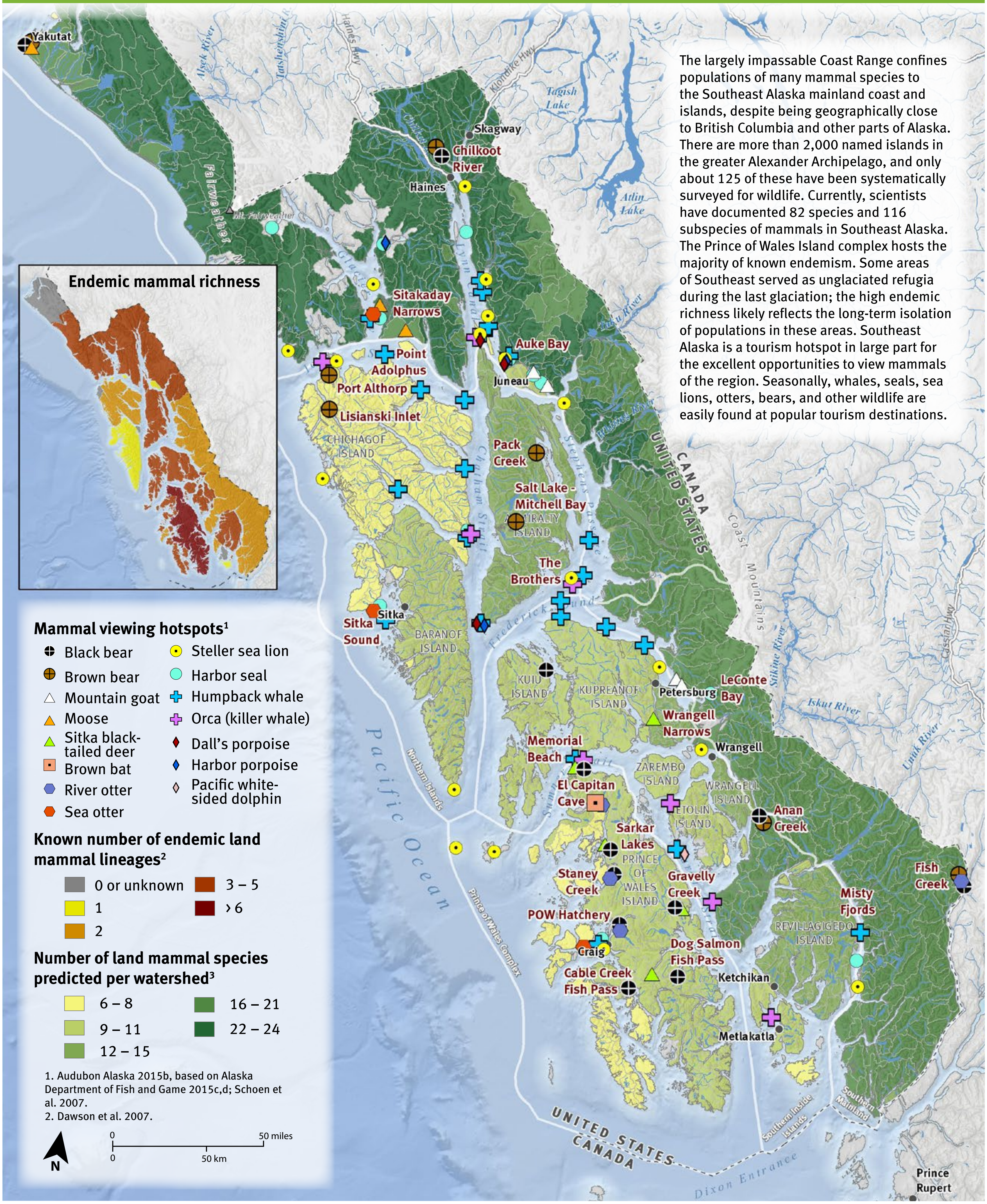
MAP DATA SOURCES

- Mammal species richness: Alaska Department of Fish and Game (2016a)
- Endemic species richness: Dawson et al. (2007)
- Mammal viewing hotspots: Audubon Alaska (2015b), based on Alaska Department of Fish and Game (2015c) and Alaska Department of Fish and Game (2015d).

Mammal Species Richness

Audubon ALASKA

The largely impassable Coast Range confines populations of many mammal species to the Southeast Alaska mainland coast and islands, despite being geographically close to British Columbia and other parts of Alaska. There are more than 2,000 named islands in the greater Alexander Archipelago, and only about 125 of these have been systematically surveyed for wildlife. Currently, scientists have documented 82 species and 116 subspecies of mammals in Southeast Alaska. The Prince of Wales Island complex hosts the majority of known endemism. Some areas of Southeast served as unglaciated refugia during the last glaciation; the high endemic richness likely reflects the long-term isolation of populations in these areas. Southeast Alaska is a tourism hotspot in large part for the excellent opportunities to view mammals of the region. Seasonally, whales, seals, sea lions, otters, bears, and other wildlife are easily found at popular tourism destinations.



Map 6.1: Mammal Species Richness

MAP ON PAGE 149

NORTHERN FLYING SQUIRREL

John Schoen, Winston Smith, and Brian Clark
Revised by Nils Warnock

The northern flying squirrel (*Glaucomys sabrinus*) is an arboreal rodent widely distributed throughout forests of the northern United States and Canada from the eastern seaboard to the Pacific coast and from California to Alaska. Because of its largely nocturnal behavior, the flying squirrel—although common in many forests—remains a mystery to most people. The flying squirrel has enormous eyes and thick, soft fur, brown on top and light underneath. Smaller than the red squirrel (*Tamiasciurus hudsonicus*), the flying squirrel does not actually fly but glides through the forest canopy by stretching out the lateral skin (patagia) between its front and back legs.

The northern flying squirrel apparently expanded into Southeast from a single refugium or isolated population (the southern continental refugium) from the east (Cook et al. 2006, Cook and MacDonald 2013). Genetic research has substantiated the occurrence of two subspecies of flying squirrels from Southeast: the Alaska Coast flying squirrel (*G. s. zaphaeus*) of the mainland and adjacent islands (such as Mitkof, Etolin, Wrangell, and Revillagigedo islands) and the POW flying squirrel (*G. s. griseifrons*) from 11 islands within the POW Complex (Demboski et al. 1998, Bidlack and Cook 2001). These studies suggest that the POW flying squirrels appear to be the result of a relatively recent (Holocene) event from a single founder population on POW Island and represent a unique island lineage of flying squirrels.

Northern flying squirrels inhabit forests along the mainland coast of Southeast Alaska east of Glacier Bay and south to the Canadian border (MacDonald and Cook 1996, MacDonald and Cook 1999). Flying squirrels also occur on at least 15 islands within the southern Alexander Archipelago south of Sumner Strait, including Mitkof, Wrangell, Etolin, POW, Kosciusko, Heceta, Suemez, Tuxekan, Dall, Revillagigedo, and the Outside islands (MacDonald and Cook 1999, Bidlack and Cook 2001).

Throughout the Pacific Northwest, the northern flying squirrel is closely associated with old-growth forests (Witt 1992, Carey 1995, Carey et al. 1999, Smith 2012). In Oregon and Washington, northern flying squirrel abundance was positively correlated with a >80 year old forest landscape; relative abundances of flying squirrels were significantly lower post-cut when more than 60% of green trees were harvested (Holloway et al. 2012).

The density of flying squirrels in the Alexander Archipelago is among the highest documented in North America. Smith and Nichols (2003) reported mean densities of 7.9 and 4.2 squirrels per ac (3.2 and 1.7 squirrels per ha) on POW Island in old-growth western hemlock-Sitka spruce (*Tsuga heterophlla-Picea sitchensis*) forest and muskeg-bog scrub forest, respectively. On POW, flying squirrel densities were higher in old-growth hemlock-spruce forests than in scrub forests in spring and autumn, but particularly in autumn when mean densities were 56% higher in old growth hemlock-spruce (Smith and Nichols 2003, Smith et al. 2004). Flying squirrel densities increased with density of large trees and snags. Other habitat variables that appear important to flying squirrels include cover of ericaceous shrubs (such as *Vaccinium spp.*) and coarse woody debris (Smith et al. 2004).

Cavities in trees and snags are used by flying squirrels in Southeast for denning habitat (Bakker and Hastings 2002). On POW, of 118 flying squirrel dens surveyed, 51% were in snags, 42% in trees with no visible drays (nests), 2% in trees with visible drays, 3% on the ground and 3% in unknown habitat. Western hemlock and western red cedar (*Thuja plicata*) were the most commonly used live trees for dens (Pyare et al. 2010). Squirrels may move their dens up to 20 times a year among many different den trees within a 20-ac (8-ha) area and can travel as much as 1.2 mi (1.9 km) in a single night (Mowrey 1994).

Bob Armstrong

Snags and old-growth trees provide important habitat for northern flying squirrels.

MAP ON PAGE 149

Northern flying squirrels are omnivores, but they play a key ecological role in forest regeneration in the Pacific Northwest because they forage on the fruiting bodies of underground fungi and disseminate fungal spores throughout the forest (Maser et al. 1985, Maser and Maser 1988, Carey et al. 1999). These colonies of mycorrhizal fungi form a symbiotic relationship with the roots of many woody plants, including conifer trees. The mycorrhizal fungi expand the root function of conifers, enhancing nutrient acquisition for trees while extracting sugars from the trees.

In Southeast, flying squirrels also consume truffles, although to a lesser degree than in southern forests (Flaherty et al. 2010). The primary summer and autumn diet of flying squirrels in old-growth forests from the POW Complex was vegetation, truffles, mushrooms, lichens, and insects (Pyare et al. 2002, Flaherty et al. 2010). In terms of relative abundance, at least on POW, 76–90% (autumn, spring) of the squirrel's diet consisted of conifer seeds and lichen, while the rest consisted of epigeous fungi, truffles, and invertebrates (Flaherty et al. 2010). Flying squirrels are also important prey for hawks, owls, and small carnivores (Smith et al. 2005, Mowrey 2008).

There do not appear to be population size or trend data for either subspecies of flying squirrel inhabiting the Tongass. Both the northern flying squirrel and its subspecies, *G. s. griseifrons*, were listed as Species of Greatest Conservation Need in the State of Alaska Wildlife Action Plan (Alaska Department of Fish and Game 2015a).

The subspecies *G. s. griseifrons*, endemic to the POW Complex, was proposed for federal listing as an endangered or threatened species in October 2011, but this petition was found by the USFWS to be unwarranted (US Fish and Wildlife Service 2012). *G. s. griseifrons* was listed as a subspecies of ecological concern in the Tongass National Forest (West 1993) and as potentially endangered in the Status Survey and Conservation Action Plan for North American Rodents prepared by the International Union for the Conservation of Nature (Hafner et al. 1998). NatureServe (2014) ranks the POW flying squirrel as G5T2 (species as a whole is not threatened, but subspecies is imperiled).

Flying squirrels were a "design" species for small size old-growth reserves (10,000 ac [<4,050 ha]) in the 1997 Tongass National Forest Land and Resource Management Plan (TLMP) (US Forest Service 1997a) because of their assumed "dependency on the forested habitats" (Suring et al. 1993). The 2008 TLMP plan amendment (US Forest Service 2008a) evaluated 14 populations of Southeast Alaska endemics and found that under all alternatives evaluated, the POW flying squirrel had the greatest viability concern over time (US Forest Service 2008a).

Multiple studies have established that large trees and snags are ecologically significant correlates of flying squirrel density and habitat use (Smith et al. 2004, Smith et al. 2005, Pyare et al. 2010). The presence of large trees and snags provides nesting cavities for flying squirrels (Bakker and Hastings 2002) and may provide food sources that are more abundant in habitats with larger trees (Smith and Nichols 2003, Smith et al. 2005).

Travel corridors are especially important to flying squirrels because of their method of gliding locomotion (volplaning) (Flaherty et al. 2008). A study of flying squirrel old-growth relationships in interior upland forests by Mowrey and Zasada (1982) found that uninterrupted forest corridors were important for maintaining flying squirrel populations. The distance between the launching and landing trees is important for flying squirrels to move through their home range. Volplaning enabled the flying squirrels to reach distances of between 33–164 ft (10–50 m) in interior Alaska (Mowrey and Zasada 1982). Wider gaps in forest cover were found to increase the risk of predation, especially those gaps wider than 98 ft (30 m) that lack tall trees scattered throughout forest openings.

CONSERVATION ISSUES

As an island endemic, the POW flying squirrel is particularly vulnerable to risk of extinction because of restricted range, small population size, minimal genetic variation, and susceptibility to random events (Soule 1984, Reichel et al. 1992, Frankham 1998). They are also susceptible to fragmentation and loss of habitat, over-harvesting, and introduction of exotic invasive species (Cook et al. 2006). Although the 1997 TLMP (US Forest Service 1997a) included standards and guidelines for reducing extinction risks to island endemics, the guidelines only applied to islands where there was evidence of endemic species (Smith 2005). Unfortunately, the distribution of small mammals on many islands remains unknown (MacDonald and Cook 1996, MacDonald and Cook 1999).

Population persistence of northern flying squirrels requires a surprisingly large intact habitat area. On POW, Shanley et al. (2013) found that habitat patches occupied by radiomarked flying squirrels had ≥ 73% old-growth forest cover or a minimum total area of 180 ac (73 ha) of old-growth forest. Modeling flying squirrel persistence in Old Growth Reserves on POW Island, Smith and Person (2007) concluded that for flying squirrels to persist with 95% certainty for 50–100 years with no immigration to a patch, Old Growth Reserves would have to have an upland old growth component of 12,355–195,213 ac (5,000–79,000 ha), respectively.

Converting structurally diverse old-growth forests with large trees and snags to clearcuts and young second-growth stands with smaller trees and snags, less large woody debris, and fewer shrubs will likely reduce carrying capacity for flying squirrels in Southeast. This forest transformation is particularly a concern on the POW Complex, where substantial timber harvest has occurred and future harvests are planned both on national forest and private lands. Although scrub forests (which are unlikely to be logged) have been demonstrated to support reasonable densities of flying squirrels and may provide a buffer against extensive logging of productive old growth (Smith and Nichols 2003, Smith 2005, Smith and Person 2007), additional fragmentation of productive old-growth stands may increase risks of maintaining viable, well-distributed populations of the endemic POW flying squirrel in the long term.

Maintaining adequate old-growth reserves across the POW Complex as well as promoting second-growth restoration (for example, including snags, large woody debris, legacy trees, and thinning) will likely be important for conserving this island endemic. Although Smith et al. (2005) indicated that flying squirrels were not an ideal management indicator species of old-growth forest structure, Smith's (2012) evaluation of northern flying squirrels as sentinels of forest ecosystem processes and condition concluded that the persistence of the northern flying squirrel affirmed the existence of essential ecological components and processes typical of healthy montane or boreal coniferous forest ecosystems.

Clearly, a comprehensive conservation strategy for populations of this important endemic arboreal rodent is needed for Southeast Alaska.

MAPPING METHODS

Habitat quality as shown was digitized from a spatial analysis of habitat relationships by Suring (2014). Suring's analysis used a Bayesian network composed of site, stand, and broad-scale indices to create an overall quality metric. High quality habitat was associated primarily with increased downed wood, and other important factors include high densities of living and dead trees, moderate canopy closure, and low fragmentation (Suring 2014). Audubon Alaska edited this layer by clipping the digitized version of Suring's results to the Alaska Department of Fish and Game (2016a) range extent of the northern flying squirrel, and removing areas covered by glaciers from GLIMS (2016). Confirmed extent of the POW subspecies was selected from the Alaska Department of Fish and Game (2016a) range extent layer, based on Figure 1 in the publication by Bidlack and Cook (2002).

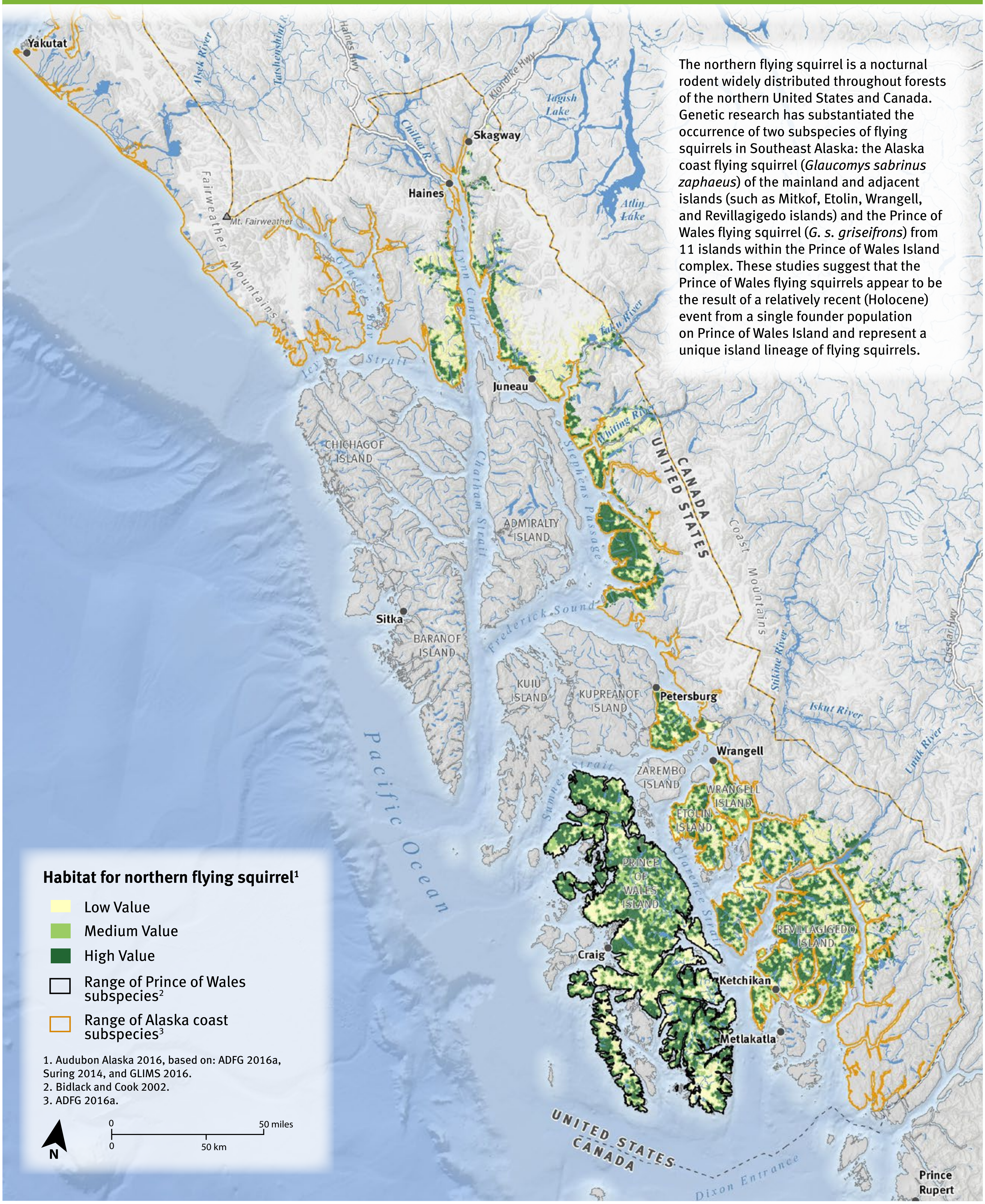
MAP DATA SOURCES

- Alaska coast subspecies range: Alaska Department of Fish and Game 2016a
- Confirmed POW subspecies range: Bidlack and Cook (2002)
- Habitat quality: Audubon Alaska (2016), based on Alaska Department of Fish and Game (2016a), Suring (2014), and GLIMS (2016).

Audubon ALASKA

Northern Flying Squirrel

The northern flying squirrel is a nocturnal rodent widely distributed throughout forests of the northern United States and Canada. Genetic research has substantiated the occurrence of two subspecies of flying squirrels in Southeast Alaska: the Alaska coast flying squirrel (*Glaucomys sabrinus zaphaeus*) of the mainland and adjacent islands (such as Mitkof, Etolin, Wrangell, and Revillagigedo islands) and the Prince of Wales flying squirrel (*G. s. griseifrons*) from 11 islands within the Prince of Wales Island complex. These studies suggest that the Prince of Wales flying squirrels appear to be the result of a relatively recent (Holocene) event from a single founder population on Prince of Wales Island and represent a unique island lineage of flying squirrels.



Map 6.2: Northern Flying Squirrel

MAP ON PAGE 154

SITKA BLACK-TAILED DEER

John Schoen and Matthew Kirchhoff
Revised by Nils Warnock

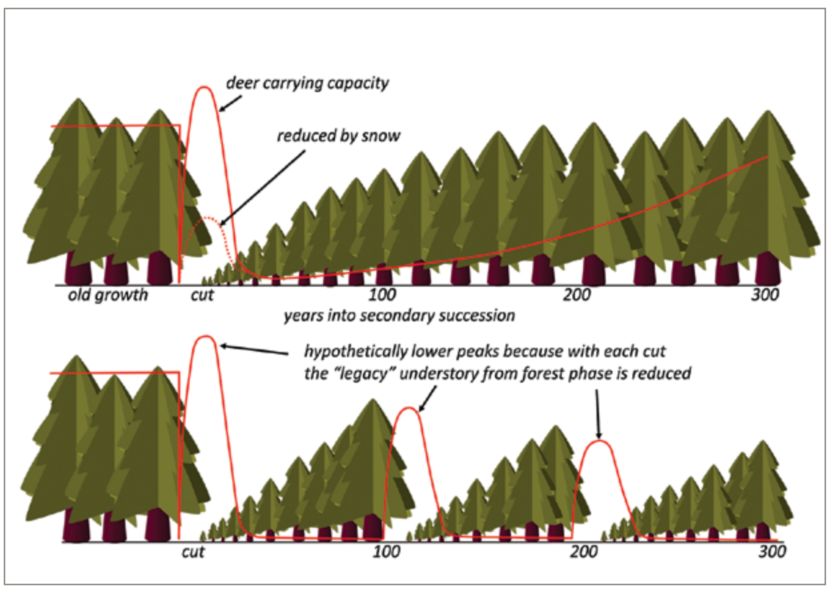
The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) is endemic and widely distributed along a narrow coastal band of northern British Columbia and Southeast Alaska (Wallmo 1981). Genetic data suggest that this subspecies of mule deer recolonized Southeast around 10,000–15,000 years ago from coastal Washington and Oregon following the retreat of glaciers (Latch et al. 2009). They are the most common and widespread large mammal of the Alexander Archipelago.

This subspecies occupies the northwestern-most extent of the natural range of mule and black-tailed deer and overlaps the occurrence of the temperate rainforest (Wallmo 1981). Deer use a variety of habitat types throughout the year from sea-level beaches, through valley-bottom forest stands, to alpine ridges more than 3,000 ft (915 m) above sea level. Alaska Natives have relied on deer as an important food resource for centuries (Crone and Mehrkens 2013), and today deer remain the most sought after big game animal throughout much of coastal Southeast (Person and Brinkman 2013).

These small, sturdy deer average about 120 lb (54 kg) for bucks and 80 lb (36 kg) for does. During summer, deer are widely scattered and commonly observed from sea level to lush subalpine meadows above tree line. As winter snow accumulates in the high country, deer move into the lower-elevation rainforest where they find shelter and food under the forest canopy.

Throughout most of Southeast, deer are closely affiliated with old-growth forests (particularly in winter) and have been at the center of public debate over forest management and wildlife conservation for decades (Wallmo and Schoen 1980, Schoen et al. 1988, Hanley 1993). See Figure 6-2 for an illustration of carrying capacity related to forest succession after clearcut logging.

Sitka black-tailed deer are naturally distributed throughout most of Southeast, south of Berner's Bay and Cape Spencer (MacDonald and Cook 1996, 1999). They occur on most islands of the Alexander Archipelago, except offshore islands like Forrester, Hazy, and St. Lazaria, and most islands within Glacier Bay (Klein 1965a). Even many small (200 ac [80 ha]) islands adjacent to larger islands often have transient deer populations. Deer were transplanted to islands within Yakutat Bay in 1934, Sullivan Island in Lynn Canal in 1951–54, and near Skagway in 1951–56 (Burris and McKnight 1973). The Skagway transplant failed (MacDonald and Cook 1999), but deer still remain on Sullivan Island and in the Yakutat area (Kirchhoff 2003b, Barten 2004). Deer from Southeast were also successfully transplanted to the large islands of Prince William Sound in 1916 and the Kodiak Archipelago in 1924–34 (Burris and McKnight 1973).



Erika Knight

FIGURE 6-2 Deer Carrying Capacity (adapted from Wallmo and Schoen 1980). Hypothesized changes in deer carrying capacity during successional development of hemlock-spruce forests in Southeast Alaska. **Upper:** forest succession from clearcutting to old-growth. **Lower:** clearcutting on 100 year rotations. In early clearcut stages (dotted line), winter carrying capacity may be reduced by snow accumulation.

Much emphasis has been placed on the importance of winter habitat and the effects of deep, prolonged snow accumulations on deer populations in Southeast (Klein and Olson 1960, Meriam 1971, Barrett 1979, Klein 1979, Olson 1979). Spring, summer, and fall range conditions are also important for maintaining the nutritional plane of deer on an annual basis and ensuring healthy, productive populations (Klein 1965a, Hanley and McKendrick 1985, Hanley et al. 1989, Parker et al. 1999). Furthermore, it is important to have a variety of habitats (including a diversity of mature and old-growth forest stands) and topographic conditions so that deer can select the most appropriate foraging habitats as seasons and environmental conditions change (Klein 1965a, Schoen and Kirchhoff 1990, Parker et al. 1999, Person and Brinkman 2013).

Figure 6-3 and the following sections briefly summarize seasonal habitats and forages used by deer throughout their annual cycle in Southeast.

SPRING SEASONAL HABITAT USE

With the advent of spring, the winter snow cover begins to recede from low to higher elevation and deer begin dispersing from winter ranges to forage on newly emerging plant growth (Schoen and Kirchhoff 1985). Most spring deer use on Admiralty Island generally occurred below 1000 ft (305 m), and southerly exposures were selected by deer over northerly exposures because they are the first to become snow free and expose new plant growth (Schoen and Kirchhoff 1990). A study in an extensively logged area of northern POW Island (Yeo and Peek 1992) revealed deer using clearcuts in spring, with a recorded 65% of radio-collared deer use occurring in clearcuts (1–30 yr after logging). Spring is a time when animals must begin replenishing their muscle and fat reserves that have been depleted during winter. Deer especially seek out the new shoots of skunk cabbage (*Lysichton americanum*); fiddlehead ferns; new leaves of devil's club (*Oplopanax horridum*) and blueberry plants (*Vaccinium spp.*); alder catkins and buds (*Alnus rubra*); and many newly emerging forbs (Hanley and McKendrick 1985, Parker et al. 1999).

SUMMER SEASONAL HABITAT USE

Summer is an important time for deer to continue to replenish their fat reserves and for female deer to meet the added nutritional costs of lactation (Parker et al. 1999). During summer, deer are widely dispersed from sea level to high alpine ridges, and they forage in a variety of habitats (Klein 1965a, Schoen and Kirchhoff 1985, Schoen and Kirchhoff 1990, Yeo and Peek 1992, Farmer 2002).

During summer, subalpine habitats are generally very productive, providing an abundance of high-quality forage (Klein 1965a, Hanley and McKendrick 1983, 1985). In portions of Southeast, where deer have access to subalpine habitats, many deer migrate seasonally to these higher-elevation sites. On POW and Heceta Islands in southern Southeast, old growth and clearcuts (1–30 yr after logging) with abundant forb and shrub communities were used extensively by deer, and second-growth forests (40–60 yr after logging) received little use (Yeo and Peek 1992, Farmer 2002).

MAP ON PAGE 154

FIGURE 6-3 **The Annual Cycle of a Southeast Deer**

1. **Fawning:** In late May and early June, black-tailed does drop their fawns. During late spring, deer are scattered from sea level to 1,500 ft (457 m) in search of new plant growth. Deer use old-growth forests and increase their use of open canopy stands, fens, tidal meadows, and young clearcuts at this time.

2. **Upward Migration:** Throughout June, migratory deer continue to disperse off their winter ranges following the receding snow line onto upper forest slopes. Resident deer generally remain at lower elevations but use more forest openings for feeding.

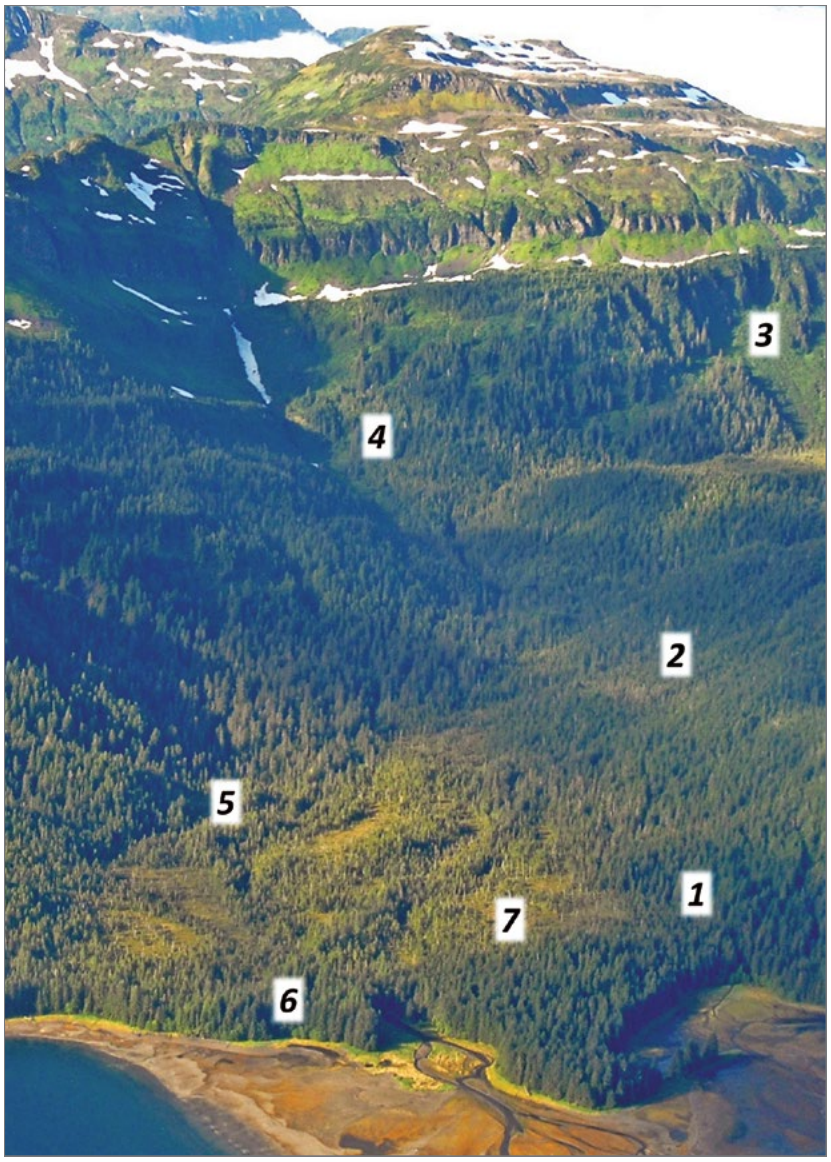
3. **Subalpine Summer Ranges:** Migratory deer generally reach their ranges by the end of June or early July. On subalpine meadows between 1,800 and 3,000 ft (549–915 m), deer find abundant and nutritious herbaceous forage interspersed among stunted stands of Sitka spruce and mountain hemlock (*Tsuga mertensiana*).

4. **Fall Migration:** Following the first high-country frosts in mid to late September, forage plants die and migratory deer move into the upper forests. Throughout the next month, many deer move down to lower elevations as snow accumulates in the high country.

5. **The Rut:** The breeding season, or rut, begins in late October and continues through November. Deer are widely dispersed from sea level to 1,500 ft (457 m). Old-growth forests are important foraging habitats but deer also make use of forest openings and muskeg fringes during the rut.

6. **Winter Range:** From December through March, deer in Southeast are generally confined to old-growth forest winter ranges below 1,000 ft (305 m). Southern exposures generally accumulate less snow and provide greater access to evergreen forbs like bunchberry dogwood and trailing raspberry. Deer move up and down forest slopes following changes in the snow pack throughout the winter. During deep snows, medium- and large-tree old-growth hemlock spruce forests provide the best winter habitat.

7. **Spring Snow Melt:** Spring is a transition period as deer begin to expand their movements beyond the confines of their winter range in search of new plant growth. Wet, open-canopy forests with newly emergent skunk cabbage shoots are important foraging sites for deer in spring. Deer can also be seen foraging along upper beaches and young clearcuts during spring at this time.



John Schoen

A Sitka black-tailed doe standing in a snow-free area under the canopy of a large old-growth tree. The broken, multi layered canopy of old growth allows sunlight to reach the forest floor, enabling abundant growth of understory plants like bunchberry dogwood and trailing raspberry. The big limb structure of old trees also intercepts substantial snowfall enabling deer to forage in snow-free or low-snow patches under the canopy.

John Schoen

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Deer in summer have been observed feeding on more than 70 plant species, especially forbs (Parker et al. 1999). Important deer forage species in summer (both in terms of deer use and nutritional quality) include skunk cabbage, devil's club leaves, blueberry leaves (*Vaccinium spp.*), leaves of other shrubs, bunchberry (*Cornus canadensis*), trailing raspberry (*Rubus pedatus*), and several fern species (Hanley and McKendrick 1985, Parker et al. 1999).

FALL SEASONAL HABITAT USE

Migratory deer begin moving off the high-elevation subalpine meadows following the first killing frosts of autumn as quality and availability of herbaceous forbs declines. As snow accumulates in the high-elevation, open habitats, these areas are avoided by deer, as are northern exposures. Old-growth forests were overwhelmingly selected by deer on Admiralty Island in fall. Within the old-growth forest type, deer selected hemlock-spruce stands with large trees (Schoen and Kirchhoff 1990). Forbs, skunk cabbage, shrub leaves, and fern rhizomes are important components of the fall diet of Southeast deer (Hanley and McKendrick 1985, Parker et al. 1999).

WINTER SEASONAL HABITAT USE

Deer distribution is most limited during winter. On unlogged lands in northern Admiralty Island in northern Southeast, virtually all winter deer use was within old-growth forest habitat below 1000 ft (300 m)(Schoen and Kirchhoff 1990). Within the old-growth forest, radio-collared deer selected large-tree hemlock-spruce stands and avoided scrub forest and small-tree stands, especially in high snow years (Schoen and Kirchhoff 1990).

Deer selection for old-growth stands of large trees is a response to the ability of bigger trees to intercept snow, reducing snow depths on the ground (Hanley and Rose 1987, Kirchhoff and Schoen 1987). Deer used old growth more during years of heavier snow, and used young clearcuts more during years of light snow (Yeo and Peek 1992). Deer can use forest openings and young clearcuts to a greater extent in southern than northern Southeast because less snow accumulates in the south.

In areas subject to persistent winter snow, the most valuable winter deer-habitat provides abundant winter forage and a well-developed forest canopy that intercepts snow. These conditions are generally found in low-elevation, old-growth forest (Bloom 1978, Barrett 1979, Wallmo and Schoen 1980, Rose 1984, Hanley et al. 1989, Schoen and Kirchhoff 1990). During winter, deer substantially increase their use of shrub stems, conifers, and arboreal lichens, particularly when snow accumulation covers other more nutritious forage (Hanley and McKendrick 1985, Parker et al. 1999). Although the quality of winter habitat provided by old growth is higher than that of second-growth forests, some mature (>150 yr), but even-aged, windthrow-generated stands of hemlock-spruce may also provide good winter deer-habitat. Some of these windthrow-generated stands, although technically not old growth, also provide adequate snow interception and abundant forage production, particularly on south-facing slopes.

POPULATION INFORMATION

Quantitative estimates of the Southeast Alaska Sitka black-tailed deer population are lacking (US Forest Service 2012). Deer populations fluctuate dramatically throughout Southeast, largely in response to the severity of winter weather, particularly the depth and duration of winter snow accumulation (Klein and Olson 1960, Olson 1979, Brinkman et al. 2011).

Although winter snowpack varies significantly across Southeast, there is a clear trend toward deeper, more prolonged snow in northern and eastern Southeast. The lower elevations along the outer coast, especially in the southern archipelago, are frequently snow-free because of the strong influence of warmer maritime weather (Klein 1979). As a result of the more severe winter snow conditions and less productive forest habitat, mainland populations of deer are generally lower than island populations. Deer consistently occur around several mainland areas, including the southern Cleveland Peninsula north of Ketchikan, Thomas Bay near Petersburg, Cape Fanshaw, and Juneau.

John Schoen

Recent clearcuts produce an abundance of deer forage including forbs, ferns, and shrubs. The availability of this forage to deer declines rapidly, however, when snow accumulations exceed 12 in (30 cm). The habitat value of clearcuts to deer also begins to decline when the conifer canopy shades out most forbs and shrubs 20 to 30 years after clearcutting. Then, these second-growth stands provide very poor deer habitat regardless of the season. Once cut, it can take several centuries to develop the full ecological characteristics of old growth again.

The major predators of deer in Southeast are wolves (*Canis lupus*), black bears (*Ursus americanus*), and brown bears (*Ursus arctos*). Deer are the major prey species for island populations of wolves in Southeast (Smith et al. 1987, Kohira 1995, Person 2001).

Deer populations in Southeast are currently highest on the northern islands north of Frederick Sound, intermediate on the central and southern islands, and lowest on the mainland coast (Kirchhoff 2003b, Lowell 2004, Mooney 2004, Porter 2004). Some islands of Game Management Unit (GMU) 3 (in central Southeast) have still not rebounded from three severe winters in the late 1960s and early 1970s (Olson 1979, Kirchhoff 2003b). This slow rebound may be the result of a combination of factors, including several severe winters, low-quality winter deer habitat in some locales (such as Kupreanof Island), and the persistence of relatively high numbers of wolves and black bears. Kuiu Island, in particular, currently has very low deer numbers (Kirchhoff 2003b) and high black bear numbers (Peacock 2004).

Deer hunting is an important and highly valued recreational and food-gathering activity throughout most of Southeast where deer are abundant (Person and Brinkman 2013). The Sitka black-tailed deer is the most-pursued species of big game in Southeast. During the 20 years from 1983 to 2003, an average annual harvest of 12,361 deer was taken by an average of 7,994 hunters (Straugh 2004). Of 20 subsistence communities in Southeast, an average of 90% of households harvested subsistence resources, and deer made up an average of 23.6% of subsistence food in those households (Kruse and Frazier 1988, US Forest Service 1997a).

CONSERVATION ISSUES

The Sitka black-tailed deer in Southeast is a Management Indicator Species under the USFS 1997 Tongass National Forest Land and Resource Management Plan (TLMP) (US Forest Service 1997b;2012). The deer is one of six species identified by the USFS (2012) as having special management concerns. Low-elevation old-growth forests have been documented as important winter habitat. This is particularly the case for large-tree old growth during deep winter snows.

Converting productive old-growth forest habitat—with abundant, high-quality food—to less-productive, even-age second growth will reduce habitat values and the productivity and resilience of deer populations throughout their range in Southeast. Although young clearcuts provide abundant forage for deer during snow-free periods, the nutritional quality of this forage is lower than that of forage in old growth, and forage is only abundant for approximately 25% of the timber rotation period. In winters with deep snow accumulation, even the temporary availability of forage in clearcuts is greatly diminished. Furthermore, Farmer et al. (2006) found that deer using clearcuts and second-growth habitats have a higher mortality risk compared to those in old-growth habitats.

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If forest management activities (such as timber harvest) reduce the carrying capacity of important deer range in the Tongass National Forest, both sport hunting and subsistence hunting opportunities will likely be restricted. This situation is already happening on POW Island (Person 2013).

Clearcutting is the dominant timber harvest method in Southeast (US Forest Service 1997a) and has a much different effect on forest structure than the natural disturbance regime caused primarily by wind (Alaback 1982, Brady and Hanley 1984). Forest succession in Southeast following clearcutting has been described by Harris (1974), Harris and Farr (1974), Harris and Farr (1979), Wallmo and Schoen (1980), and Alaback (1982). In general, deer forage (herbs, ferns, and shrubs) and conifer seedlings grow abundantly several years after logging and peak at about 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, conifers completely dominate second growth, the forest floor is continually shaded, and deer forage (including forbs, shrubs, and lichens) largely disappears from the even-aged, second-growth stand.

The absence of deer forage in second growth generally continues for more than a century following canopy closure (30–130 yr). Consequently, clearcutting old growth and managing second growth on 100- to 120-year rotations significantly reduces foraging habitat for deer for 70–80% of the timber rotation (Harris 1974, Wallmo and Schoen 1980, Alaback 1982, Person and Brinkman 2013). Forage production for deer can be prolonged in young second growth by a series of precommercial thinnings (Kessler 1984, Doerr and Sandburg 1986, DellaSala et al. 1994, Doerr et al. 2005). However, the benefits of these techniques appear to be relatively short-lived (15–25 yr) (Alaback and Tappeiner 1984, Alaback and Herman 1988). Doerr et al. (2005) suggested that, through thinning treatments, the forage productivity of clearcuts could be extended up to about 40 years. Use of very wide tree spacing to prolong understory productivity, however, reduces gross timber volume and wood quality (DeMars 2000). On POW Island, deer densities on managed land logged >30 years ago supported significantly fewer deer compared to both managed land logged <30 years ago and unmanaged land (Brinkman et al. 2011).

Compared to clearcutting, removal of individual trees through partial harvest or selection logging offers good potential for maintaining understory abundance and deer habitat values (Harris and Farr 1979, Kirchhoff and Thomson 1998, Duncan 1999, Deal 2001).

Studies comparing winter deer use of old growth to clearcuts and second growth found significantly lower use (by seven times) of logged sites in both the northern and southern archipelago (Wallmo and Schoen 1980, Rose 1984). The same studies revealed increased use of clearcuts during spring and summer in the absence of snow. In fact, more deer use of clearcuts than old growth occurred in the southern study area during spring (Rose 1984).

Regardless of season or snow conditions, second-growth forests (30–40 yr after logging) provide poor foraging habitat for deer (Harris and Farr 1979, Wallmo and Schoen 1980, Alaback 1982, Farmer et al. 2006, Brinkman et al. 2011, Person and Brinkman 2013). Under deep-snow conditions, arboreal lichens—blown from the forest canopy—provide an important food resource for deer (Parker et al. 1999). Lichens are abundant in old-growth forests but are largely absent from clearcuts and second growth. Once an old-growth forest is placed under a timber rotation of fewer than 200 years, long-term habitat values are reduced because of limited forage resources within the closed-canopy, even-aged second growth. This permanent cycle of diminishing forage has been described as "succession debt" (Person 2001, Person and Brinkman 2013).

Not just the quantity of forage is important to deer but also the quality of forage. Plants grown in open clearcuts generally have higher tannins (compounds that lower digestibility and increase toxicity) and lower digestible protein than plants grown under the shaded forest canopy (Hanley et al. 1987, Van Horne et al. 1988, Hanley et al. 1989). Thus although the plant biomass in clearcuts (5–20 yr after logging) is generally abundant during snow-free periods, the quality of forage may not meet the protein requirements of lactating does, and when given a choice, deer appear to prefer forest-grown plants to clearcut-grown plants (Hanley et al. 1987).

During winter, the most nutritious deer forage (such as herb-layer evergreen forbs) generally becomes unavailable when snow depths exceed 4 in (10 cm) (Parker et al. 1999). At depths greater than 12 in (30 cm), not only is food buried, but the energetic costs of moving through snow also increase significantly (Parker et al. 1984). During heavy snow conditions, old growth with large trees (which intercept snow and reduce accumulation on the ground) provides much of the winter habitat selected by deer (Bloom 1978, Barrett 1979, Hanley and Rose 1987, Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990).

Optimal habitat conditions in Southeast Alaska must encompass diverse habitats that provide deer with a variety of options to satisfy changing seasonal needs and variable weather conditions. Large- and medium-tree stands of hemlock-spruce, particularly at low elevations, have high habitat value for deer in deep-snow winters. In Southeast, large-tree old growth represents a small (<4%) proportion of the land area, but these stands have been disproportionately harvested throughout the region (Albert and Schoen 2013). The disproportionate loss of this scarce but important habitat will disproportionately affect deer during severe winters (Schoen and Kirchhoff 1990, Person and Brinkman 2013).

To maintain productive deer populations at the watershed scale will require retaining a mosaic of representative habitats that are well distributed across the area and available to deer throughout their annual cycle. Seasonal habitat values vary geographically throughout Southeast in response to local environmental factors, including weather and predation. To ensure that deer populations are well represented throughout their natural range in Southeast and available for human use and enjoyment, watersheds with a variety of high-value deer habitat should be identified and protected at the watershed scale (Schoen et al. 1984) within each biogeographic province of Southeast (Albert and Schoen 2007b).

MAPPING METHODS

The winter habitat capability model for deer (Albert and Schoen 2007b), adapted from a model described in Suring et al. (1992), provides a relative index of winter habitat, based on the following inputs: snow accumulation, elevation, aspect, and land cover. Each of these was divided into categories, then attributed in a matrix of relative habitat capability values:

- Elevation: < 800 ft, 800–1,500 ft, >1,500 ft (< 244 m, 244–457 m, >457 m)
- Aspect: South, West, East, North
- Snow: Low, Intermediate, High
- Land Cover: High Volume, Medium Volume, and Low Volume Productive Old Growth; Non-Productive Old Growth; Young Growth, 0–25 years old; Young Growth, 2–200 years old; Other.

See Albert and Schoen (2007b) for more details and the complete capability value matrix.

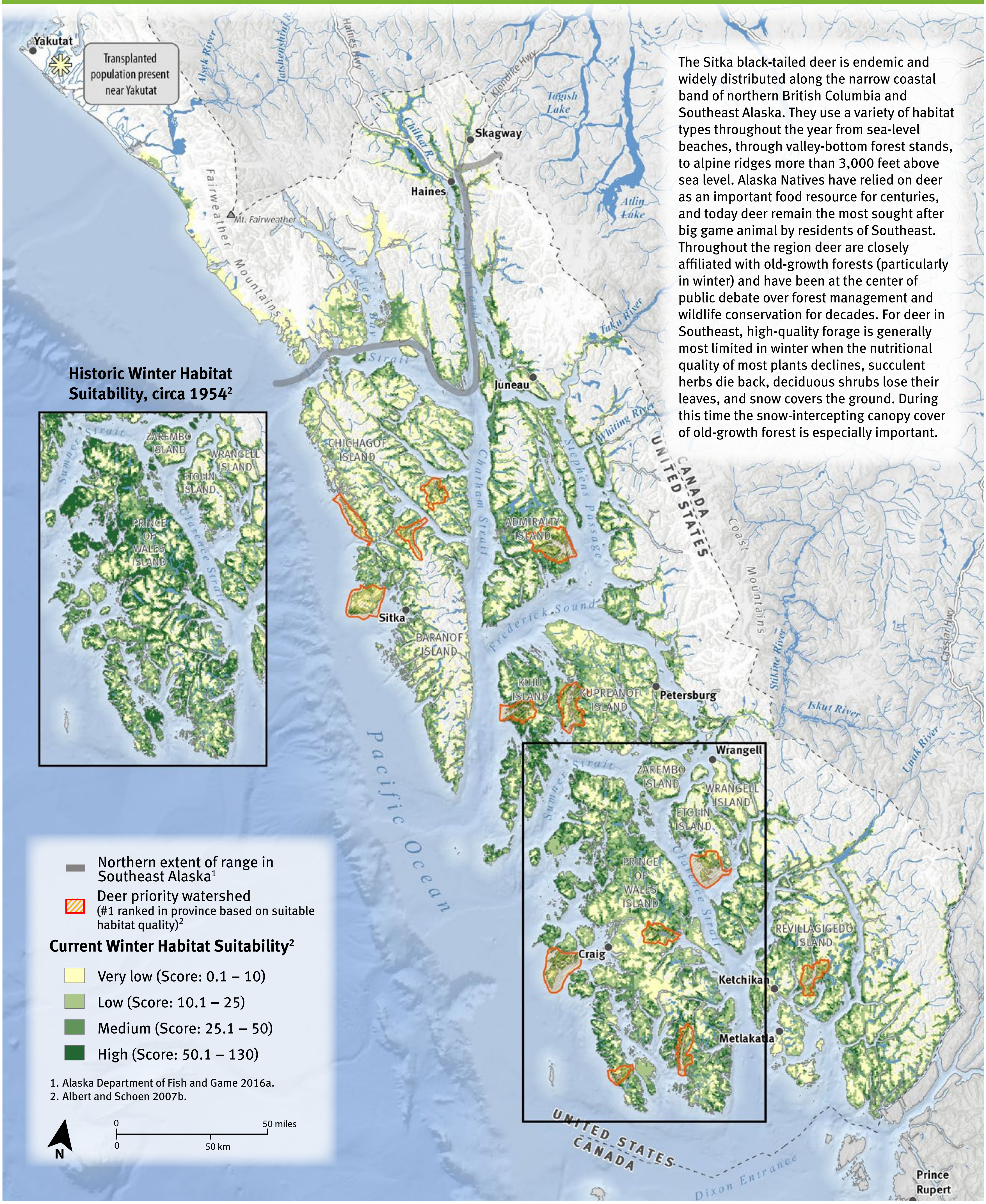
This model was evaluated in March 2005 by an interagency expert review panel, including ADFG, Audubon Alaska, The Nature Conservancy, USFS, and USFWS, and as a result of this workshop, the relative snowfall model was updated using the PRISM climatic model. This model uses point data from weather stations from 1961–1990, combined with a digital elevation model, to generate gridded estimates of monthly and annual temperature, better accounting for the effects of terrain and mountains.

MAP DATA SOURCES

- Habitat suitability index model: Albert and Schoen (2007b).
- Northern range extent: Alaska Department of Fish and Game (2016a).

Sitka Black-tailed Deer

The Sitka black-tailed deer is endemic and widely distributed along the narrow coastal band of northern British Columbia and Southeast Alaska. They use a variety of habitat types throughout the year from sea-level beaches, through valley-bottom forest stands, to alpine ridges more than 3,000 feet above sea level. Alaska Natives have relied on deer as an important food resource for centuries, and today deer remain the most sought after big game animal by residents of Southeast. Throughout the region deer are closely affiliated with old-growth forests (particularly in winter) and have been at the center of public debate over forest management and wildlife conservation for decades. For deer in Southeast, high-quality forage is generally most limited in winter when the nutritional quality of most plants declines, succulent herbs die back, deciduous shrubs lose their leaves, and snow covers the ground. During this time the snow-intercepting canopy cover of old-growth forest is especially important.



Map 6.3: Sitka Black-tailed Deer

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ALEXANDER ARCHIPELAGO WOLF

Melanie Smith, John Schoen, David Person, and Benjamin Sullender

Although the gray wolf (*Canis lupus*) was once widely distributed and occupied a variety of habitats throughout the northern hemisphere, its current range has been substantially reduced (Nowak 1979, Mech 1995). In recent years, the wolf has recolonized portions of its historic range and today there are more than 5,500 wolves in the contiguous US (US Fish and Wildlife Service 2015). In North America, most people associate wolves with the northern wilderness areas of Canada, Alaska, and Minnesota. Unlike most of the Lower 48 states where wolf populations have been extirpated or significantly reduced in numbers and range, the wildlands of Alaska generally maintain secure and productive wolf populations.

Wolves are highly social canids that generally organize into packs. Packs utilize a specific home territory for hunting and breeding, and defend their territory from other wolf packs. In most parts of Alaska, wolf packs depend on large ungulate populations—primarily moose (*Alces alces*) and caribou (*Rangifer tarrandus*)—as their major food resource. Wolves in Southeast Alaska are largely co-located with their primary prey, the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), which populate the islands and southern mainland. Southeast Alaskan wolves also prey upon moose and mountain goats (*Oreamnos americanus*) along much of the mainland coast. Deer are an especially important food source during winter months, comprising up to 90% of their diet (Person et al. 1996). Other important food items consumed by wolves include beaver (*Castor canadensis*) and spawning salmon (*Oncorhynchus spp.*) (Wood 1990, Kohira 1995).

Within Southeast Alaska, the Alexander Archipelago wolf (*C. l. ligoni*) is smaller and has darker fur than other Alaskan wolf populations (Goldman 1944, Wood 1990). As a result of the isolated and naturally fragmented geography of Southeast, the Alexander Archipelago wolf is more restricted in distribution and potentially more sensitive to human activity and habitat disturbance than elsewhere in the state. This greater sensitivity is especially concerning in the southern archipelago where deer populations are strongly impacted by the loss and fragmentation of old-growth forest habitat.

DISTRIBUTION

Wolves are distributed throughout the Southeast Alaska mainland and most of the larger islands south of Frederick Sound (Klein 1965b, MacDonald and Cook 1999). It is likely that only the largest islands (including POW, Kuiu, Kupreanof, Mitkof, Etolin, Revillagigedo, Kosciusko, Zarembo, and Dall islands) maintain persistent wolf populations (Person et al. 1996). Wolf packs may occur on smaller islands and overlap several islands at a time, but usually do not persist there permanently (Klein 1965b, Person et al. 1996). The distribution of wolves in Southeast is similar to the distribution of black bears (*Ursus americanus*). Neither wolves nor black bears occur on the northern islands of Admiralty, Baranof, or Chichagof (ABC Islands), where brown bears (*U. Arctos*) are abundant.

Wolves are good swimmers and regularly travel between nearby islands. Although wolves can swim up to 2.5 mi (4 km) (Person et al. 1996), larger expanses of open water appear to act as a barrier to movement and likely limit wolf distribution throughout Southeast (Person et al. 1996). The areas surrounding the Sitkine River Delta in central Southeast comprise the most significant dispersal corridor between the southern islands and the mainland.

TAXONOMY

Because fossil evidence of wolves is lacking in Southeast, it appears that wolves have occurred in the region only during the last 10,000 years and the species likely colonized the area from glacial refugia to the south (Klein 1965b, Weckworth et al. 2005). Weckworth et al. (2005) have described two distinct genetic clusters of wolves within

Bob Armstrong

A black wolf near Juneau. Southeast wolves are generally smaller and darker than interior Alaska wolves.

Southeast: the isolated POW Complex, and the rest of Southeast. This relationship parallels the high level of endemism (i.e., taxonomic group restricted to a particular region) found in that area for other species (MacDonald and Cook 1996, Bidlack and Cook 2002, Fleming and Cook 2002, Lucid and Cook 2004).

Recently, due in part to the USFWS status review process, debate about Alexander Archipelago wolf taxonomy intensified. Most recently, Cronin et al. (2014) sampled wolves across North America to identify geographic genetic differentiation, concluding that there is "considerable differentiation…between wolves in Southeast Alaska and wolves in other areas." They also concluded that the immense variability within the Southeast Alaska population precludes designation of Southeast Alaska wolves as a unique subspecies of gray wolf.

Following that, Weckworth et al. (2015) and Fredrickson et al. (2015) challenged Cronin et al.'s logical framework, making a compelling case for the existence of the Alexander Archipelago wolf subspecies as well as the POW population segment. Most recently, in early 2016, the USFWS published its status review, and found the Alexander Archipelago wolf of Southeast Alaska and coastal British Columbia to

ALEXANDER ARCHIPELAGO WOLF

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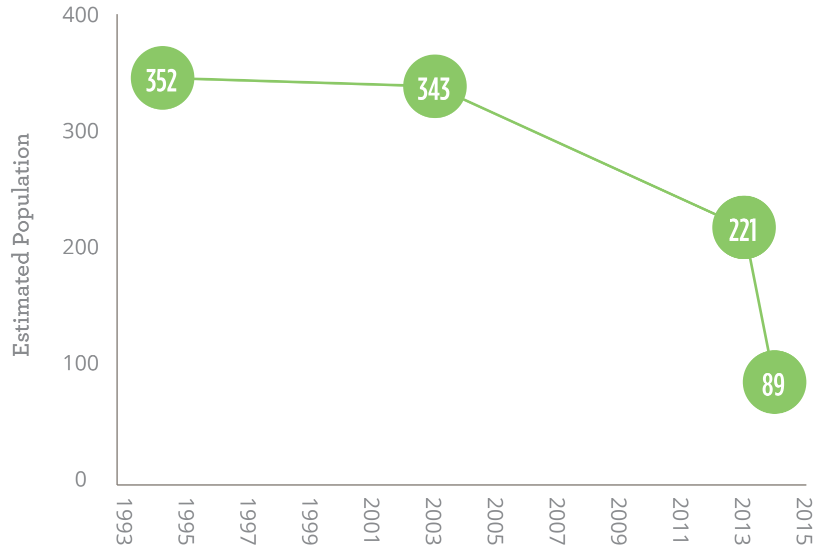
TABLE 6-2. Estimated abundance of wolves in Game Management Unit 2 (Prince of Wales Complex).

Source	Estimate[1]	Year	GMU2 Total
Person et al. (1996)	39 wolves per 1000 km^2	Fall 1994	352
ADFG (2009)	38 wolves per 1000 km^2	Fall 2003	343
ADFG (2015b)	24.5 wolves per 1000 km^2	Fall 2013	221
ADFG (2009)	9.9 wolves per 1000 km^2	Fall 2014	89

[1]Wolf density estimates were applied across the Game Management Unit 2 (GMU2) extrapolation area (9025 km^2). Note that the 2003 ADFG estimate was expressed as 326 wolves on POW and surrounding islands (~8615 km^2) rather than as a density, then converted to cover the same area.



be a valid subspecies of gray wolf and described the POW Complex as a discrete population. However, they also found that listing was not warranted at this time.

ABUNDANCE

Person et al. (1996) estimated the Southeast Alaska wolf population as between 700 and 1,000 individuals during the fall of 1995; island populations generally occur at higher densities than mainland populations. In 1995, an estimated 352 wolves populated POW and the complex of adjacent islands including Kosciusko, Dall, and Outside islands (i.e. the POW Complex); these wolves likely represented a third of the total Southeast Alaska wolf population and thus the highest-density wolf population in the state (Person et al. 1996, Person 2001). However, the abundance of wolves in the POW Complex has significantly decreased in the last two decades.

In 2013, Person and Brinkman developed a predator-prey model for POW and Kosciusko islands that represented past and future conditions. The researchers conducted a thought experiment as though the wolf had been listed as threatened under the Endangered Species Act (ESA), and used their model to simulate the likely outcome. The model included hypothetical data of a wolf harvest curtailment in 1996. Even with this hypothetical listing included in the model, the researchers found that “wolf and deer populations will decline substantially by 2045” (Person and Brinkman 2013).

ADFG estimated 221 wolves resided in the POW Complex in 2013, which represented a 37% decline during the 18 years since the 1995 estimate of 352. This decline caused great concern among experts, reflecting what they called the unraveling of a healthy ecosystem and previously functioning predator-prey relationship on POW Island (Person 2013, Person and Brinkman 2013).

One year later, in 2014, a follow-up population estimate by ADFG indicated a more dramatic decline: an estimate that only 89 wolves remained. This number reflected a 60% loss from the previous year and a total 75% loss over the 1994 to 2014 time period. Additionaly, the 2014 estimate was calculated prior to the documented legal harvest of 29 wolves in 2015.

In 2016, the USFWS concluded a status review for the Alexander Archipelago wolf subspecies in consideration of these changes in population abundance and habitat impacts. USFWS found the GMU2 population to be discrete under its distinct population segment policy, but did not find the population to be significant, citing that it constituted only 6% of the rangewide population on only 9% of the suitable range (US Fish and Wildlife Service 2016). Using the current depressed population numbers to make this finding appears to be circular reasoning. Although the current population may make up only 6% of the estimated total individuals, the historic GMU 2 population (circa 1995) constituted approximately 20% of Alexander Archipelago wolves. According to Table 6-1, POW wolves historically occurred in densities four times greater than today, likely among the highest density occurrence across their range.

WOLF HUNTING AND TRAPPING

Alaska classifies wolves as both furbearers and big-game species and allows harvest by both trapping and hunting. From 2001 to 2010, the average annual wolf harvest for Southeast (GMUs 1–5) was 152 animals (Alaska Department of Fish and Game 2012). During this time, the average annual harvests were 61 wolves for the mainland (GMUs 1 and 5) and 91 wolves for the islands (GMUs 2–3).

The trapping season for wolves in Southeast generally runs from late fall to late spring. The hunting season generally runs from early fall to late spring. Dates vary to some extent across units, and are currently significantly shortened in GMU2 (POW and adjacent islands). On the southern islands (GMUs 2 and 3), hunting and trapping mortality of wolves was significantly higher in areas with the highest road densities (Person et al. 1996, Person and Russell 2008).

Research shows that the legal harvest number significantly underestimates the total take of wolves in the POW area. Illegal take of wolves on the Forest is common and “may at times equal the legal harvest” (Person and Brinkman 2013). Person and Russell (2008) reported in their study of radio-collared wolves on POW Island that 47% of the total wolf take was from unreported illegal harvest.

HABITAT RELATIONSHIPS

The wolf is identified as a Management Indicator Species under the 2008 TLMP. The USFS selects Management Indicator Species for emphasis in planning, and monitors the species during forest plan implementation to assess the effects of management activities on their populations and the populations of other species whose habitat needs are similar (US Forest Service 2008b).

Throughout much of Southeast, particularly on the southern islands and portions of the mainland, wolves primarily prey upon deer, which represent the largest component (up to 77%) of their diet (Smith et al. 1987, Kohira 1995, Person et al. 1996). Person et al. (1996) estimated that the annual predation rate was approximately 26 deer per wolf. Pack size on the southern islands ranged from 2–16 wolves per pack, and home range size was correlated with pack size, which is in turn related to the area of winter deer habitat (Person 2001).

Critical winter deer habitat is a good indicator of habitat quality for wolves in southern Southeast (Person 2001). On northern POW Island (which has been extensively logged during the last 60 years), clearcuts within 30 years of logging and old-growth hemlock forests received the highest proportion of winter use by radio-collared deer (Yeo and Peek 1992). During winters with increasing snow depths, deer used old growth more than clearcuts. Optimal habitat conditions for deer in Southeast must encompass a diversity of habitats that provide deer with a variety of options to satisfy changing seasonal needs and variable weather conditions. Large- and medium-tree old growth (particularly at low elevations and on southerly exposures) has high habitat value for deer, particularly when deep snow accumulations occur (Hanley and Rose 1987, Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990).

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Melanie Smith

High road density is linked to increased wolf mortality rates in Southeast Alaska.

The absence of deer forage in second growth generally continues for more than a century following canopy closure (30–130 years). Therefore, clearcutting old growth and managing second growth on 100-to 120-year rotations significantly reduces foraging habitat for deer for 70%–80% of the timber rotation (Harris 1974, Wallmo and Schoen 1980, Alaback 1982). Experts describe this situation as "succession debt" (Person 2001, Person and Brinkman 2013) because the full impacts on wildlife, particularly deer, may not immediately be expressed, but will continue for many decades after timber harvesting.

This succession debt is most prounounced on the POW Complex, and has implications for the island's wolves. Over the next twenty years, an estimated 360,000 ac (146,000 ha) of clearcut land in GMU2 will be in the stem exclusion phase, equal to about 35% of the total historic productive old growth. Similarly, approximately 40% of the high-quality deer habitat in the POW Complex has been clearcut in the last 60 years. This reduction in deer habitat will likely translate to a significant population decline in deer, which will in turn precipitate a consequent decline in the number of wolves in the region.

In addition to potentially reducing the density of the wolf's primary prey, forest management also has a direct effect on wolf mortality. As deer populations decline, people in local communities may turn to predator control to limit competition for their deer hunting, which can result in illegal poaching and increased political pressure to raise the legal harvest (Person and Brinkman 2013). The current high rate of illegal wolf take in the POW Complex (Person and Russell 2008) suggests that some members of the community may already be practicing unauthorized "wolf control" to enhance deer populations.

The roads constructed for old-growth logging facilitate legal hunting and trapping as well as illegal poaching. Not surprisingly, hunting and trapping generally take place near roads and beaches because access is easier. Brinkman et al. (2009) found that deer hunters on POW Island generally do not travel more than 6 mi (10 km) from a road in pursuit of large game, with a median distance of 2 mi (3.2 km). The further away a game animal stays from a beach or road, the more likely it is to survive. The POW Complex has about 4,200 mi (6,760 km) of roads. With such an extensive network of existing roads, the average distance to any road within GMU2 is 2.1 mi (3.4 km), and only 1.7 mi (2.7 km) on POW Island itself, leaving little secure habitat for wolves or deer.

Wolf research in the lake states has identified a strong negative correlation between road density and wolf abundance, with wolves being extirpated in areas where road densities exceeded 0.9 mi/mi^2 (0.6 km/km^2) (Jensen et al. 1986, Mech et al. 1988, Fuller 1989). Similarly, in Alaska, Person and Russell (2008) found that mortality rates increase up to a road density of 1.4 mi/mi^2 (0.9 km/km^2), after which population instability ensues.

Road density in the region is high. Density averages 0.8 mi/mi^2 (0.5 km/km^2) across GMU2 and 1.1 mi/mi^2 (0.7 km/km^2) for the North POW Province (based on a 6-mi [10-km] search radius, approximately equal to the average size of the analysis units used in the Person and Russell study). Because those values are averages, many areas have density values well over 1.4 mi/mi^2 (0.9 km/km^2). These broad landscape patterns corroborate habitat modeling, expert opinion, and recent population estimates that illustrate heavy regional habitat impacts.

According to Person (2013), logging has a direct and quantitative impact on the health of wolf populations, especially on isolated POW Island:

"When about 40% of a [wolf] pack's total home range is logged and roaded, there is a very high risk that mortality (mostly from hunting and trapping) will exceed reproduction and the pack area becomes a population sink. Indeed, even when as little as 25% of a pack's home range is logged, the ratio of reproduction to mortality is very close to one. Sinks are only maintained by immigration of wolves from other areas, which…is not likely to happen on Prince of Wales Island given the population's isolation and small numbers."

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Audubon Alaska conducted a spatial analysis using the 25% and 40% thresholds identified by Person (2013) to identify wolf population sinks in GMU2. The analysis included all previously logged areas and all existing roads, buffered to 0.6 mi (1 km; the distance considered readily accessible to hunters and trappers, per Brinkman et al. (2009)). The analysis also used a search area equivalent to an average wolf core home range of 17 mi^2 (44 km^2) (D. Person, personal communication, March 2014). The data combination created a continuous surface that estimated the total logged and roaded area within a wolf home range. Based on the above road density thresholds, most of GMU2 is a population sink for wolves, with 69% classified as likely sink habitat (>40% logged and roaded), 9% more as potential sink habitat (>25% logged and roaded), and 22% as potential source habitat (<25% logged and roaded).

The southern portion of POW Island is less densely roaded, but still may not provide much refuge for wolf populations. This part of the island has lower habitat productivity and smaller deer populations (Woodford 2014), indicating poor habitat quality for wolves (Person 2001). The scarcity of prey likely prevents wolves in southern areas from achieving sufficient density to recolonize the heavily roaded northern areas. With increasing road-induced mortality in the north and insufficient habitat in the south, the POW wolves face an uncertain future.

CONSERVATION ISSUES

To many people, Alaskan wolves represent a symbol of wilderness and ecosystem integrity. For many years, the wolf population in the Lower 48 states was listed as endangered or threatened under the Endangered Species Act. Some portions of the population have now been recovered at great expense and effort, while others remain listed. Alaska has the opportunity and responsibility to avoid the mistakes that led to such situations. The wolf's large area requirements and ecological position as a top-level carnivore make it an important umbrella species for maintaining ecosystem integrity throughout its range in Southeast. And because of its vulnerability to cumulative human activities, the wolf also serves as an indicator of wildland values. These attributes justify identification of the wolf as a focal species for ecosystem management throughout its range in Southeast and the Tongass National Forest.

Currently, there are significant concerns about the Alexander Archipelago wolf in southern Southeast Alaska. This concern arises from a number of mutually reinforcing factors:

- Genetic evidence for designation as a subspecies (Alexander Archipelago population) and distinct population segment (POW Complex sub-population)
- Very small population estimate
- Steeply declining population trend
- Low female:male ratio resulting in impaired ability to recover population
- Cumulative broad-scale habitat fragmentation and degredataion which depress deer populations and thereby food abundance for wolves
- Persistent anthropogenic threats, including clearcut logging, road construction and rehabilitation, and poaching
- High levels of illegal take.

These myriad factors and the associated uncertainty around the future of the POW Complex discrete population of Alexander Archipelago wolves in particular call for prudent and conservative population management and habitat conservation. Hunting and trapping must take place at a sustainable level for the POW Complex wolf population to survive. The American Society of Mammologists (2015) estimates that 200 wolves are a minimum population needed in the POW Complex before further hunting and trapping should be considered. For now, ADFG, the Alaska Board of Game, and the Federal Subsistence Board should halt all hunting and trapping of wolves in the region, and conduct scientific research to identify a population goal and sustainabale population level. Once a population goal is identified and achieved, a conservative management regime should recognize the high rate of illegal take of wolves and the potential challenges the region's wolf population will face as deer populations on POW decline as a result of succession debt.

Along with these measures by the State, the Forest Service can take immediate and important steps to protect POW Complex wolves. The USFWS (2016) found timber to be the primary stressor on wolf and deer habitat in Southeast Alaska, and report expected further decline in the POW wolf and deer populations. To address this, the USFS should end large-scale old-growth clearcut logging and road-building. Second, the USFS should close unneccessary logging roads in the POW Complex to create large areas of habitat that are more difficult for legal and illegal hunters to access.

MAPPING METHODS

ADFG developed the wolf range layer based on expert input and known habitat associations (Alaska Department of Fish and Game 2016b).

The inset map shows areas predicted as potential sources, potential sinks, or likely sinks. Audubon mapped these patterns based on research by David Person, as described earlier in this account, published in Audubon's Prince of Wales Wolves report (2015a).

MAP DATA SOURCES

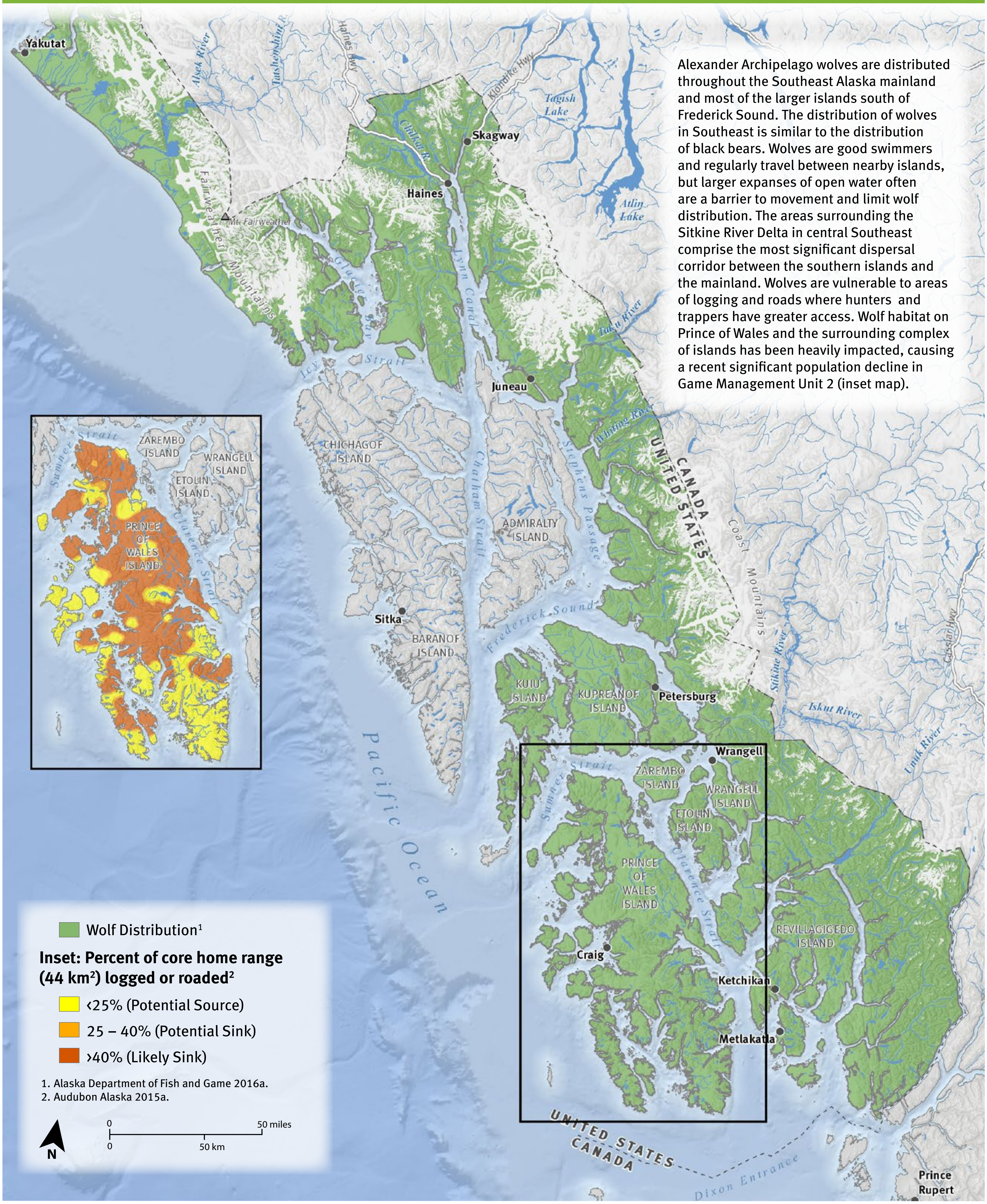
- Range: Alaska Department of Fish and Game (2016a)
- Wolf source-sink analysis: Audubon Alaska (2015a).

John Hyde

Audubon ALASKA

Alexander Archipelago Wolf

Alexander Archipelago wolves are distributed throughout the Southeast Alaska mainland and most of the larger islands south of Frederick Sound. The distribution of wolves in Southeast is similar to the distribution of black bears. Wolves are good swimmers and regularly travel between nearby islands, but larger expanses of open water often are a barrier to movement and limit wolf distribution. The areas surrounding the Sitkine River Delta in central Southeast comprise the most significant dispersal corridor between the southern islands and the mainland. Wolves are vulnerable to areas of logging and roads where hunters and trappers have greater access. Wolf habitat on Prince of Wales and the surrounding complex of islands has been heavily impacted, causing a recent significant population decline in Game Management Unit 2 (inset map).



Map 6.4: Alexander Archipelago Wolf

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BROWN BEAR

John Schoen and Scott Gende
Revised by Nils Warnock

Alaska remains the last stronghold in North America for the brown bear (*Ursus arctos*), supporting roughly 95% of the US population and 55% of the North American population (Miller et al. 1997, Miller and Schoen 1999, McLellan et al. 2008). Brown bears are indigenous to Southeast Alaska, and on the northern islands they occur in some of the highest-density populations on earth (Schoen and Beier 1990, Miller et al. 1997).

Hiking up a fish stream on the ABC Islands during late summer reveals a network of deeply rutted bear trails winding through tunnels of devil's club (*Oplopanax horridum*) and currant shrubs (*Ribes spp.*) beneath centuries-old, giant spruce (*Picea sitchensis*) trees where brown bears fish for spawning salmon (*Oncorhynchus spp.*). These riparian forests play an important role in the productivity and diversity of the Southeast rainforest ecosystem where brown bears, salmon, and large trees have been inextricably linked for millennia.

Studies of brown bears in Southeast highlight the fact that there are at least two clades of bears to consider: the brown bears of the Southeast mainland and the brown bears of the ABC islands. Genetic analyses have revealed new and remarkable insights into the biological diversity and geological history of Southeast bears. Mitochondrial DNA results (Talbot and Shields 1996b, Talbot and Shields 1996a) initially suggested that the brown bears of the ABC islands represented an ancient and unique lineage that separated from other brown bear populations approximately 550,000 to 700,000 years ago. Evidence indicated that the DNA of ABC island brown bears was most closely related to polar bears (*Ursus maritimus*) (Talbot and Shields 1996b, Talbot and Shields 1996a). Further microsatellite studies of ABC bears concluded that the bears of Baranof and Chichagof represented a genetic population distinct from the Admiralty population (Paetkau et al. 1998).

However, in a recent paradigm-changing paper presenting results of genome-wide sequence work on ABC bears, it was concluded that the ABC brown bears actually derive from a population of polar bears stranded in the area by the receding ice at the end of the last glacial period (Cahill et al. 2013). As this polar bear population hybridized with migrating brown bears from the mainland, an admixed population formed, with brown bear phenotypes and, to a certain degree, genotypes (Cahill et al. 2013). Clearly, the brown bears of ABC and adjacent islands represent an important component of the biodiversity of Southeast and continue to provide key information about the biogeographic history of this island ecosystem.

Brown bears are found in highest densities on the ABC islands where it is the only large omnivore; the wolf (*Canis lupus*) and black bear (*Ursus americanus*) occur primarily on the southern islands south of Frederick Sound and the mainland. Brown bears are generally absent on the larger islands to the south of the ABC islands. Notable is the lack of brown bears on POW Island, although fossil records indicate that brown bears historically occurred there as recently as about 7,000 years ago (Heaton et al. 1996). Brown bears appear to be regularly dispersed between the mainland coast near the Stikine River Delta and the islands of central Southeast, including Wrangell, Mitkof, Etolin, and Deer (Lowell 2004). People often see bears swimming the smaller (<1 mi [1.6 km]) channels between islands. In addition, brown bears, (albeit at significantly lower densities) are widely distributed on the Southeast mainland from the southern border with Canada to Yakutat Bay, particularly in the vicinity of the large transboundary river drainages (e.g. Flynn et al. 2010, Crupi et al. 2014).

Brown bears have the ability to capture many spawning salmon, as indicated by predation rates at many streams in Southeast and Southwest Alaska (Quinn et al. 2003). Bears often carry the captured salmon to the riparian forest where they are only partially consumed. This sequence, capture-carry-partial consumption, represents an important process for the riparian ecosystem in Southeast because it makes a tremendous amount of salmon-derived nutrients and energy available to riparian biota (Gende et al. 2002). For example, salmon, which are rich in nutrients and energy, can represent an important food source for scavengers that feed on carcasses abandoned by bears in the riparian area. Insects, birds, mammals, and many other species use these carcasses (Cederholm et al. 2000, Gende et al. 2002, Schindler et al. 2003). The nutrients from carcasses and bear scat also leach into the forest soil and are taken up by riparian plants, including trees (Ben-David et al. 1998, Hilderbrand et al. 1999a). Growth rates of plants have also been correlated with the amounts of salmon-derived nitrogen available to them, particularly in areas where bears typically carry the fish to be consumed (Helfield and Naiman 2001, and see Kirchhoff 2003a). The ecological importance of bear-salmon relationships to the forest ecosystem is complex and not completely understood; but clearly, the interrelationships among salmon, bears, large-tree forests, and other myriad organisms are critically important to the integrity of these productive and increasingly rare ecosystems.

A female brown bear walks the beach near Pack Creek on Admiralty Island.

David Shaw

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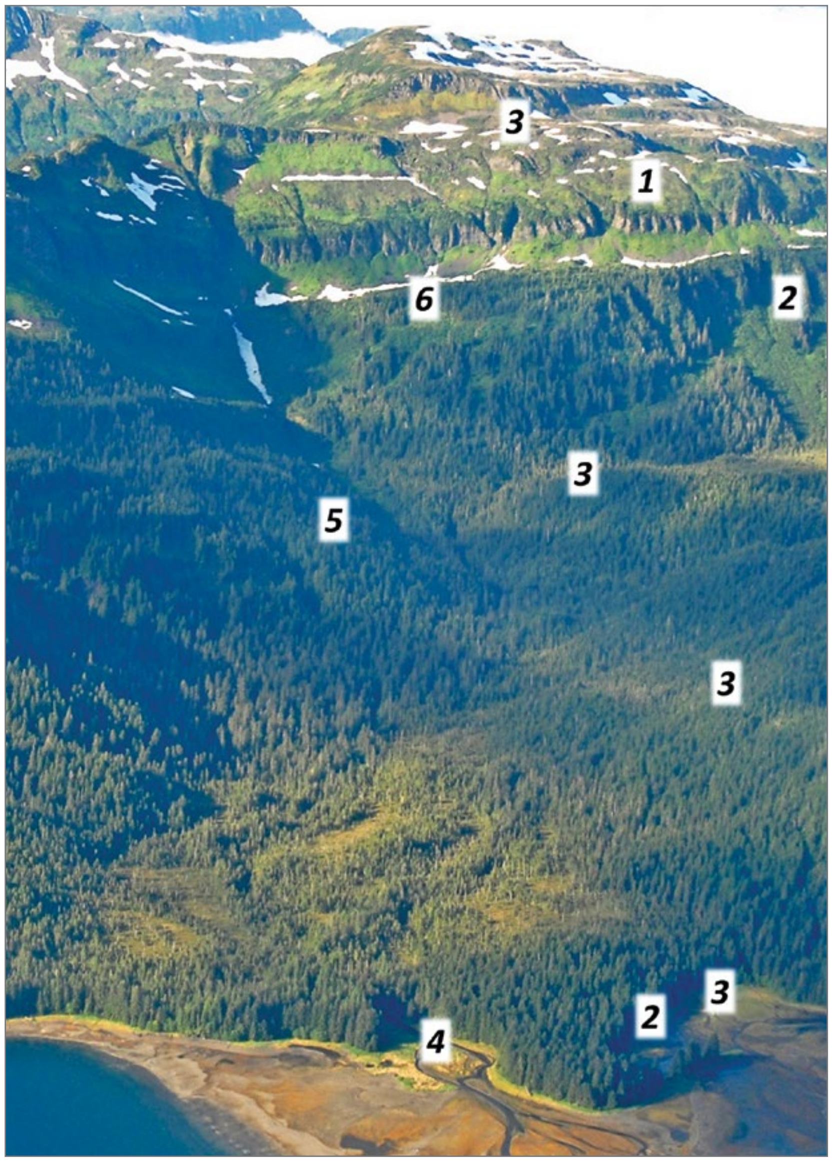
FIGURE 6-4 The Annual Cycle of a Southeast Brown Bear

1. **Den Emergence:** From late March through May most bears emerge from their high-country dens. Males leave earliest and females with newborn cubs latest.
2. **Spring Foraging:** Bears generally move down from den areas in search of new succulent vegetation including sedges, skunk cabbage, roots, or animal carcasses. South-facing avalanche slopes, fens, wet forests, and beaches are commonly used habitats.
3. **Early Summer Travels:** From mid-May through mid-July, many bears are actively engaged in breeding and individuals are widely distributed from sea level to alpine ridges. Some bears continue to use tidal sedge flats for grazing while others travel and graze extensively in lush subalpine meadows. Upland forest and avalanche slopes are also used extensively.
4. **Salmon Spawning:** By mid-July, most bears concentrate their activities in riparian forests and tidal estuaries in search of good fishing sites to feast on salmon. Small, shallow streams are the most efficient fishing sites and bears spend much of their time fishing, resting within the cover of riparian forests within 500 ft (152 m) of salmon streams. Dominant bears always get the best fishing sites. Sedges and berries also remain important food items at this time.
5. **End of the Fish Runs:** As most fish runs wind down by mid-September, many bears begin moving into the upper forest and onto avalanche slopes where they feed on currants and devil's club berries.
6. **Fall Denning:** By mid-October, pregnant females begin entering their winter dens. Most dens occur on steep slopes above 1,000 ft (305 m). Dens are often excavated under the root structure of large old-growth trees. In some areas, natural rock caves are also used. Males are the last to enter winter dens.



John Schoen

Brown bears travel extensively and use a variety of habitats throughout their range. The average sizes of annual home ranges for radio-collared bears on Admiralty Island were 39 mi^2 (100 km^2) and 14 mi^2 (37 km^2) for males and females, respectively (Schoen and Beier 1990), and were comparable to home ranges of radio-collared bears on Chichagof Island (Titus and Beier 1999, Flynn et al. 2007). These home range areas are much smaller than those found along the mainland coast like the Malaspina Forelands near Yakutat (Crupi et al. 2014), to the southeast of Wrangell (Flynn et al. 2010), and in interior portions of North America (Schwartz et al. 2003), presumably because salmon and other food resources are more concentrated on the ABC islands (see graph by Crupi et al. 2014). Seasonal habitat use often varies widely among individuals of both sexes (Titus and Beier 1999, Flynn et al. 2007). These seasonal habitat preferences are affected by changing food quality and abundance.

Because bears are large bodied, are relatively inefficient at digesting low-quality forage, and may only be active for five to eight months of the year, they must concentrate their foraging activity on abundant, high-quality foods. Bears have adapted to periods of food scarcity by seeking secluded refuge in a dormant state in winter dens. Winter denning enables bears to reduce their high metabolic costs of activity and draw upon their accumulated fat reserves until high-quality food again becomes abundant. A den also provides a secure place for a pregnant female to give birth to one to four tiny cubs, usually in January.

Figure 6-4 and the following sections briefly summarize the annual cycle of a brown bear.

Spring: Den Emergence through Sea-Level Green-up (late March to mid-May)

Most brown bears in Southeast emerge from high-elevation dens (mean of 2,100 ft [640 m]) during April and May (Schoen et al. 1987). During spring, brown bears are generally widely scattered from sea level, where they forage on tidal sedge flats, to south-facing avalanche slopes and higher subalpine ridges. The mean elevation of radio-collared brown bears on Admiralty and Chichagof islands during spring was above 1,000 ft (305 m) (Schoen and Beier 1990). Upland old-growth forests and avalanche slopes were the habitats most extensively used by radio-collared brown bears on Admiralty and Chichagof islands during spring (Schoen and Beier 1990, Titus and Beier 1994). During spring, brown bear diets on Admiralty Island are composed largely of sedges (*Carex spp.*), other green vegetation, and roots (McCarthy 1989). Skunk cabbage roots (*Lysichton americanum*) and horsetail (*Equisetum spp.*) are particularly important spring forage plants. The primary animal components of the spring diet of Admiralty Island bears are deer (*Odocoileus hemionus sitkensis*), voles (*Microtus spp.*), and herring (*Clupea pallasii*) roe (McCarthy 1989).

Early Summer: Green-up to Beginning of Salmon Runs (mid-May to mid-July)

By mid-May, most bears have emerged from their winter dens. Early summer is the peak of the breeding season in Southeast, and courting pairs are often observed in coastal sedge meadows and on upper subalpine and alpine ridges. During early summer, bears are widely distributed and habitat use varies greatly. By mid-June, many radio-collared bears on Admiralty and Chichagof islands were observed at higher elevations where they foraged on the new growth of succulent plants in alpine and subalpine meadows and avalanche slopes (Schoen and Beier 1990, Titus et al. 1999). Old-growth forest habitat is used substantially by bears throughout this season both for feeding and travel between coastal and alpine habitats. During early summer, brown bear diets on Admiralty Island are dominated by sedges, other green vegetation, and roots (McCarthy 1989).

Late Summer: Primary Salmon Spawning (mid-July to mid–September)

By mid-July, most brown bears in Southeast have moved to low-elevation coastal salmon streams (Schoen and Beier 1990, Titus and Beier 1999, Flynn et al. 2007, Flynn et al. 2010, Crupi et al. 2014). During late summer and early fall, bears consume large quantities of fish to rebuild their body condition and lay on essential fat reserves required to successfully reproduce and survive another four to seven months in winter dens. Brown bears can increase their body mass over the summer and fall by as much as 50% when salmon are abundant

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(Hilderbrand et al. 1999b). Salmon make up a major portion of the brown bear diet, although sedges, skunk cabbage, and the berries of devil's club, blueberries (*Vaccinium spp.*), currant, salmonberry (*Rubus spectabilis*), strawberries (*Frageria spp.*)and twisted stalk (*Streptopus spp.*) are also used (McCarthy 1989, Willson and Gende 2004, Crupi et al. 2014).

In this period, brown bears are more concentrated than at any other time of the year and their activities are most focused on fishing for spawning salmon along low-elevation fish streams. During this period, riparian old-growth forest represented about half of the habitat use of radio-collared bears on Admiralty and Chichagof islands. Two-thirds of all Admiralty Island bear locations occurred within a 525-ft (160-m) band on either side of salmon streams (Schoen and Beier 1990).

The additive costs of hibernation, gestation, and lactation put great energetic demands on female bears in general (Watts and Jonkel 1988, Farley and Robbins 1995), and reproductive success is strongly correlated to fall body weight in black, polar, and brown bears (Rogers 1976, Schwartz and Franzmann 1991, Atkinson and Ramsay 1995, Hilderbrand et al. 1999c). The availability of spawning salmon as a food resource in late summer and fall positively affects body size, reproductive success, and population density of brown bears and represents a major element of bear habitat quality (Hilderbrand et al. 1999c, Crupi et al. 2014).

Although salmon streams provide highly valuable feeding habitat in Southeast, not all brown bears use salmon streams. In late summer on northeast Chichagof Island, selection probabilities for habitats used by male bears were highest in estuaries and closed forest, while for females it was estuaries followed by avalanche slopes (Flynn et al. 2007). On Admiralty Island, some females (14% of radio-collared bears) and their offspring remained in interior areas of the island at higher elevations (Schoen et al. 1986). This subpopulation of "interior" bears did not use salmon (Hilderbrand et al. 1996, Ben-David et al. 2004). Female brown bears that remained at higher elevations foraged on sedges, grasses, and other green vegetation, and also consumed deer and voles (McCarthy 1989). It is likely that a degree of avoidance of salmon streams by females with young cubs is a tradeoff between reducing risks of cub mortality in high bear densities around fish streams and acquiring higher-quality food (Wielgus and Bunnell 1995, Ben-David et al. 2004).

Fall: Decline in Fish Runs to Denning (mid-September to mid-December)

By mid-September, many salmon runs are in decline, herbaceous vegetation has gone to seed, and peak berry production at sea level is over. Most brown bears begin to move away from coastal salmon streams during September and head toward higher elevations. Upland old growth and avalanche slopes were the habitat types most used by radio-collared brown bears during fall on Admiralty and Chichagof islands (Schoen and Beier 1990, Titus and Beier 1999). During this time, it is important for bears to pack on the fat in preparation for their long winter dormancy. Some bears, particularly males, may continue to fish for salmon into November on streams with late runs. However, most bears move into higher elevation avalanche slopes where they forage on berries, particularly devil's club and stink currants (*Ribes bracteosum*) (McCarthy 1989). Other plants used include skunk cabbage, sedges, red elderberry (*Sambucus racemosa*), and roots of beach lovage (*Ligusticum scoticum*).

By early October, the first winter snowfall usually occurs in the high country, and herbaceous forage is no longer available after the first frosts. Winter denning begins in October and November. Pregnant females are the first to enter winter dens; females with older cubs and single females den later; males are the last to seek out winter den sites. By mid-November, about 80% of males and 95% of female brown bears have entered dens and begun their winter dormancy. Dens occur on moderate to steep slopes, ranging from about 350 to 4,300 ft (107 to 1311 m), but usually between about 500 to 2,000 ft (152 to 610 m) elevation (Schoen et al. 1987, Flynn et al. 2010, Crupi et al. 2014). Upland old-growth forest habitat at higher elevations is most commonly used by brown bears, although alpine and subalpine slopes are also used substantially for denning. Dens on Admiralty and Chichagof islands most commonly occurred in natural rock cavities or were excavated under the root structure of old-growth trees or into earthen slopes (Schoen et al. 1987). On Admiralty and Chichagof islands, radio-collared male brown bears spent an average of 165 days in winter dens, compared with 211 days for females with newborn cubs (Schoen et al. 1987). Flynn et al. (2010) noted that at least four of their marked bears left their original den sites for extended periods of time during the winter.

Brown bear densities on the ABC islands are estimated between 823 and 1700 bears/1000 mi^2 (318 to 656 bears/1,000 km^2), which are among the highest in the world. Elsewhere in Alaska, brown bear densities ranged from 26 bears/1000 mi^2 (10 bears/1,000 km^2) in the Alaska Range to 1427 bears/1000 mi^2 (551 bears/1,000 km^2) in the Katmai region of the Alaska Peninsula (Miller et al. 1997).

Human Management

Brown bears have been a species of high human interest throughout Southeast for centuries. Bears are deeply embedded within the culture of the Tlingit and Haida people. The Tlingit people of Admiralty Island call their island "Kootznoowoo," which means "fortress of the bear." Throughout much of the late nineteenth and twentieth centuries, brown bears in Southeast, particularly Admiralty Island bears, attracted big game hunters from all over the world. Today, Southeast brown bears continue to attract big game hunters as well as increasing numbers of wildlife enthusiasts who want to observe bears in their natural habitat.

During the last 100 years, brown bear conservation in Southeast has been highly controversial. Although President Theodore Roosevelt recommended in 1901 that the ABC islands become a bear preserve, many local people in Southeast advocated for the extermination of brown bears because they were dangerous and an obstacle to developing the region's resources.

The first plan for the management of brown bears on Admiralty Island was prepared by the Alaska Game Commission and National Forest Service in 1932 (Heintzleman and Terhune 1934). For many years afterward, bear conservation was assured. Controversy over brown bear management erupted when the USFS established several 50-year timber contracts in the Tongass in the 1950s and the demand for timber increased. Major logging began on Admiralty Island in the 1960s. After this initial logging another large contract was planned for Admiralty Island and, in reaction, a lawsuit was filed in 1970 and was followed by appeals that stretched over many years. In 1978, President Jimmy Carter declared Admiralty Island a National Monument under the Antiquities Act. In 1980, much of Admiralty Island was designated by Congress, under the Alaska National Interest Lands Conservation Act (ANILCA), as the Kootznoowoo Wilderness.

Brown bear hunting remains an important and highly valued recreational activity in Southeast and particularly on the ABC islands. The average annual harvest of brown bears for all of Southeast is approximately 210 bears (~4% of estimated minimum population), of which about 80% is by nonresidents. The ABC islands (GMU 4) support the highest bear harvest in Southeast and rank the third highest in the state behind Kodiak and the Alaska Peninsula. While harvest of bears within the GMUs (where data are collected) generally falls within guidelines (Alaska Dept of Fish and Game 2011), the annual human-caused mortality of brown bears in GMU4 in recent years is of management concern (US Forest Service 2012).

Interest in brown bear viewing in Southeast has a long history associated with the first hunting closures established on Admiralty Island at Pack Creek and Thayer Mountain in 1934 (Howe 1996). The Pack Creek Bear Viewing Area-Stan Price State Game Sanctuary on Admiralty Island is one of the most popular and well-known areas for brown bear viewing in the state. Public use of this area increased steadily from 668 people in 1988, when a permit system was established, to 1,585 people in 2014 (Alaska Dept of Fish and Game 1998; personal communication, Kevin Hood, USFS, Dec 2015). Additional viewing areas in Southeast

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include the Salt Lake-Mitchell Bay Closed Area on Admiralty Island, Port Althorp Closed Area on northern Chichagof Island, Anan Creek Wildlife Viewing Area on the mainland south of Wrangell, Fish Creek Bear Viewing Area near Hyder, and Chilkoot River State Recreation Site near Haines. The latter three sites offer viewing of both black and brown bears. Clearly, bear viewing is a growing and economically valuable activity throughout Southeast.

CONSERVATION ISSUES

Because of their large habitat area requirements and varied habitat use, brown bears represent an important umbrella species for maintaining ecosystem integrity throughout their range in Southeast. The coastal brown bear may also be considered a keystone species because of its role in transferring marine nutrients into the terrestrial environment; and because of its vulnerability to cumulative human activities, the brown bear serves as an indicator of wildland values. These attributes justify identifying the brown bear as a focal species for ecosystem management throughout its range in Southeast and the Tongass National Forest. To ensure that brown bear populations are well represented throughout their natural range in Southeast and available for human use and enjoyment, areas with a variety of high-value habitat should be identified and protected at the watershed scale within each biogeographic province that supports brown bear populations.

The Alaska population densities of coastal brown bears, where salmon are abundant, are significantly higher (up to 80 times) than those of interior bears without salmon (Miller et al. 1997). Riparian forest habitat in association with productive salmon spawning streams is considered seasonally critical habitat and a key component for ensuring productive brown bear populations in Southeast (Schoen and Beier 1990, Titus et al. 1999).

The brown bear is identified as a Management Indicator Species under the 1997 TLMP. Management Indicator Species are selected by the USFS for emphasis in planning and are monitored during forest plan implementation to assess the effects of management activities on their populations and the populations of other species with similar habitat needs (US Forest Service 1997b). The brown bear is also one of six Southeast species identified by the USFS (US Forest Service 1997b) as having special management concerns.

Although brown bears are very adaptable and once ranged widely across the northern hemisphere, they possess many biological characteristics that increase their vulnerability to human interactions and forest management (Schoen 1990). For example, bear traits of high ability to learn, omnivorous diet, and opportunistic behavior have allowed them to exploit a variety of food resources over a wide range of habitats. However, because bears have relatively inefficient digestive systems for processing low-quality forage (Bunnell and Hamilton 1983) and are active for only a portion of the year, they must exploit the most valuable feeding areas. This feeding requirement often brings them into contact with humans who are using the same productive lands (such as coastal areas, valley bottoms, and fish streams). Along the southern mainland coast of the Southeast, bears are highly vulnerable to spring and fall hunting because of their propensity to move to estuarine and beach fringe habitats (Flynn et al. 2010).

While old-growth forest habitat is used extensively by brown bears in Southeast, clearcuts were sparingly used by radio-collared bears on Chichagof Island (Schoen et al. 1994, Titus and Beier 1994). Riparian areas that have been clearcut with little or no buffer along salmon spawning streams receive limited use by brown bears (Schoen et al. 1994, Titus and Beier 1999); further, the dense second-growth forests that succeed clearcuts offer poor foraging habitat for bears and other herbivores. Therefore, the conversion of old growth to younger forests will reduce habitat value for brown bears in Southeast and potentially decrease the ecological services (such as transfer of marine nutrients to riparian forests and seed dispersal) that bears provide.

Roads generally result in harmful impacts to large carnivores (Noss et al. 1996, Trombulak and Frissell 2000, Person and Brinkman 2013). The construction of roads into roadless brown bear habitat has been demonstrated by many investigators to have significant adverse impacts on bear populations by increasing human access, which results in displacement of bears or the direct mortality of bears through legal hunting, defense of life or property kills, illegal killing, and road kills (McLellan and Shackleton 1989, Mattson 1990, McLellan 1990, Schoen et al. 1994, Mace et al. 1996, Apps et al. 2004).

In Southeast, brown bears are most concentrated during late summer (mid-July through mid-September) in riparian forest habitat associated with anadromous spawning streams. Maintaining this important riparian habitat and abundant salmon runs is considered essential for maintaining productive brown bear populations in Southeast (Schoen et al. 1994, Titus and Beier 1999). The maintenance of riparian buffers along anadromous salmon streams is also vitally important for sustaining productive salmon runs (US Forest Service 1995). Although riparian forests make up only a small portion of the land base of Southeast, they have been heavily and disproportionately logged (Shephard et al. 1999, Albert and Schoen 2013).

In 1996 and 1997, the USFS convened a brown bear risk-assessment panel to assess the likelihood that the alternatives in the revision to the TLMP would result in habitat sufficient to support viable and well-distributed brown bear populations across their historical range in the Tongass National Forest. The panel recommended a 500-ft (153-m) buffer along each side of anadromous salmon streams (Swanston et al. 1996). More recently, based on studies of collared brown bears on Northeast Chichagof Island, either complete watershed protection or no-cut buffers of 1000 ft (305 m) were recommended for maintaining abundant, healthy brown bear populations (Flynn et al. 2007). The panel also unanimously agreed that the likelihood of maintaining viable and well-distributed populations of brown bears declined with increasing acres of forest harvested. For reasons discussed above, the panel stressed the importance of maintaining roadless reserves distributed throughout the range of brown bears.

Conservation of brown bears in Southeast depends on maintenance and conservation of key habitats, including important food resources, and management of mortality rates within sustainable levels. Maintaining the productivity of Pacific salmon stocks throughout Southeast is an essential component of conserving brown bear populations.

MAPPING METHODS

To evaluate areas as habitat for brown bear, the habitat capability model developed by Schoen et al. (1994) and applied in the TLMP (US Forest Service 1997b), was used (Albert and Schoen 2007b). This model was designed to evaluate habitat capability on a landscape scale based on (1) habitat characteristics and (2) proximity to human activity. Application of this model provided an index of relative habitat values at a landscape scale, and not prediction of density or population size. Availability of salmon is one primary characteristic of high-quality habitat for brown bears in late summer. Vegetation types specified in the model include floodplain forest, beach-fringe forest, upland forest, clearcut or second-growth, subalpine forest, avalanche slopes, alpine tundra, estuary, and other.

In addition to the habitat distribution, this map also shows the top watershed in each biogeographic province, as well as information on how the brown and black bears are distributed throughout the region, based on Cook and MacDonald (2007).

MAP DATA SOURCES

- Habitat suitability index model: Albert and Schoen (2007b)
- Bear regions: Cook and MacDonald (2007)
- Mammal viewing hotspots: Audubon Alaska (2015b), based on Alaska Department of Fish and Game (2015c) and Alaska Department of Fish and Game (2015d).

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BLACK BEAR

John Schoen and Lily Peacock
Revised by Nils Warnock

The black bear (*Ursus americanus*) is the most abundant bear in Alaska. It is indigenous to Southeast Alaska where the species is common along the mainland coast and southern islands. Throughout their range in Southeast, black bears are often observed during spring and early summer grazing along tidal sedge flats at dusk.

Most Southeast black bears have the characteristic coloration of a black coat and brown muzzle. Some brown-colored “cinnamon bears” occur on the mainland, and a white to blue color-phase “glacier bear,” although rare, occurs most commonly on the northern mainland between Juneau and Yakutat. The subspecies *U.a. pugnax* is recognized as occurring throughout most of Southeast (MacDonald and Cook 1999). The subspecies *U. a. emmonsii* also is recognized near Yakutat Bay and includes the glacier bear color-phase (MacDonald and Cook 1999).

Adult male black bears in Alaska weigh from 200 to more than 400 lb (91–182 kg), with adult females weighing about half that amount. Southeast bears are the largest black bears in Alaska, and some big males may weigh more than 500 lb (227 kg).

Black bears are distributed along the entire Southeast mainland and on most of the southern islands of the Alexander Archipelago from the Canadian border to Frederick Sound (except Warren, Coronation, and Forrester islands) (Klein 1965b, Manville and Young 1965, MacDonald and Cook 1999). Black bears do not occur on the islands north of Frederick Sound, including the ABC Islands, which are inhabited by brown bears. Black bears occur on Douglas Island near Juneau and Sullivan Island in Lynn Canal. Throughout the islands, the black color-phase is predominant.

In comparison to brown bears, black bears are generally more secretive, more tolerant of human activity, less aggressive and threatening to humans, and have higher reproductive rates than brown bears. Therefore, the vulnerability of black bears to resource development and increasing human interactions is likely lower than for brown bears.

Habitat loss and fragmentation of forestland, however, has isolated some peripheral populations, increasing conservation concerns throughout the southern range of the black bear in North America (Servheen 1990). And because of its vulnerability to cumulative human activities, the black bear may serve as an indicator of wildland values. Because bears are large bodied, are relatively inefficient at digesting low-quality forage, and remain dormant for approximately half the year, they must concentrate their foraging activity on abundant, high-quality foods. Bears have adapted to periods of food scarcity by seeking secluded refuge in a dormant state in winter dens. Winter denning enables bears to reduce their high metabolic costs of activity and draw on their accumulated fat reserves until high-quality food again becomes abundant. Dens also provide a secure place for pregnant females to give birth to one to four tiny cubs, usually in January. In two studies on the mainland near Juneau, home ranges were 4–5 mi^2 (10–13 km^2) (Barten 2002).

Most black bears in Southeast probably emerge from winter dens during April and May. Presumably like brown bears, males leave their winter dens before females, particularly females with spring cubs. Following den emergence, many black bears are observed foraging on tidal sedge flats and south-facing avalanche slopes for newly emergent sedges and other vegetation (Erickson et al. 1982). In late May and early June, Sitka black-tailed deer fawns (*Odocoileus hemionus sitkensis*) are an important food item.

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A black bear female and two cubs walking a salmon stream in the fall searching for fish.

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By mid-summer, many black bears in Southeast seek out anadromous fish streams where they fish for spawning salmon (*Oncorhynchus spp.*). On the mainland, where black bears overlap with brown bears (*Ursus arctos*), black bears may use salmon streams less frequently to avoid conflict with dominant brown bears. The availability of spawning salmon as a food resource in summer and fall positively affects body size in bears, and reproductive success is strongly correlated to fall body weight in black and brown bears (Rogers 1976, Schwartz and Franzmann 1991, Hilderbrand et al. 1999c).

During summer and fall, black bears also consume abundant berries when available, including salmonberries, blueberries, currants, and devil's club berries (*Vaccimium spp.*). Habitats with abundant berry crops include riparian forest (salmonberry, currants, devil's club), avalanche slopes (salmonberry, currants, devil's club), young clearcuts (salmonberries, blueberries), and alpine-subalpine ridges (blueberries).

By early October, the first winter snowfall generally occurs in the high country and most herbaceous forage is unavailable after the first frosts. Winter denning begins in October and November. Bears require large-diameter trees and snags for denning. Because large trees and snags occur only in old-growth forests (Kramer et al. 2001), old growth represents important winter denning habitat.

POPULATION INFORMATION

Peacock (2004) reported one of the highest-density populations of black bears in North America on northern Kuiu Island. The northern Kuiu density estimate was 3.9 bears/mi^2 (1.5/km^2). In contrast, measured black bear densities on the Kenai Peninsula and in the Susitna basin of Southcentral Alaska were 0.7 and 0.4 bear mi^2 (0.27 and 0.17 bear/km^2), respectively (Schwartz and Franzmann 1991, Miller et al. 1997).

Few other population studies or density estimates have been conducted on black bears in Southeast. However, in 2002 the ADFG (Alaska Dept of Fish and Game 2002) estimated black bear numbers, assuming a density of 1.5 bears/mi^2 (0.58 bear/km^2) throughout forested habitat, in each GMU throughout Southeast.

The ADFG estimates for black bear numbers throughout forested habitat were 7,666 bears for the Southeast mainland from the Canadian Border to Yakutat and 8,740 bears for the southern island population. The total population estimate of more than 16,000 black bears for Southeast may be conservative based on Peacock's research. Although these estimates should be considered very general, the southern island populations likely occur at higher densities than the mainland populations.

No population trend data appear to exist for black bear populations in Southeast Alaska. The black bear is one of the most popular species of big game in Southeast and is hunted by resident and nonresident sport hunters and local subsistence hunters. The 1991–2000 10-year reported annual kill (including sport hunting, defense of life or property, and other) of black bears on the Southeast mainland from the Canadian Border to Yakutat (including Revillagigedo and adjacent islands near Ketchikan) was 224 bears (Alaska Dept of Fish and Game 2002).

Forest management influences habitat quality for bears and also expands road infrastructure, which increases human access (Schoen 1991). In nearly all areas of Southeast, the reported annual kill of black bears has increased significantly (e.g. Pinjuv 2013). This area has been receiving substantial hunting pressure because it is widely recognized for producing trophy black bears. Kuiu Island accounts for the bulk of the harvest (Lowell 2002). The expanding harvest of black bears is compounded by the increasing density of roads that are being constructed concurrently with logging in the southern islands.

Although old-growth forest habitats are often used by black bears in Southeast, young clearcuts are also used extensively by black bears for foraging habitat (Erickson et al. 1982, Lindzey 1986). However, more than 25 years after logging, clearcuts become stem-exclusion forest. Over time, the conversion of old-growth forest to a mix of clearcuts and second growth can be expected to reduce both foraging and denning habitat for black bears (Lindzey 1986).

National Park Service

Glacier bear color-phase of black bear.

CONSERVATION ISSUES

Because of large habitat area requirements and varied habitat use, bears are an umbrella species for maintaining ecosystem integrity throughout their range. The black bear is identified as a Management Indicator Species under the TLMP of 1997 and the Amendment of 2008 (US Forest Service 1997b;2008a). Management Indicator Species are selected by the USFS for emphasis in planning and are monitored during forest plan implementation to assess the effects of management activities on their populations and the populations of other species with similar habitat needs (US Forest Service 1997b). It is reasonable to assume that black bears (like brown bears) might play a role in transferring marine nutrients into the terrestrial environment and, therefore, could be considered a keystone species.

To ensure that black bear populations are well represented throughout their natural range in Southeast, areas with a variety of high-value habitat should be identified and protected at the watershed scale within each biogeographic province that supports productive bear populations. The associated map highlights the top-ranked watershed for black and brown bear summer foraging habitat for each biogeographic province.

Roads generally result in harmful impacts to large carnivores (Noss et al. 1996, Trombulak and Frissell 2000), including black bears (Edwards et al. 2013). The construction of roads into roadless black bear habitat will increase human access, which will likely increase the direct mortality of bears through legal hunting, kills in defense of life or property, illegal killing, and road kills.

Little habitat research has been conducted on black bears in Southeast, and this lack of information must be corrected. Conservation of black bears in Southeast will require a comprehensive assessment of bear habitat relationships and a better understanding of the effects of forestry and roads on bear populations.

Maintaining important riparian habitat and abundant salmon runs is considered essential for maintaining productive brown bear populations in Southeast (Schoen et al. 1994, Titus and Beier 1999) and is likely also important for black bears. The maintenance of riparian buffers along anadromous salmon streams is also vitally important for sustaining productive salmon runs (US Forest Service 1995). Although

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riparian forests make up only a small portion of the land base of Southeast, they have been heavily and disproportionately logged (Shephard et al. 1999, Albert and Schoen 2013).

In 1996 and 1997, the USFS convened a brown bear risk-assessment panel to assess the likelihood that the alternatives in the revision to the TLMP would result in habitat sufficient to support viable and well-distributed brown bear populations across their historic range in the Tongass National Forest. One major finding of the panel was that an undisturbed buffer (no harvest, no roads) along salmon-bearing streams where bears concentrate and feed helps to maintain brown bear habitat (Swanston et al. 1996). The final TLMP record of decision (US Forest Service 1997b) established riparian buffers for brown bears. There are no requirements in the TLMP for black bear riparian buffers. The brown bear risk-assessment panel stressed the importance of maintaining roadless reserves distributed throughout the range of brown bears. In addition, the TLMP fish and riparian risk-assessment panel identified roads as a high risk factor for anadromous fish. It is reasonable to assume that maintaining a network of roadless reserves also would be a sound investment for black bear conservation throughout their range in Southeast. Based on the Audubon-TNC conservation assessment, Southeast provinces with the greatest impacts on black bear habitat were North POW, Etolin / Zarembo, Kupreanof / Mitkof, and Kuiu which have lost 52%, 35%, 33%, and 30% of their original habitat value, respectively (Albert and Schoen 2007a).

Black bear conservation will be enhanced by the protection of key habitats, including important feeding and denning habitats, and management of mortality rates within sustainable levels. Maintaining the productivity of Pacific salmon stocks throughout Southeast is an essential component for conserving productive bear populations.

MAPPING METHODS

To evaluate areas as habitat for black bears, the brown bear habitat capability model was applied (Albert and Schoen 2007b). An interagency group of experts (representing ADFG, USFS, USFWS, Audubon, and TNC) concluded that, in the absence of empirical data on black bear habitat relationships, the brown bear model provided a reasonable representation of summer habitat capability for the black bear throughout its range in Southeast (Albert and Schoen 2007b). This model was designed to evaluate habitat capability on a landscape scale based on (1) habitat characteristics and (2) proximity to human activity. Application of this model provided an index of relative habitat values at a landscape scale, and not prediction of density or population size. Availability of salmon is one primary characteristic of high-quality habitat for bears in late summer.

In addition to habitat distribution, this map also shows the top bear watershed in each biogeographic province (Albert and Schoen 2007b), as well as information on how black and brown bears are distributed throughout Southeast Alaska, based on Cook and MacDonald (2007).

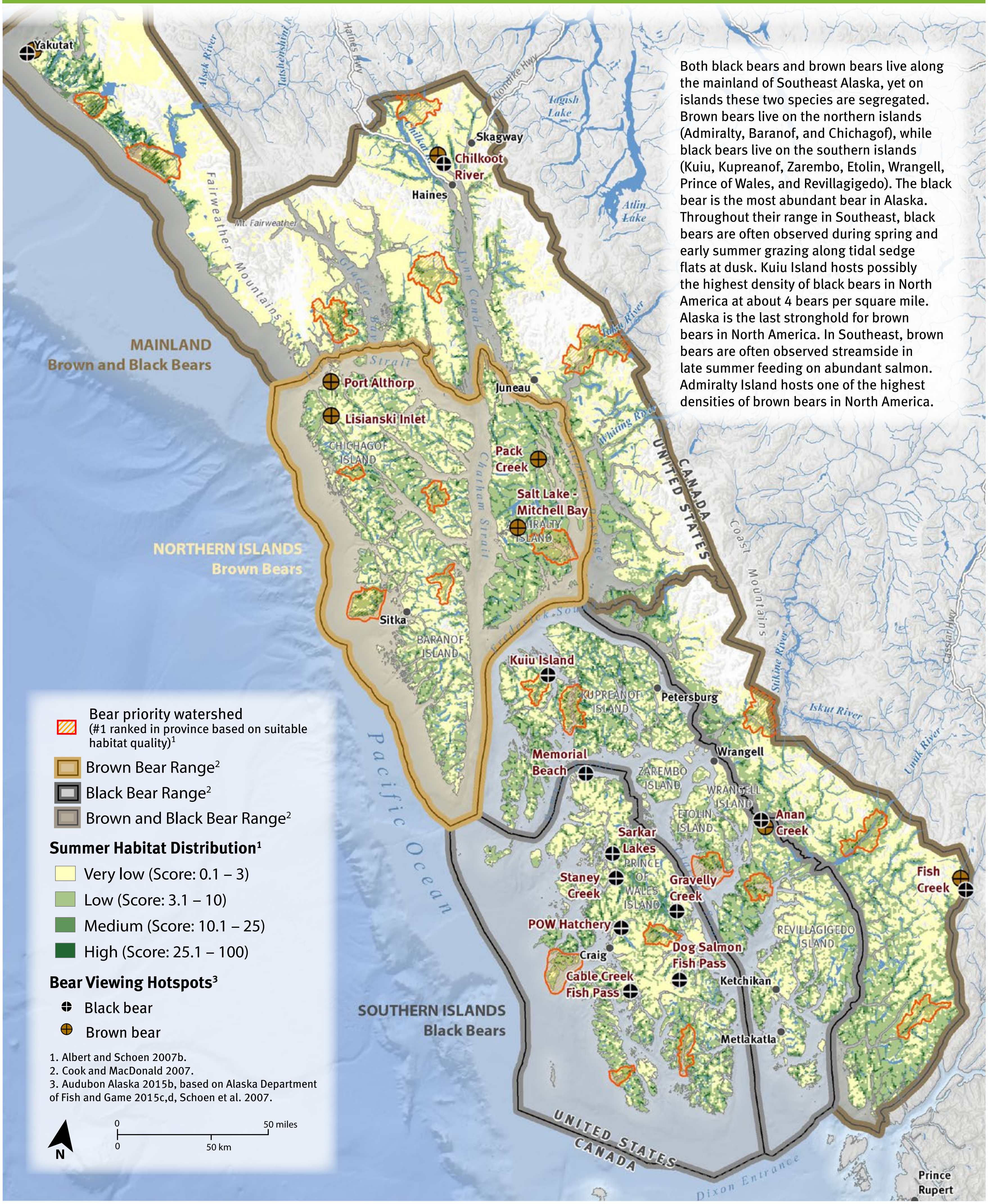
MAP DATA SOURCES

- Habitat suitability index model: Albert and Schoen (2007b)
- Bear regions: Cook and MacDonald (2007)
- Mammal viewing hotspots: Audubon Alaska (2015b), based on Alaska Department of Fish and Game (2015c) and Alaska Department of Fish and Game (2015d).

Bob Armstrong

Brown Bear and Black Bear

Both black bears and brown bears live along the mainland of Southeast Alaska, yet on islands these two species are segregated. Brown bears live on the northern islands (Admiralty, Baranof, and Chichagof), while black bears live on the southern islands (Kuiu, Kupreanof, Zarembo, Etolin, Wrangell, Prince of Wales, and Revillagigedo). The black bear is the most abundant bear in Alaska. Throughout their range in Southeast, black bears are often observed during spring and early summer grazing along tidal sedge flats at dusk. Kuiu Island hosts possibly the highest density of black bears in North America at about 4 bears per square mile. Alaska is the last stronghold for brown bears in North America. In Southeast, brown bears are often observed streamside in late summer feeding on abundant salmon. Admiralty Island hosts one of the highest densities of brown bears in North America.



Map 6.5: Brown Bear and Black Bear

REFERENCES

Alaback, P. B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. *Ecology* 63:1932-1948.

Alaback, P. B. and F. Herman. 1988. Long-term response of understory vegetation to stand density in Picea-Tsuga forests. *Canadian Journal of Forest Research* 18:1522-1530.

Alaback, P. B. and J. C. Tappeiner. 1984. Response of Understory Vegetation to Thinning in the Sitka Spruce-Western Hemlock Forests of Southeastern Alaska. Forest Science Laboratory. US Forest Service, Juneau, AK.

Alaska Department of Fish and Game. 1998. Brown Bears of Unit 4, Past, Present and Future: A Status Report and Issues Paper. Alaska Department of Fish and Game, Juneau, AK.

______. 2002. Black Bear Managment Report of Survey-Inventory Activities, 1 July 1998 - 30 June 2001. Project 17.0. Alaska Department of Fish and Game, Juneau, AK.

______. 2009. Wolf Management Report of Survey and Inventory Activities, 1 July 2005-30 June 2008. Alaska Department of Fish and Game.

______. 2011. Brown Bear Management Report of Survey-Inventory Activities, 1 July 2008 - 30 June 2010. Alaska Department of Fish and Game, Juneau, AK.

______. 2012. Wolf Management Report of Survey-Inventory Activities, 1 July 2008-30 June 2011.

______. 2015a. 2015 Alaska Wildlife Action Plan. ADFG Division of Wildlife Conservation, Juneau, AK.

______. 2015b. Memorandum: GMU 2 Wolf Population Estimate Update, Fall 2014. State of Alaska, Ketchikan, AK.

______. 2015c. Prince of Wales Wildlife Viewing Guide. ADFG, Juneau, AK. Accessed online at https://www.adfg.alaska.gov/static/viewing/pdfs/pow.pdf.

______. 2015d. Southeast Alaska: Wildlife Viewing. ADFG, Juneau, AK. Accessed online at http://www.yakutatalaska.com/activities.html.

______. 2016a. Mammals Found in Alaska. Alaska Department of Fish and Game, Accessed online 2016 at http://www.adfg.alaska.gov/index.cfm?adfg=animals.listmammals.

______. 2016b. Wolf (*Canis lupus*). Alaska Department of Fish and Game, Accessed online 2016 at http://www.adfg.alaska.gov/index.cfm?adfg=wolf.rangemap.

Alaska Department of Fish and Game and US Forest Service. 2006. *Alaska's Inside Passage Wildlife Viewing Guide*. Alaska Department of Fish and Game, Juneau, AK.

Albert, D. M. and J. W. Schoen. 2007a. A comparison of relative biological value, habitat vulnerability, and cumulative ecological risk among biogeographic provinces in Southeastern Alaska, In *A conservation assessment and resource synthesis for the coastal forests & mountains ecoregion in southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

______. 2007b. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

______. 2013. Use of historical logging patterns to identify disproportionately logged ecosystems within temperate rainforests of southeastern Alaska. *Conservation Biology* 27:774–784.

Apps, C. D., B. N. McLellan, J. G. Woods, and M. F. Proctor. 2004. Estimating grizzly bear distribution and abundance relative to habitat and human influence. *Journal of Wildlife Management* 68:138-152.

Atkinson, S. N. and M. A. Ramsay. 1995. The effects of prolonged fasting of the body composition and reproductive success of female polar bears (*Ursus maritimus*). *Functional Ecology*: 559-567.

Audubon Alaska. 2015a. Prince of Wales Wolves: The Long-term Impacts of Logging and Roads Push a Tongass Wolf Population Toward Extinction. Audubon Alaska, Anchorage, AK.

______. 2015b. Southeast Alaska Mammal Viewing Hotspots. Audubon Alaska, Anchorage, AK.

______. 2016. Northern Flying Squirrel Range and Habitat Quality in Southeast Alaska. Anchorage, AK.

Bakker, V. J. and K. Hastings. 2002. Den trees used by northern flying squirrels (*Glaucomys sabrinus*) in Southeastern Alaska. *Canadian Journal of Zoology* 80:1623-1633.

Barrett, R. H. 1979. Admiralty Island Deer Study and the Juneau Unit Timber Sale. R10-48. In Sitka Deer Symposium, Juneau, Alaska. USDA Forest Service Technical Report R10-48. US Forest Service, Juneau, AK.

Barten, N. 2002. Unit 1C Black Bear Management Report. Alaska Dept of Fish and Game, Juneau, AK.

Barten, N. 2004. Personal Communication. Alaska Dept of Fish and Game, Juneau, AK.

Ben-David, M., T. Hanley, and D. Schell. 1998. Fertilization of terrestrial vegetation by spawning Pacific salmon: The role of flooding and predator activity. *Oikos* 83:47-55.

Ben-David, M., K. Titus, and L. R. Beier. 2004. Consumption of salmon by Alaskan brown bears: A trade-off between nutritional requirements and the risk of infanticide? *Oecologia* 138:465-474.

Bidlack, A. L. and J. A. Cook. 2001. Reduced genetic variation in insular northern flying squirrels (*Glaucomys sabrinus*) along the North Pacific Coast. *Animal Conservation* 4:283-290.

______. 2002. A nuclear perspective on endemism in northern flying squirrels (*Glaucomys sabrinus*) of the Alexander Archipelago, Alaska. *Conservation Genetics* 3:247-259.

Bloom, A. M. 1978. Sitka black-tailed deer winter range in the Kadashan Bay area, Southeast Alaska. *The Journal of Wildlife Management* 42:108-112.

Brady, W. W. and T. A. Hanley. 1984. The role of disturbance in old-growth forests: Some theoretical implications for Southeastern Alaska, In *Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium (Juneau, Alaska, 12-15 April 1982)*. W. R. Meehan, T. R. Merrell Jr, and T. A. Hanley eds., pp. 213-218. American Institute of Fishery Research Biologists, Morehead City, NC.

Brinkman, T. J., T. Chapin, G. Kofinas, and D. K. Person. 2009. Linking hunter knowledge with forest change to understand changing deer harvest opportunities in intensively logged landscapes. *Ecology and Society* 14.

Brinkman, T. J., D. K. Person, F. S. Chapin, W. Smith, and K. J. Hundertmark. 2011. Estimating abundance of Sitka black-tailed deer using DNA from fecal pellets. *The Journal of Wildlife Management* 75:232-242.

Bunnell, F. L. and T. Hamilton. 1983. Forage digestibility and fitness in grizzly bears, In *Fifth International Conference on Bear Research and Management*. Madison, WI.

Burris, O. E. and D. E. McKnight. 1973. Game Transplants in Alaska. Alaska Department of Fish and Game, Juneau, AK.

Buskirk, S. W. and L. F. Ruggiero. 1994. American marten, In *The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States*. L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski eds., pp. 7-37.

Cahill, J. A., R. E. Green, T. L. Fulton, M. Stiller, F. Jay, N. Ovsyanikov, R. Salamzade, J. S. John, I. Stirling, and M. Slatkin. 2013. Genomic evidence for island population conversion resolves conflicting theories of polar bear evolution. *PLoS Genetics* 9:1-8.

Carey, A. B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. *Ecological Applications* 5:648-661.

Carey, A. B., J. Kershner, B. Biswell, and L. D. de Toledo. 1999. Ecological scale and forest development: Squirrels, dietary fungi, and vascular plants in managed and unmanaged forests. *Wildlife Monographs*:3-71.

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

Carstens, B. C. and T. A. Dewey. 2010. Species delimitation using a combined coalescent and information-theoretic approach: an example from North American Myotis bats. *Systematic Biology* 59:400-414.

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. Pacific Salmon and Wildlife: Ecological Contexts, Relationships, and Implications for Management. Washington Dept of Fish and Wildlife, Olympia, WA.

Cook, J. and S. MacDonald. 2001. Should endemism be a focus of conservation efforts along the North Pacific Coast of North America? *Biological Conservation* 97:207-213.

______. 2007. *Mammals and Amphibians of Southeast Alaska*. University of New Mexico, Albuquerque, NM.

Cook, J. A., N. G. Dawson, and S. O. MacDonald. 2006. Conservation of highly fragmented systems: The north temperate Alexander Archipelago. *Biological Conservation* 133:1-15.

Cook, J. A. and S. O. MacDonald. 2013. Island life: Coming to grips with the insular nature of Southeast Alaska and adjoining coastal British Columbia, *In North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 19-42. University of Washington Press, Seattle, WA.

Crone, L. K. and J. R. Mehrkens. 2013. Indigenous and Commercial Uses of the Natural Resources in the North Pacific Rainforest with a Focus on Southeast Alaska and Haidi Gwaii, In *North Pacific Temperate Rainforests: Ecology and Conservation*. J. W. Schoen and G. H. Orians eds., pp. 73–88. University of Washington Press, Seattle, WA.

Cronin, M. A., A. Cánovas, D. L. Bannasch, A. M. Oberbauer, and J. F. Medrano. 2014. Single nucleotide polymorphism (SNP) variation of wolves (*Canis lupus*) in Southeast Alaska and comparison with wolves, dogs, and coyotes in North America. *Journal of Heredity* 106:26-36.

______. 2015. Wolf subspecies: Reply to Weckworth et al. and Fredrickson et al. *Journal of Heredity*.

Crupi, A. P., R. W. Flynn, L. R. Beier, D. P. Gregovich, and J. N. Waite. 2014. Movement Patterns, Home Range Size, and Resource Selection of Brown Bears Near the Malaspina Glacier, Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Dawson, N. G., S. O. MacDonald, J. A. Cook, and A. R. Wallace. 2007. Endemic mammals of the Alexander Archipelago, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Deal, R. L. 2001. The effects of partial cutting on forest plant communities of western hemlock-Sitka spruce stands in Southeast Alaska. *Canadian Journal of Forest Research* 31:2067-2079.

DellaSala, D. A., K. A. Engel, D. P. Volsen, R. L. Fairbanks, J. C. Hagar, W. C. McComb, and K. J. Raedeke. 1994. Effectiveness of Silvicultural Modifications of Young-growth Forest for Enhancing Wildlife Habitat on the Tongass National Forest, Southeast Alaska. US Forest Service, Juneau, AK.

DeMars, D. J. 2000. Stand-density Study of Spruce-hemlock Stands in Southeastern Alaska. US Forest Service, Portland, OR.

Demboski, J. R., B. K. Jacobsen, and J. A. Cook. 1998. Implications of cytochrome *b* sequence variation for biogeography and conservation of the northern flying squirrels (*Glaucomys sabrinus*) of the Alexander Archipelago, Alaska. *Canadian Journal of Zoology* 76:1771-1777.

Dickerman, R. and J. Gustafson. 1996. The Prince of Wales spruce grouse: A new subspecies from southeastern Alaska. *Western Birds* 27:41-47.

Doerr, J. G., E. J. Degayner, and G. Ith. 2005. Winter habitat selection by Sitka black-tailed deer. *The Journal of Wildlife Management* 69:322-331.

Doerr, J. G. and N. H. Sandburg. 1986. Notes: Effects of precommercial thinning on understory vegetation and deer habitat utilization on Big Level Island in Southeast Alaska. *Forest Science* 32:1092-1095.

Duncan, S. 1999. Alternatives to clearcutting of old growth in Southeast Alaska. *Science Findings. US Forest Service* October:1-5.

Edwards, R. T., D. D'Amore, E. Norberg, and F. Biles. 2013. Riparian ecology, climate change, and management in North Pacific Coastal Rainforests, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 43-72. University of Washington Press, Seattle, WA.

Erickson, A. W., B. Hanson, and J. J. Brueggeman. 1982. Black Bear Denning Study, Mitkof Island, Alaska. University of Washington, School of Fisheries, Fisheries Research Institute, Seattle, WA.

Farley, S. D. and C. T. Robbins. 1995. Lactation, hibernation, and mass dynamics of American black bears and grizzly bears. *Canadian Journal of Zoology* 73:2216-2222.

Farmer, C. J. 2002. Survival and Habitat Selection of Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*) in a Fragmented Coastal Temperate Rainforest. Graduate thesis, State University of New York, Syracuse, NY.

Farmer, C. J., D. K. Person, and R. T. Bowyer. 2006. Risk factors and mortality of black-tailed deer in a managed forest landscape. *The Journal of Wildlife Management* 70:1403-1415.

Flaherty, E., W. Smith, S. Pyare, and M. Ben-David. 2008. Experimental trials of the northern flying squirrel (*Glaucomys sabrinus*) traversing managed rainforest landscapes: Perceptual range and fine-scale movements. *Canadian Journal of Zoology* 86:1050-1058.

Flaherty, E. A., M. Ben-David, and W. P. Smith. 2010. Diet and food availability: implications for foraging and dispersal of Prince of Wales northern flying squirrels across managed landscapes. *Journal of Mammalogy* 91:79-91.

Fleming, M. A. and J. A. Cook. 2002. Phylogeography of endemic ermine (*Mustela erminea*) in Southeast Alaska. *Molecular Ecology* 11:795-807.

Flynn, R. W., S. B. Lewis, L. R. Beier, and G. W. Pendleton. 2007. Brown Bear Use of Riparian and Beach Zones on Northeast Chichagof Island: Implications for Streamside Management in Coastal Alaska. Alaska Department of Fish and Game, Douglas, AK.

Flynn, R. W., S. B. Lewis, L. R. Beier, and G. W. Pendleton. 2010. Spatial Relationships, Movements, and Abundance of Brown Bears on the Southern Mainland Coast of Southeast Alaska: Wildlife Research Final Report. Alaska Department of Fish and Game, Juneau, AK.

Frankham, R. 1998. Inbreeding and extinction: Island populations. *Conservation Biology* 12:665-675.

Fredrickson, R. J., P. W. Hedrick, R. K. Wayne, and M. K. Phillips. 2015. Mexican Wolves Are a Valid Subspecies and an Appropriate Conservation Target. *Journal of Heredity*:1-2.

Fuller, T. K. 1989. Population dynamics of wolves in north-central Minnesota. *Wildlife Monographs*:3-41.

Gende, S. M., R. T. Edwards, M. F. Willson, and M. S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. *BioScience* 52:917-928.

GLIMS. 2016. Randolph Glacier Inventory 5.0. Accessed online at http://www.glims.org/RGI/rgi50_dl.html.

Goldman, E. A. 1944. Classification of wolves, In *The Wolves of North America. 2 parts*. S. P. Young and E. A. Goldman eds. Dover Publications, New York, NY.

Hafner, D. J., E. Yensen, and G. L. Kirkland Jr. 1998. *North American Rodents: Status Survey and Conservation Action Plan*. IUCN, Gland, Switzerland.

Hanley, T. A. 1993. Balancing economic development, biological conservation, and human culture: The Sitka black-tailed deer *Odocoileus hemionus sitkensis* as an ecological indicator. *Biological Conservation* 66:61-67.

Hanley, T. A., R. G. Cates, B. Van Horne, and J. D. McKendrick. 1987. Forest stand-age-related differences in apparent nutritional quality of forage for deer in southeastern Alaska, In *Proceedings—Symposium on Plant-herbivore Interactions*. 7–9 Aug 1985, Snowbird, UT.

Hanley, T. A. and J. D. McKendrick. 1983. Seasonal Changes in Chemical Composition and Nutritive Value of Native Forages in a Spruce-hemlock Forest, Southeastern Alaska. US Forest Service, Juneau, AK.

Hanley, T. A. and J. D. McKendrick. 1985. Potential nutritional limitations for black-tailed deer in a spruce-hemlock forest, southeastern Alaska. *The Journal of Wildlife Management* 49:103-114.

Hanley, T. A., C. T. Robbins, and D. E. Spalinger. 1989. Forest Habitats and the Nutritional Ecology of Sitka Black-tailed Deer: A Research Synthesis with Implications for Forest Management. US Forest Service, Pacific Northwest Research Station, Portland, OR.

Hanley, T. A. and C. L. Rose. 1987. Influence of Overstory on Snow Depth and Density in Hemlock-spruce Stands: Implications for Management of Deer Habitat in Southeastern Alaska. US Forest Service, Pacific Northwest Research Station, Portland, OR.

Harris, A. S. 1974. Clearcutting, reforestation and stand development on Alaska's Tongass National Forest. *Journal of Forestry* 72:330-337.

Harris, A. S. and W. A. Farr. 1974. The Forest Ecosystem of Southeast Forest Ecology and Timber Management. US Forest Service, Pacific Northwest Forest and Range Experiment Station, Juneau, AK.

Harris, A. S. and W. A. Farr. 1979. Timber Management and Deer Forage in Southeast Alaska. US Forest Service, Region 10, Juneau, AK.

Heaton, T. H., S. L. Talbot, and G. F. Shields. 1996. An ice age refugium for large mammals in the Alexander Archipelago, Southeastern Alaska. *Quaternary Research* 46:186-192.

Heintzleman, B. F. and H. W. Terhune. 1934. A Plan for the Management of Brown Bear in Relation to Other Resources on Admiralty Island, Alaska. US Dept of Agriculture, Washington, DC.

Helfield, J. M. and R. J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. *Ecology* 82:2403-2409.

Hilderbrand, G. V., S. Farley, C. Robbins, T. Hanley, K. Titus, and C. Servheen. 1996. Use of stable isotopes to determine diets of living and extinct bears. *Canadian Journal of Zoology* 74:2080-2088.

Hilderbrand, G. V., T. A. Hanley, C. T. Robbins, and C. C. Schwartz. 1999a. Role of brown bears (*Ursus arctos*) in the flow of marine nitrogen into a terrestrial ecosystem. *Oecologia* 121:546-550.

Hilderbrand, G. V., S. Jenkins, C. Schwartz, T. Hanley, and C. Robbins. 1999b. Effect of seasonal differences in dietary meat intake on changes in body mass and composition in wild and captive brown bears. *Canadian Journal of Zoology* 77:1623-1630.

Hilderbrand, G. V., C. Schwartz, C. Robbins, M. Jacoby, T. Hanley, S. Arthur, and C. Servheen. 1999c. The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. *Canadian Journal of Zoology* 77:132-138.

Holloway, G. L., W. P. Smith, C. B. Halpern, R. A. Gitzen, C. C. Maguire, and S. D. West. 2012. Influence of forest structure and experimental green-tree retention on northern flying squirrel (*Glaucomys sabrinus*) abundance. *Forest Ecology and Management* 285:187-194.

Howe, J. R. 1996. *Bear Man of Admiralty Island: A Biography of Allen E. Hasselborg*. University of Alaska Press, Fairbanks, AK.

Jensen, W., T. Fuller, and W. Robinson. 1986. Wolf, *Canis lupus*, distribution on the Ontario-Michigan border near Sault Ste. Marie. *Canadian Field-Naturalist. Ottawa ON* 100:363-366.

Kessler, W. 1984. Management potential of second-growth forest for wildlife objectives in Southeast Alaska, *In Symposium on Fish and Wildlife Relationships in Old-growth Forests*. Juneau, AK.

Kirchhoff, M. D. 2003a. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity: Comment. *Ecology* 84:3396-3399.

Kirchhoff, M. D. and J. W. Schoen. 1987. Forest cover and snow: Implications for deer habitat in Southeast Alaska. *The Journal of Wildlife Management* 51:28-33.

Kirchhoff, M. D. and S. R. G. Thomson. 1998. Effects of Selection Logging on Deer Habitat in Southeast Alaska: A Retrospective Study. Alaska Department of Fish and Game, Juneau, AK.

Kirchhoff, M. J. 2003b. Deer Pellet-group Surveys in Southeast Alaska. Alaska Department of Fish and Game, Douglas, AK.

Klein, D. 1979. Ecology of Deer Range in Alaska. R10-48. US Forest Service, Juneau, AK.

Klein, D. R. 1965a. Ecology of deer range in Alaska. *Ecological Monographs* 35:259-284.

______. 1965b. Postglacial distribution patterns of mammals in the southern coastal regions of Alaska. *Arctic* 18:7-20.

Klein, D. R. and S. T. Olson. 1960. Natural mortality patterns of deer in Southeast Alaska. *The Journal of Wildlife Management*:80-88.

Kohira, M. 1995. Diets and Summer Habitat Use by Wolves on Prince of Wales Island, Southeast Alaska. Graduate thesis, University of Alaska Fairbanks, Fairbanks, AK.

Kondzela, C., C. Guthrie, S. Hawkins, C. d. Russell, J. Helle, and A. Gharrett. 1994. Genetic relationships among chum salmon populations in Southeast Alaska and northern British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 51:50-64.

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

Kruse, J. and R. Frazier. 1988. Reports to the Communities. Tongass and 1990. Seasonal Habitat Use by Sitka Black-tailed Deer. Resource Use and Cooperative Survey. Institute of Social and Economic Research, University of Alaska Anchorage, Anchorage, AK.

Latch, E. K., J. R. Heffelfinger, J. A. Fike, and O. Rhodes Jr. 2009. Species-wide phylogeography of North American mule deer (*Odocoileus hemionus*): Cryptic glacial refugia and postglacial recolonization. *Molecular Ecology* 18:1730-1745.

Lindzey, K. B., R. Peters, and E. Meslow. 1986. Responses of a black bear population to a changing environment, In *International Conference on Bear Research and Management*. Grand Canyon, AZ.

Lowell, R. 2002. Unit 3 Black Bear Management Report. Alaska Department of Fish and Game, Juneau, AK.

Lowell, R. 2004. Personal Communication. Alaska Department of Fish and Game, Petersburg, AK.

Lucid, M. K. and J. A. Cook. 2004. Phylogeography of Keen's mouse (*Peromyscus keeni*) in a naturally fragmented landscape. *Journal of Mammalogy* 85:1149-1159.

MacDonald, S. and J. Cook. 1999. *The Mammal Fauna of Southeast Alaska*. University of Alaska Museum, Fairbanks, AK.

MacDonald, S. O. and J. A. Cook. 1996. The land mammal fauna of Southeast Alaska. *Canadian Field-Naturalist* 110:571-598.

MacDonald, S. O. and J. A. Cook. 2007. *Mammals and Amphibians of Southeast Alaska*. Volume Speical Publication No. 8.University of New Mexico, Museum of Southwestern Biology, Albuquerque, NM.

Mace, R. D., J. S. Waller, T. L. Manley, L. J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. *Journal of Applied Ecology* 33:1395-1404.

Manville, R. H. and S. P. Young. 1965. Distribution of Alaskan Mammals. US Fish and Wildlife Service, Anchorage, AK.

Maser, C. and Z. Maser. 1988. Interactions among squirrels, mycorrhizal fungi, and coniferous forests in Oregon. *Western North American Naturalist* 48:358-369.

Maser, Z., C. Maser, and J. M. Trappe. 1985. Food habits of the northern flying squirrel (*Glaucomys sabrinus*) in Oregon. *Canadian Journal of Zoology* 63:1084-1088.

Mattson, D. J. 1990. Human impacts on bear habitat use, In *Bears: Their Biology and Management*. pp. 33-56. International Association for Bear Research and Management, Victoria, BC, Canada.

McCarthy, T. M. 1989. Food Habits of Brown Bears on Northern Admiralty Island, Southeast Alaska. Graduate thesis, University of Alaska Fairbanks, Fairbanks, AK.

McLellan, B. N. 1990. Relationships between human industrial activity and grizzly bears, In *Bears: Their Biology and Management*. pp. 57-64. International Association for Bear Research and Management, Victoria, BC, Canada.

McLellan, B. N., C. Servheen, and D. Huber. 2008. *Ursus arctos*. www.iucnredlist.org, Cambridge, UK. Accessed online 16 January 2015 at www.iucnredlist.org.

McLellan, B. N. and D. M. Shackleton. 1989. Immediate reactions of grizzly bears to human activities. *Wildlife Society Bulletin* 17:269-274.

Mech, L. D. 1995. The challenge and opportunity of recovering wolf populations. *Conservation Biology* 9:270-278.

Mech, L. D., S. H. Fritts, G. L. Radde, and W. J. Paul. 1988. Wolf distribution and road density in Minnesota. *Wildlife Society Bulletin*:85-87.

Meriam, H. 1971. Deer Report. Federal Aid in Wildlife Restoration. Progress Report Project. Alaska Department of Fish and Game, Juneau, AK.

Miller, S. D. and J. Schoen. 1999. Status and Management of the Brown Bear in Alaska. International Union for Conservation of Nature, Gland, Switzerland, and Cambridge, UK.

Miller, S. D., G. C. White, R. A. Sellers, H. V. Reynolds, J. W. Schoen, K. Titus, V. G. Barnes Jr, R. B. Smith, R. R. Nelson, W. B. Ballard, and C. C. Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. *Wildlife Monographs* 133:3-55.

Mooney, P. 2004. Personal Communication. Alaska Department of Fish and Game, Sitka, AK.

Mowrey, R. 2008. Northern Flying Squirrel. Alaska Department of Fish and Game, Juneau, AK.

Mowrey, R. A. and J. C. Zasada. 1982. Den tree use and movements of northern flying squirrels in interior Alaska and implications for forest management, In *Fish and Wildlife Relationships in Old-growth Forests: Proceedings of a Symposium*. Juneau, AK.

NatureServe. 2014. NatureServe Explorer: An Online Encyclopedia of Life. NatureServe, Arlington, VA. Accessed online July 22 2014 at http://explorer.natureserve.org.

Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. *Conservation Biology* 10:949-963.

Nowak, R. M. 1979. *North American Quaternary Canis*. Volume 6. Museum of Natural History, University of Kansas, Lawrence, KS.

Olson, S. 1979. The Life and Times of the Black-tailed Deer in Southeast Alaska. US Forest Service, Juneau, AK.

Paetkau, D., G. F. Shields, and C. Strobeck. 1998. Gene flow between insular, coastal and interior populations of brown bears in Alaska. *Molecular Ecology* 7:1283-1292.

Parker, D. I., J. A. Cook, and S. W. Lewis. 1996. Effects of timber harvest on bat activity in southeastern Alaska's temperate rainforests. In Bats and Forests Symposium. Research Branch, Ministry of Forests, Victoria, BC.

Parker, K. L., M. P. Gillingham, T. A. Hanley, and C. T. Robbins. 1999. Energy and protein balance of free-ranging black-tailed deer in a natural forest environment. *Wildlife Monographs* 143:3-48.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. *The Journal of Wildlife Management* 48:474-488.

Pauli, J. N., W. E. Moss, P. J. Manlick, E. D. Fountain, R. Kirby, S. M. Sultaire, P. L. Perrig, J. E. Mendoza, J. W. Pokallus, and T. H. Heaton. 2015. Examining the uncertain origin and management role of martens on Prince of Wales Island, Alaska. *Conserv Biol* 29:1257-1267.

Peacock, E. 2004. Population, Genetic and Behavioral Studies of Black Bears *Ursus americanus* in Southeast Alaska. PhD thesis, University of Nevada, Reno, NV.

Person, D. K. 2001. Alexander Archipelago Wolves: Ecology and Population Viability in a Disturbed, Insular Landscape. PhD thesis, University of Alaska, Fairbanks, AK.

______. 2013. Statement of David K. Person, Regarding the Big Thorne Project, Prince of Wales Island (submitted to ADFG, on file at Audubon Alaska).

Person, D. K. and T. J. Brinkman. 2013. Succession debt and roads: Short- and long-term effects of timber harvest on a large-mammal predator-prey community in Southeast Alaska, *In North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 143-167. University of Washington Press, Seattle, WA.

Person, D. K., M. D. Kirchhoff, V. Van Ballenberghe, G. C. Iverson, and E. Grossman. 1996. The Alexander Archipelago Wolf: A Conservation Assessment. General Tech. Report PNW-GTR-384. US Forest Service, Juneau, AK.

Person, D. K. and A. L. Russell. 2008. Correlates of Mortality in an Exploited Wolf Population. *Journal of Wildlife Management* 72:1540-1549.

Pinjuv, K. 2013. Estimating Black Bear Minimum Population Size in Gustavus, Alaska: Implications for Determining the Effect of Human Caused Mortality on Population Size. Unpublished M.Sc. thesis, The Evergreen College, Olympia, WA.

Porter, B. 2004. Personal Communication. Alaska Department of Fish and Game, Ketichikan, AK.

Pyare, S., W. P. Smith, J. V. Nicholls, and J. A. Cook. 2002. Diets of northern flying squirrels, *Glaucomys sabrinus*, in Southeast Alaska. *Canadian Field-Naturalist* 116:98-103.

Pyare, S., W. P. Smith, and C. S. Shanley. 2010. Den use and selection by northern flying squirrels in fragmented landscapes. *Journal of Mammalogy* 91:886-896.

Quinn, T., S. Gende, G. Ruggerone, and D. Rogers. 2003. Density-dependent predation by brown bears (*Ursus arctos*) on sockeye salmon (*Oncorhynchus nerka*). *Canadian Journal of Fisheries and Aquatic Sciences* 60:553-562.

Reichel, J. D., G. J. Wiles, and P. O. Glass. 1992. Island extinctions: The case of the endangered Nightingale Reed-Warbler. *The Wilson Bulletin* 104:44-54.

Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. *Transactions of the North American Wildlife and Natural Resources Conference* 41:431-438.

Rose, C. 1984. Deer response to forest succession on Annette deer on Admiralty Island, Alaska. In Proceedings of the symposium on fish and wildlife relationships in old-growth forests, 1982. American Institute of Fisheries Research Biologists, Juneau, AK.

Schindler, D. E., M. D. Scheuerell, J. W. Moore, S. M. Gende, T. B. Francis, and W. J. Palen. 2003. Pacific salmon and the ecology of coastal ecosystems. *Frontiers in Ecology and the Environment* 1:31-37.

Schoen, J. 1991. Forest management and bear conservation. The Fifth International Congress of Ecology, Dordrecht, the Netherlands.

Schoen, J., M. Kirchhoff, and J. Hughes. 1988. Wildlife and old-growth forests in southeastern Alaska. *Natural Areas Journal* 8:138-145.

Schoen, J., M. Kirchhoff, and O. Wallmo. 1984. Sitka black-tailed deer/old-growth relationships in Southeast Alaska: Implications for management. In Symposium on Fish and Wildlife Relationships in Old-growth Forests, 1982. American Institute of Fisheries Research Biologists, Juneau, AK.

Schoen, J. W. 1990. Bear habitat management: A review and future perspective, In *Eighth International Conference on Bear Research and Management*. Victoria, BC, Canada.

Schoen, J. W. and L. Beier. 1990. Brown Bear Habitat Preferences and Brown Bear Logging and Mining Relationships in Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Schoen, J. W., L. R. Beier, J. W. Lentfer, and L. J. Johnson. 1987. Denning ecology of brown bears on Admiralty and Chichagof Islands. *Bears: Their Biology and Management: International Conference on Bear Research and Management* 7:293-304.

Schoen, J. W., R. W. Flynn, L. H. Suring, K. Titus, and L. R. Beier. 1994. Habitat-capability model for brown bear in Southeast Alaska, In *Bears: Their Biology and Management*. Missoula, Montana.

Schoen, J. W. and M. D. Kirchhoff. 1985. Seasonal distribution and home-range patterns of Sitka black-tailed deer on Admiralty Island, Southeast Alaska. *The Journal of Wildlife Management* 49:96-103.

Schoen, J. W. and M. D. Kirchhoff. 1990. Seasonal habitat use by Sitka black-tailed deer on Admiralty Island, Alaska. *The Journal of Wildlife Management* 54:371-378.

Schoen, J. W., J. W. Lentfer, and L. Beier. 1986. Differential distribution of brown bears on Admiralty Island, Southeast Alaska: A preliminary assessment. In Bears: Their Biology and Management. International Association for Bear Research and Management, Grand Canyon, AZ.

Schwartz, C., S. Miller, and M. Haroldson. 2003. Grizzly bear (*Ursus arctos*), *In Wild Mammals of North America: Biology, Management, and Conservation*. G. A. Feldhamer, B. C. Thompson, and J. A. Chapman eds., pp. 556-586. Johns Hopkins University Press, Baltimore, MD.

Schwartz, C. C. and A. W. Franzmann. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. *Wildlife Monographs* 113:3-58.

Servheen, C. 1990. The status and conservation of the bears of the world, In *International Conference on Bear Research and Management*. Vivtoria, BC,.

Shafer, A. B. A., C. I. Cullingham, S. D. Côté, and D. W. Coltman. 2010. Of glaciers and refugia: a decade of study sheds new light on the phylogeography of northwestern North America. *Molecular Ecology* 19 (21):4589-4621.

Shanley, C. S., S. Pyare, and W. P. Smith. 2013. Response of an ecological indicator to landscape composition and structure: Implications for functional units of temperate rainforest ecosystems. *Ecological Indicators* 24:68-74.

Shephard, M., L. Winn, B. Flynn, R. Myron, J. Winn, G. Killinger, J. Silbaugh, T. Suminski, K. Barkhau, E. Ouderkirk, and J. Thomas. 1999. Southeast Chichagof Landscape Analysis. US Tongass National Forest, Sitka, AK.

Smith, C. A., E. L. Young, C. R. Land, and K. P. Bovee. 1987. Predator-induced Limitations on Deer Population Growth in Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Smith, W. and D. Person. 2007. Estimated persistence of northern flying squirrel populations in temperate rain forest fragments of Southeast Alaska. *Biological Conservation* 137:626-636.

Smith, W. P. 2005. Evolutionary diversity and ecology of endemic small mammals of southeastern Alaska with implications for land management planning. *Landscape and Urban Planning* 72:135-155.

______. 2012. Sentinels of ecological processes: The case of the northern flying squirrel. *BioScience* 62:950-961.

Smith, W. P., S. M. Gende, and J. V. Nicholls. 2005. The northern flying squirrel as an indicator species of temperate rain forest: Test of an hypothesis. *Ecological Applications* 15:689-700.

Smith, W. P., S. M. Gende, and J. V. Nichols. 2004. Ecological correlates of flying squirrel microhabitat use and density in temperate rainforests of Southeastern Alaska. *Journal of Mammalogy* 85:663-674.

Smith, W. P. and D. K. Person. 2007. Estimated persistence of northern flying squirrel populations in temperate rain forest fragments of southeast Alaska. *Biological Conservation* 137:626-636.

Soule, M. 1984. What do we really know about extinction?, In *Genetics and Conservation*. C. M. Schonewald-Cox, S. M. Chambers, B. MacBryde, and W. L. Thomas eds. Benjamin/Cummings Publishing Company, Inc., Menlo Park, CA.

Straugh, T. P. 2004. 2003 Deer Hunter Survey Summary Statistics. Alaska Department of Fish and Game, Juneau, AK.

Suring, L. H. 2014. Describing Habitat Quality for Species of Conservation Concern in Southeast Alaska, USA. *Northern Ecologic L.L.C. Technical Bulletin* 2014-2.

Suring, L. H., D. C. Crocker-Bedford, R. W. Flynn, C. L. Hale, G. C. Iverson, M. D. Kirchoff, T. E. Schenck II, and L. C. Shea. 1993. A Strategy for Maintaining Well-distributed, Viable Populations of Wildlife Associated with Old-growth Forests in Southeast Alaska. Report of an Interagency Committee. Review Draft. US Tongass National Forest, Juneau, AK.

Suring, L. H., E. J. Degayner, R. W. Flynn, M. D. Kirchhoff, J. W. Schoen, and L. C. Shea. 1992. Habitat capability model for Sitka black-tailed deer in Southeast Alaska: Winter habitat. Version 6.5 April 1992. US Forest Service, Region 10, Juneau, AK. Accessed online at http://www.fs.usda.gov/r10.

Swanston, D. N., C. G. S. III, W. P. Smith, K. R. Julin, G. A. Cellier, and F. H. Everest. 1996. Scientific Information and the Tongass Land Management Plan: Key Findings from the Scientific Literature, Species Assessments, Resource Analyses, Workshops, and Risk Assessment Panels. PNW-GTR-386. US Forest Service, Juneau, AK.

Talbot, S. L. and G. F. Shields. 1996a. A phylogeny of the bears (*Ursidae*) inferred from complete sequences of three mitochondrial genes. *Molecular Phylogenetics and Evolution* 5:567-575.

Talbot, S. L. and G. F. Shields. 1996b. Phylogeography of brown bears (*Ursus arctos*) of Alaska and paraphyly within the Ursidae. *Molecular Phylogenetics and Evolution* 5:477-494.

Titus, K. and L. Beier. 1994. Population and Habitat Ecology of Brown Bears on Admiralty and Chichagof Islands. Federal Aid in Wildlife Restoration. Research Progress Report W-24-2. Alaska Department of Fish and Game, Juneau, AK.

Titus, K. and L. R. Beier. 1999. Suitability of stream buffers and riparian habitats for brown bears. *Ursus* 11:149-156.

Titus, K., R. Flynn, G. Pendelton, and L. Beier. 1999. Population and Habitat Ecology of Brown Bears on Admiralty and Chichagof Islands. Federal Aid in Wildlife Restoration. Research Progress Report 4.26. Alaska Department of Fish and Game, Juneau, AK.

Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14:18-30.

US Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition To List the Prince of Wales Flying Squirrel as Threatened or Endangered. 77:168. Federal Register, Washington, DC.

______. 2015. Conserving the Nature of America: Gray Wolf (*Canis lupus*). U.S. Fish and Wildlife Service, Online. Accessed online 10/19/2015 2015 at http://www.fws.gov/home/wolfrecovery/.

______. 2016. 12-Month Finding on a Petition to List the Alexander Archipelago Wolf as an Endangered or Threatened Species; codified at 50 C.F.R. Part 17. *Federal Register* 81.

US Forest Service. 1995. Report to Congress: Anadromous Fish Habitat Assessment. R10-MB-279. US Forest Service, Juneau, AK.

______. 1997a. Tongass Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 1997b. Tongass Land Management Plan Revision, Final Environmental Impact Statement. US Forest Service, Juneau, AK.

______. 2008a. Tongass Land and Resource Management Plan, Final Environmental Impact Statement, Plan Amendment, Volume I. 1:R10-MB-603c. US Forest Service, Juneau, AK.

______. 2008b. Tongass National Forest Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 2012. Wildlife Management Indicator Species Monitoring Report, 2012. Tongass Monitoring and Evaluation Report. US Forest Service, Juneau, AK.

Van Horne, B., T. A. Hanley, R. G. Cates, J. D. McKendrick, and J. D. Horner. 1988. Influence of seral stage and season on leaf chemistry of southeastern Alaska deer forage. *Canadian Journal of Forest Research* 18:90-99.

Vonhof, M. J., A. L. Russell, and C. M. Miller-Butterworth. 2015. Range-wide genetic analysis of little brown bat (*Myotis lucifugus*) populations: Estimating the risk of spread of white-nose syndrome. PLoS ONE 10:e0128713.

Wallmo, O. 1981. Mule and black-tailed deer distribution and habitats, In *Mule and Black-tailed Deer of North America*. O. Walmo ed., pp. 1-25. University of Nebraska Press, Lincoln, NE.

Wallmo, O. C. and J. W. Schoen. 1980. Response of deer to secondary forest succession in Southeast Alaska. *Forest Science* 26:448-462.

Watts, P. and C. Jonkel. 1988. Energetic cost of winter dormancy in grizzly bear. *The Journal of Wildlife Management* 52:654-656.

Weckworth, B. V., N. G. Dawson, S. L. Talbot, and J. A. Cook. 2015. Genetic distinctiveness of Alexander Archipelago wolves (*Canis lupus ligoni*): Reply to Cronin et al.(2015). *Journal of Heredity*.

Weckworth, B. V., S. Talbot, G. K. Sage, D. K. Person, and J. Cook. 2005. A signal for independent coastal and continental histories among North American wolves. *Molecular Ecology* 14:917-931.

Weckworth, B. V., S. L. Talbot, and J. A. Cook. 2010. Phylogeography of wolves (*Canis lupus*) in the Pacific Northwest. *Journal of Mammalogy* 91:363-375.

West, E. W. 1993. Rare Vertebrate Species of the Chugach and Tongass National Forests, Alaska. US Forest Service Alaska Region 10 and Alaska Natural Heritage Program, Juneau, AK.

Wielgus, R. B. and F. L. Bunnell. 1995. Tests of hypotheses for sexual segregation in grizzly bears. *The Journal of Wildlife Management* 59:552-560.

Willson, M. F. and S. M. Gende. 2004. Seed dispersal by brown bears, *Ursus arctos*, in southeastern Alaska. *The Canadian Field-Naturalist* 118:499-503.

Witt, J. W. 1992. Home range and density estimates for the northern flying squirrel, *Glaucomys sabrinus*, in western Oregon. *Journal of Mammalogy* 73:921-929.

Wood, R. 1990. Wolf: Annual Report of Survey and Inventory Activities: Game Management in Unit 1A. Alaska Department of Fish and Game, Juneau, AK.

Woodford, R. 2014. Deer Hunting Forecast and "State of the Deer." Alaska Department of Fish and Game, Juneau, AK. Accessed online Aug 25 2015 at http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=672.

Yeo, J. J. and J. M. Peek. 1992. Habitat selection by female Sitka black-tailed deer in logged forests of southeastern Alaska. *The Journal of Wildlife Management* 56:253-261.

Bob Armstrong

HUMAN USES

Humans did not arrive in Alaska's coastal rainforests until quite recently. The first colonists probably continued on southwards because at that time the area was mostly buried under massive glaciers. Archaeological data reveal human presence 13,000 years ago and evidence of continuous human occupation of the area is confined to the last 5,000 years. The first colonists were hunter/gatherers. They arrived without an agricultural tradition, and the cold, wet climate of Southeast Alaska was, in any case, unsuitable for agriculture development. However, the remarkably rich marine resources and the availability of massive trees whose trunks could be molded into seaworthy boats led to the development of one of the few human cultures with permanent villages and a hierarchical social structure without an agricultural base. Indigenous culture depended primarily on fish, marine invertebrates, and marine mammals (harbor seals, porpoises and whales that washed ashore). Terrestrial mammals (bears, deer, mountain goats, marmots) were eaten and were sources of fur for clothing. Baskets and clothing were woven from tree roots and bark, but the traditional culture had almost no impact on the terrestrial environment.

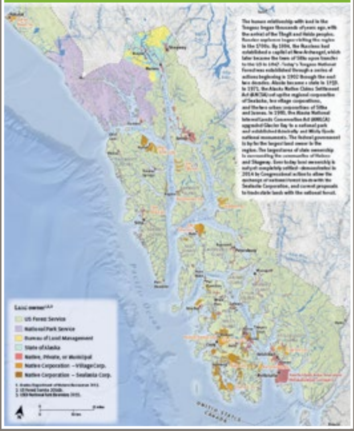
A major transition began with the arrival of Russians (1741), Spaniards (1775), French (1786), and English (1793) traders. Russians established a trading post at Sitka that marked the beginning of a culture based on exporting the region's natural resources. Mining was the first resource-based industry to develop in the region, followed by commercial fishing, timber and wood products, and tourism. A substantial timber and wood products industry was slow to develop because of the high operating costs in the cold, wet environment and the long distance to the mills and markets. But, owing to large governmental subsidies, a substantial timber harvest began in the 1960s and continued for several decades. Tourism and commercial fishing are today more important to the economy than mining or logging, but they are highly seasonal. The local natural resources that sustained indigenous people for millennia continue to make major contributions to the region's economic well-being but today, in marked contrast to the past, they must be managed in the context of a global economy and associated global environmental changes.

~ Gordon Orians

Nils Warnock

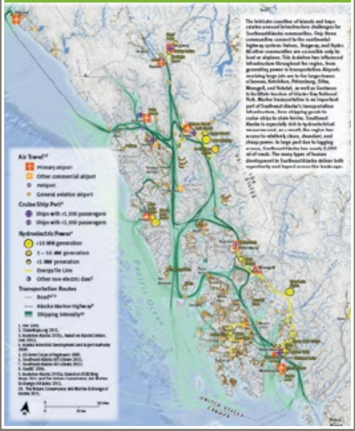
HUMAN USES MAPS INDEX

Land Ownership



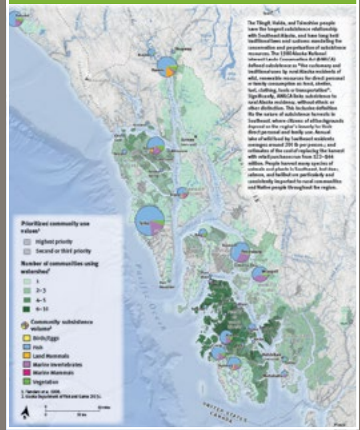
MAP 7.1 / PAGE 179

Transportation and Energy Infrastructure



MAP 7.2 / PAGE 186

Community Subsistence Use



MAP 7.3 / PAGE 190

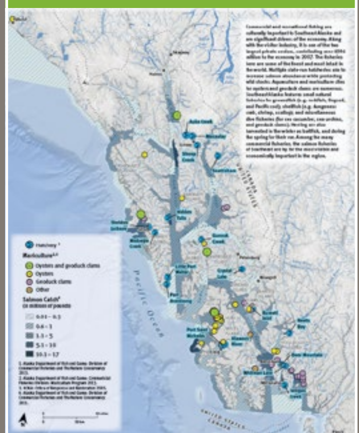
Timber

MAP 7.4 / PAGE 194

Metals Mining

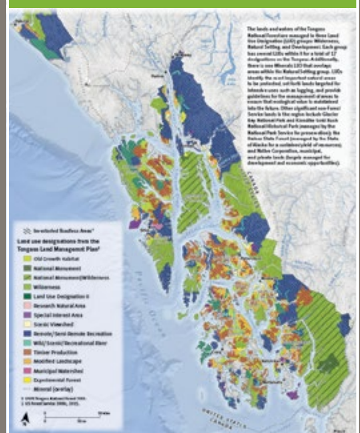
MAP 7.5 / PAGE 200

Commercial Fishing



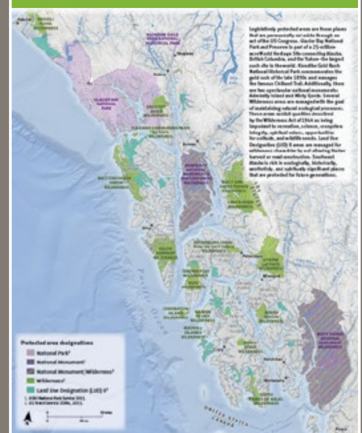
MAP 7.6 / PAGE 205

Land Use Designations



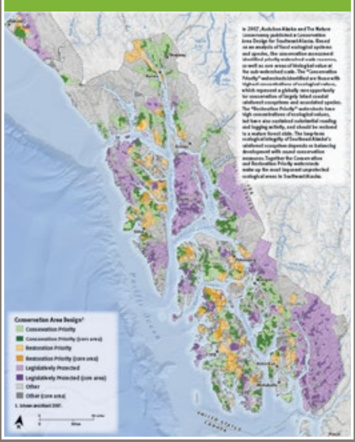
MAP 7.7 / PAGE 209

Legislatively Protected Areas



MAP 7.8 / PAGE 210

A Conservation Area Design for Southeast Alaska



MAP 7.9 / PAGE 213

Tongass 77 Watersheds

MAP 7.10 / PAGE 216

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LAND OWNERSHIP

Susan Culliney

HISTORY

Land "Ownership" by Native Alaskans

The human relationship with land in the Tongass began thousands of years ago, with the arrival of the Tlingit and Haida peoples. The Tlingit occupied most of what is now the Tongass National Forest, and the Haida lived primarily on Prince of Wales Island and in areas beyond Southeast Alaska including Haida Gwaii, or the Queen Charlotte Islands (Voluck 1999). The two cultures are distinct, but share similar attributes. Both ascribed nuanced property concepts to tangible items (including land), as well as intangible items (such as names and oral histories) (Crone and Mehrkens 2013). The tribe itself exercised ownership over particular sites, including salmon streams and culturally significant locations. But individual clans or house groups held rights to actually using the physical locations for activities like fishing and gathering (Crone and Mehrkens 2013). For example, one clan or house group may have returned to using a particular berry picking location for over 2000 years (Crone and Mehrkens 2013).

Deeper understanding of the Alaska Native concept of land ownership arises from research of other Alaska cultures. Elders from the Yupiit tribe (an Alaskan tribe that occupied areas of coastal western Alaska) testified at Congressional hearings on Native land claims in the 1960s. Their remarks echo the southeast Native Alaskans' notion that ownership is closely tied with physical use of the land. A respected Alaska anthropologist offered the following summary of the Yupiit elders' congressional testimony:

> The Native right to land . . . was not based on and could not be reduced to an isolatable relationship of possession between an individual man or group at any one point in time to a particular site. Rather, the concept of ownership expressed here is a relational one, where a man has a right to, and in fact an obligation to, use a site because of his relationship to previous generations of people who had a definite relationship to the species taken at the same place. In other words, you have a right to use a site not because you own the land, but because your grandfather hunted there and had a relationship with the animals of that area. (Case and Voluck 2012; Fienup-Riordan 1984).

Although modern property laws now impose more stringent notions of land title and ownership over Southeast Alaska, these aboriginal perspectives on land persist and are important to keep in mind when considering Alaska land ownership.

Russian Presence

Russian explorers and colonists, drawn to Southeast Alaska by the abundance of sea otters, began visiting the region in the 1700s. By 1804, the Russians had established a capital at New Archangel, which later became the town of Sitka upon transfer to the United States. The Russians did not press land ownership claims far beyond their stockaded colonies. They chose instead to exercise dominion over the region through the export of natural resources, by harvesting sea otters (*Enhydra lutris*) and operating a few saw mills.

Whatever form of ownership Russia had over Alaska ended in 1867, when the Czar executed a Treaty of Cession to transfer the land to the United States in exchange for $7.2 million. The treaty did not involve any Alaska Native peoples, nor did Russia or the US ever treaty directly with any Alaska tribes (Case and Voluck 2012). Some experts therefore view this land transfer as essentially a quit-claim deed, by which the United States acquired whatever property rights Russia held at the time (Case and Voluck 2012). Most Americans took a dim view toward their nation's property acquisition, deriding the remote and chilly purchase as "Seward's folly," after Secretary of State William Seward who had promoted the deal.

Early Federal Land Transfers

At first the American public's humorous view on the Alaska purchase seemed accurate. The US did not know quite what to do with the enormous northern land mass, and attempted to open the tundra to homesteading. But the remoteness, the difficulty surveying the treacherous expanse, and the tundra's relatively low farming quality deterred most would-be homesteaders, and the program was ultimately discontinued (Hull and Leask 2000).

But over time, Alaska's natural value became apparent. The first half of the 1900s was marked by Congress and Presidents periodically selecting Alaskan lands for preservation as National Forests and National Parks (Hull and Leask 2000). Two of the very first Alaskan conservation land actions occurred in Southeast. In 1902 Congress established the Alexander Archipelago Forest Reserve, and in 1907 President Theodore Roosevelt established the Tongass National Forest, prior even to the establishment of Denali National Park in 1917. The two forest areas were later merged to become the Tongass of today.

The federal government also spent the years after the Alaska purchase attempting to provide land for the numerous Alaska Native tribes. During an 80 year time span, from 1891 to 1971, the US government created what were essentially Indian reservations for Alaska Natives (Case and Voluck 2012). Although these reservations were not technically reservations in the eyes of the law, the government intended that the set-aside lands provide Native Alaskans with space and resources. Additionally, the federal government granted small numbers of acres to native peoples through the Alaska Native Allotment Act of 1906 and the Alaska Native Townsite Act of 1926 (Case and Voluck 2012). The Alaska Native Claims Settlement Act (ANCSA) in 1971 ultimately extinguished these actions by providing 44 million acres to Native Alaskans in exchange for releasing claims to other lands.

The only enduring reminder of the reservations time period is the Metlakatla community on Annette Island in the Alexander Archipelago of Southeast Alaska. The story begins in Canada, where a group of native Tsimshian lived in their village of Metlakatla and ascribed to the religious teachings of an Anglican missionary named William Duncan. The group encountered difficulty with the Canadian government, and in 1887, Duncan asked the US for help in relocating the peoples who had become known as the Metlakatlans. In 1891, Congress established a reservation on Annette Island, and in 1916 President Woodrow Wilson added the coastal waters up to 3000 feet offshore (Case and Voluck 2012). The reserve was unique in that it provided land for a native group originating from outside Alaska, but regulation remained under the auspices of the federal Department of the Interior.

Metlakatla was the first federal Indian reservation established in Alaska, and remains in existence today in Southeast Alaska, as the only reservation to persist following the passage of ANCSA.

Native Land Claims and Statehood

Alaska became a state in 1959. The Alaska Statehood Act allowed the new state to select 104 million acres for its use, which constituted almost a third of the Alaska land area. But the State selections were ultimately subservient to federal decisions and to Native land claims. First, the Act instructed the State to choose land that was "vacant, unappropriated, and unreserved" by any federal option (Alaska Department of Natural Resources 1987). Second, the State could not select "any lands or property (including fishing rights), the right or title to which may be held by any Indians, Eskimos, or Aleuts…or is held by the United States in trust for said Natives." (Case and Voluck 2012).

At the time of statehood, some Native Alaskans had already begun filing their own land claims, with varying results (Case and Voluck 2012). In Southeast Alaska, the Tlingit and Haida tribes had already

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filed a land claim in the federal court of claims. The court held that the native peoples had used and occupied their Southeast Alaskan territories such that Russia had owned those lands subject to aboriginal title, and therefore transferred only such encumbered title to the United States in 1867 (Tlingit and Haida Indians of Alaska v. US 1959; Case and Voluck 2012). Previous case law developed in the 1940s and 50s had held that Native Alaskans did not own tracts of land on an individual basis, and therefore did not have a right to monetary compensation for extractive activities such as timber sales, but these decisions did not close the issue of aboriginal title (Miller v. US 1947; Tee-Hit Ton Band of Indians v. US 1955; Case and Voluck 2012). The Tlingit-Haida ruling in 1959 essentially meant that these Alaska Natives did hold aboriginal land rights to the areas that President Roosevelt had already previously established as the Tongass National Forest in 1907. Other native tribes responded to the Statehood Act's land grant by pressing their own land claims.

Thus, only a few years after statehood, the problem of who owned Alaska had become increasingly complicated. Native claims competed with prior federal withdrawals, and there loomed the prospect that the State's land selections could add further fuel to the fire. In 1966, the US Secretary of the Interior halted the State's land selection process, pending resolution of the complex network of Native claims. The coincident discovery in 1967 of oil in Prudhoe Bay simultaneously galvanized the State to cooperate and quickly settle Native claims in order to move forward with oil production (Case and Voluck 2012; Hull and Leask 2000). The result of such fast-paced and dramatic historic events was the relatively quick passage of ANCSA.

ANCSA and ANILCA

In 1971, the federal law ANCSA terminated nearly all of the prior land grants made to Alaska Natives (the only exception being the Metlakatla reservation) and extinguished any remaining aboriginal claims to title. In return, the law granted 44 million acres and $1 billion to Alaska's native peoples.

The law also imposed a complex corporate structure on Alaska Natives, organizing the tribes into more than 200 Native corporations. In Southeast Alaska, the Native corporate structure is organized into the regional corporation of Sealaska, ten village corporations, and the two urban corporations of Sitka and Juneau (Case and Voluck 2012). The law did not create village corporations for five mostly non-native communities that currently are seeking new retroactive land selections (Haines, Petersburg, Wrangell, Ketchikan, and Tenakee), but did place these villages under the regional Sealaska corporation. Tribal leaders allocated the 44 million acres from ANCSA to village and regional corporations on the basis of population, with lesser numbers of acres given to the smaller urban corporations.

The Southeast corporations chose their allotted acres from the Tongass National Forest. With a corporate eye toward revenue sharing, the corporations gravitated toward the most profitable lands (Nie 2006). The Southeast allocation ended up with fewer acres than calculated by the population-based method, perhaps in part because the Tongass land grants represented particularly lucrative opportunities in large-scale logging operations (Case and Voluck 2012).

Sheldon Museum and Cultural Center

Interior of Klukwan Whale House, circa 1895. Tlingit clan houses were rectangular in shape with a post and beam construction. The more important houses were partly subterranean with one or two step-like platforms descending to a central square enclosure from 4-6 ft below the surface of the ground. This photo of the Klukwan Whale House of the Gaanaxteidi (Raven) Clan shows many Clan and House treasures.

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As a result of ANCSA, Native Alaskans have a markedly different relationship with their land when compared with Native Americans in the Lower 48 states. Unlike the reservation system, by which the US federal government occupies a sort of trustee or fiduciary role for native tribes, Alaska Native corporations hold land ownership directly as title owners.

ANCSA also included a land preservation goal. The law intended for the federal government to withdraw 80 million acres as conservation lands. But the slow pace of Congress and a lawsuit filed by the State of Alaska over conflicts between state selections and federal withdrawals prevented this provision from occurring. The conservation aim of ANCSA was finally fulfilled in 1980, when the Alaska National Interest Lands Conservation Act (ANILCA) followed through with the conservation objective.

ANILCA added 104 million acres to conservation, 56 million of which were designated as wilderness. ANILCA also placed a priority for subsistence on federal lands. Several parcels of conservation land in Southeast benefited from ANILCA's preservation objective. The law enlarged what was then Glacier Bay National Monument and established it as a national park and preserve; created the Admiralty Island National Monument; and statutorily established the Misty Fjords National Monument, thereby putting to rest a prior political struggle between the federal government and the State of Alaska over the Misty Fjords lands.

Final Selections & Transfers

After ANCSA cleared the way for the State of Alaska to proceed with its land selection, the State began to choose properties with an eye toward settlement, natural resources, and recreation (Alaska Department of Natural Resources 2000). The State strategically gravitated toward lands with maximum benefits, aiming for lands offering several resource values, and focusing on profitable natural resources and opportunities for economic development (Alaska Department of Natural Resources 1987). But the State would still find itself occasionally constrained in its selections, as it vied with federal withdrawals and competing Native selections. In Southeast Alaska, many of the acres the State selected came out of the Tongass National Forest, and were aimed at expanding existing towns or promoting the development of budding communities (Alaska Department of Natural Resources 1987).

Portions of the State's property eventually transferred to municipalities or to private individual ownership (Hull and Leask 2000). Today, the Alaska Department of Natural Resources grants Alaskan citizens opportunities to acquire a wide variety of property rights on state land, including staking mining claims for certain minerals, establishing trapper cabins, and obtaining shore fishery leases. And if one needed further evidence that Alaska still embodies the frontier spirit, the State of Alaska also offers land sales at sealed bids (limited to Alaska residents), "over-the-counter" sales (for those parcels not sold in the previous sealed bid), as well as a remote cabin site staking program (Alaska Department of Natural Resources 2015b). Land parcels in Southeast Alaska are particularly popular. In Southeast, sites offered in 2015 all sold quickly in the residential sealed bid (Alaska Department of Natural Resources 2015a).

Alaska land ownership is not yet completely settled. The State and the Native tribes have yet to receive the entire acreage allotted to them (Bureau of Land Management 2015). In Southeast, the Native corporation Sealaska only recently acquired all the land promised to them (Brehmer 2015), in an amended land selection process that required congressional action to allow the corporation to select outside of ANCSA-approved areas. This controversial land selection process gave the corporation ownership of very valuable timber lands previously under management by the Tongass National Forest. In 2015, a House Bill proposed to grant additional acres to the "landless natives" groups that did not receive separate village corporation status under ANCSA. It remains to be seen whether the bill will become law.

TABLE 7-1 Summary of current land ownership in Southeast Alaska.

Landowner	Sum of Acres	Percent
Bureau of Land Management	386,260	2%
National Forest Service	16,745,197	78%
National Park Service	2,695,270	13%
Native Corporation	625,952	3%
Native, Private, Municipal, Other	629,527	3%
State of Alaska	457,577	2%
Grand Total	21,539,783*	

*Note that due to status of various land selections and transfers, different entities choosing to include or exclude submerged lands from acreage compilations, precision of land ownership layers, and alternate definitions of the northern extent of Southeast Alaska, these acreages are not exact.

Current Ownership

Southeast Alaska is comprised of approximately 22.9 million acres (9.2 million ha). Today, the three top land holders in Southeast Alaska are the federal government (21.2 million ac; 8.6 million ha), Native corporations (0.6 million ac; 253,000 ha), and the State of Alaska (0.5 million ac; 185,000 ha). See Table 7-1 for more information.

Federal ownership comprises over 90% of the land in Southeast. More specifically, the US Forest Service (USFS) owns the Tongass National Forest, which at 16.7 million acres (6.8 million ha) encompasses nearly 80% of the land area of Southeast. Glacier Bay National Park & Preserve, managed by the National Park Service, covers about 2.7 million acres (1.1 million ha), or 13% of the region. The State of Alaska also owns a substantial portion of the land in Southeast, including the Haines State Forest, at 286,000 acres (115,740 ha), as well as navigable waters, tidelands, other smaller holdings. Native corporations (primarily Sealaska) own approximately 625,000 acres (253,000 ha) of land in Southeast. Municipal governments and private individuals own the remaining acres.

CONSERVATION ISSUES

Given the varied ownership patterns, lands in Southeast Alaska vary widely between having many restrictions and protections to having almost no restrictions on development. Understanding plans for the future development of the region is important for creating good conservation planning and policies for the people and wildlife that live there. Understanding the history of land ownership can also aid conservation managers in navigating the complex perspectives that arise in the relationship between Alaska's land and its people.

MAPPING METHODS

This map depicts TNF ownership using a USFS layer that details status of inholdings within the Forest boundary (US Forest Service 2016b). Lands outside of the TNF were mapped using two data sources. (1) the Alaska Department of Natural Resources (ADNR), Information Resource Management division's general land status information, at the Public Land Survey System section level, and clipped to the coastline (1:63,360 scale) This dataset is current as of October 2015. and (2) the National Park Service's official boundary dataset. This dataset is current as of December 2015.

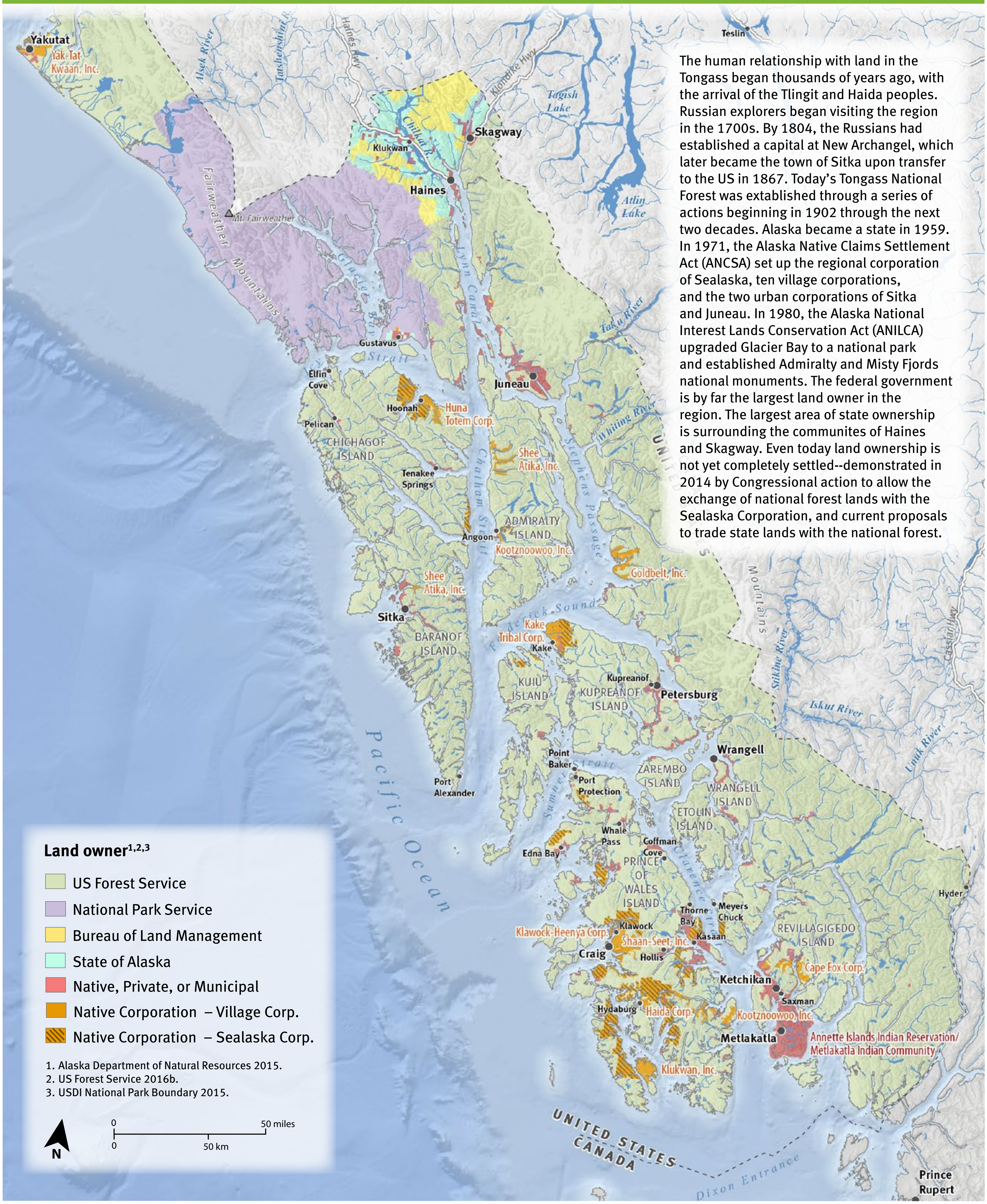
MAP DATA SOURCES

- Ownership: US Forest Service (2016b), USDI National Park Service (2015), Alaska Department of Natural Resources: Information Resource Management (2015).

Audubon ALASKA

Land Ownership

The human relationship with land in the Tongass began thousands of years ago, with the arrival of the Tlingit and Haida peoples. Russian explorers began visiting the region in the 1700s. By 1804, the Russians had established a capital at New Archangel, which later became the town of Sitka upon transfer to the US in 1867. Today's Tongass National Forest was extablished through a series of actions beginning in 1902 through the next two decades. Alaska became a state in 1959. In 1971, the Alaska Native Claims Settlement Act (ANCSA) set up the regional corporation of Sealaska, ten village corporations, and the two urban corporations of Sitka and Juneau. In 1980, the Alaska National Interest Lands Conservation Act (ANILCA) upgraded Glacier Bay to a national park and established Admiralty and Misty Fjords national monuments. The federal government is by far the largest land owner in the region. The largest area of state ownership is surrounding the communites of Haines and Skagway. Even today land ownership is not yet completely settled--demonstrated in 2014 by Congressional action to allow the exchange of national forest lands with the Sealaska Corporation, and current proposals to trade state lands with the national forest.



Map 7.1: Land Ownership

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TRANSPORTATION AND ENERGY INFRASTRUCTURE

Beth Peluso and Susan Culliney

The intricate coastline of islands and bays creates unusual infrastructure challenges for Southeast Alaska communities. Only three communities connect to the continental highway system: Haines, Skagway, and Hyder (through Canada). All other communities, including Alaska's capital city Juneau, are accessible only by boat or airplane. This isolation has influenced infrastructure throughout the region, from generating power to transportation.

Airports

Air travel, whether by commercial jet or private float plane, is a staple in Southeast Alaska despite the often rainy weather. There are 16 airports with commercial service in Southeast Alaska. Of those, ten are considered primary commercial airports (10,000 or more passenger boardings per year), and six are non-primary commercial airports (2,500–10,000 passenger boardings per year). Airports receiving large jets are in the larger towns of Juneau, Ketchikan, Petersburg, Sitka, Wrangell, and Yakutat, as well as Gustavus to facilitate tourism of Glacier Bay National Park. Small jets service Haines, Skagway, Hoonah, Angoon, Kake, Craig, Thorne Bay, Hollis, and Metlakatla. In addition, there are 7 heliport sites, and about fifty general aviation airports in Southeast Alaska, the majority of them floatplane facilities (FAA 1995).

Marine Vessel Traffic

Marine transportation is an important part of Southeast Alaska's transportation infrastructure, from shipping goods to cruise ships to state ferries. A recent report about marine vessel traffic examined the make-up of large vessel traffic in the Inside Passage. Based on the number of weeks operating per year, the following describes traffic by type of vessel: Ferries 28%, overnight passenger vessels (ships from 125–200 or more feet in length that carry 30–90 passengers) 21%, cruise ships 19%, freight barges 18%, tank barges 11%, log carriers 2%, and ore carriers 1% (Nuka Research and Planning Group LLC. 2012). Ferries, source of the highest vessel traffic, recorded 327.9 operating weeks in Southeast Alaska in 2012, while ore carriers had the least number of operating weeks at 6.7 (numbers from 2011). Some of this traffic is highly seasonal, however, "vessel activity that is dominated by cruise ships, ferries and small passenger vessels in the summer months declines dramatically in the winter" (Nuka Research and Planning Group LLC. 2012). Some freight traffic passes through on the way to ports in other parts of Alaska and does not stop at Southeast Alaska ports.

Ferries

One of the main methods of intercommunity transportation is by commercial or state ferry. From school sports teams to people traveling for medical appointments, the Alaksa Marine Highway System (AMHS) connects people throughout the region. Steve Homer and Ray Gelotte started the precursor of the AMHS—the Chilkoot Motorship Lines—out of Haines in 1948. Their former navy landing craft the MV *Chilkoot* sailed weekly between Juneau, Haines, and Skagway, connecting the territorial capital to the road system. Although the company provided a valuable service, it ran into financial difficulties because it could not operate year-round. In 1951, as word spread that the service was faltering, the territoral government agreed to purchase the company (Alaska Marine Highway System 2015).

Demand increased in the growing territory, and by 1957, a new, larger ship, the MV *Chilkat*, ran daily service between Juneau, Haines, and Skagway. In Alaska's first year of statehood in 1959, residents of the new state voted for a bond to expand the ferry system to include four new vessels that would extend service to more of Southeast Alaska and up to the Kenai Peninsula. In 1967, AMHS began service to Seattle, connecting Alaska to the Lower 48; the port changed to Bellingham, Washington in 1989 (Alaska Marine Highway System 2015). In 1998, the MV *Kennicott* came online. In the wake of the *Exxon Valdez* oil spill

John Schoen

Large cruise ships in the Juneau harbor bring thousands of tourists each day during summer.

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disaster in 1989, this ship was specially designed to serve as a mobile command center for emergency response to an oil spill. It includes a helipad, a floating dock stored below deck, additional communications, and decontamination showers (Alaska Marine Highway System 2015).

As of the AMHS's 50th anniversary in 2013, it provided service to 35 communities (Alaska Marine Highway System 2015). In 2014, the state ferries carried nearly 243,000 passengers and more than 78,000 vehicles (Alaska Marine Highway System 2014). With service along the spectacular Alaska coastline from Southeast Alaska to the Aleutian Islands, the AMHS is the only marine route to be designated a National Scenic Byway and All American Road (Alaska.org 2016). Additionally, the commercial Inter-Island Ferry Authority runs daily round-trip service between Ketchikan and the Prince of Wales Island community of Hollis. During the summers of 2006–2008, they also had round-trip service from Coffman Cove to Wrangell and Petersburg, but that service has been suspended. In 2014, the State of Alaska started construction on two new ferries in a shipyard in Ketchikan. The "Alaska Class" ships will hold 300 passengers and 53 vehicles. They are scheduled for completion in 2018 (Alaska Marine Highway System 2015).

Cruise Ships

Tourism is a major economic force in the region; total visitor industry spending in the region brought in $1.09 billion in 2013–2014 (McDowell Group 2015a). Cruise ships bring in a large number of visitors, ranging from small ecotourism boats that carry two dozen passengers to enormous vessels carring more than 3,000 passengers. As of 2016, there are about 17 cruise lines plying the waters of Southeast Alaska. Some start their tour in either Seattle, Washington or Vancouver, British Columbia. A few smaller boats start in Juneau or Sitka and spend the entire time exploring bays and inlets. Ketchikan and Juneau have the highest number of cruise ships that dock there (AlaskaCruises.com 2015).

Hydropower

Southeast Alaska is especially rich in hydroelectrical resources and, as a result, the region has access to relatively clean, abundant, and cheap power. Alaska Electric Light and Power Company (AELP) is a major operator of hydroelectric power in Southeast. The company began its operations in 1893 with a single water wheel and electric generator at Gold Creek in Juneau (Alaska Electric Light and Power Company 2015). This early facility supplied electricity to a few dozen of Juneau's commercial and residential customers, and generated enough power to light up to 2,500 incandescent bulbs (Alaska Electric Light and Power Company 2015). Thomas Edison had only recently invented the electric lightbulb 14 years prior, and AELP's entrepreneurial endeavors swept Juneau into an energetic modern world. Today, the operation at Gold Creek remains as a run-of-the-river facility, meaning the power plant generates electricity for Juneau seasonally, when the river runs, and ceases operations when winter temperatures freeze the flow of water.

Hydropower development in Alaska had a close relationship with mining. Mining operations needed easy access to power and provided the motivation behind many of Alaska's early hydropower plants. By 1908, there were 30 hydropower sites in Southeast, primarily established by private developers to supply the power needs of nearby gold mining operations in Juneau and Douglas Island (Alaska Center for Energy and Power 2015a). Juneau's electricity generation truly blossomed with the 1910 completion of the Sheep Creek plant, driven in large part by the energy demand of the local Treadwell mines (Alaska Electric Light and Power Company 2015). The Alaska Gastineau Mining Company, headed by entrepreneur Bart Thane, further galvanized hydropower development in Southeast by establishing the Salmon Creek Dam and the Annex Creek plant, both of which ran year round, an innovative step from the prior seasonal facilities (Alaska Electric Light and Power Company 2015).

Over the century, the industry has proven resilient. Some of the region's historic hydro facilities continue to operate reliably today (Alaska Center for Energy and Power 2015a). For example, in 1914, a power plant replaced AELP's simple water wheel at Gold Creek in downtown Juneau (Susitna-Watana Hydro 2015). Now, over 100 years later, Gold Creek remains in operation.

Operating and transmitting hydropower in Southeast is not without its obstacles. First, the balance between electrical supply and demand can be difficult to achieve, especially in the smaller towns and villages. Utilities therefore continue to use diesel powered systems as a backup, to supplement hydroelectric power generation when demand is greater than hydro supply (Alaska Center for Energy and Power 2015b). Second, energy interties between hydro projects remain uncommon, even though such interconnection would bring greater flexibility to the overall system. Ketchikan's Swan Lake facility connects to the Lake Tyee facility, which primarily supplies electricity to Petersburg and Wrangell. This connection stabilizes energy production over a larger landscape. Various small projects also connect to each other, albeit on a localized level. Planning authorities recognize both the benefits of an interconnected energy system, as well as the limits and challenges to establishing interties in Southeast's wild landscape (Black & Veatch 2012).

Despite such challenges, Southeast Alaska continues to invest in hydroelectric systems to power its communities with this renewable and cheap energy source. Table 7-2 offers a list of the hydroelectric projects that presently power Southeast Alaska's human population. Future projects, which do not appear on the map, are in various stages of planning, funding, or construction, and may or may not come to fruition, depending on funding and support.

Interties connect various regional power systems, for example the Swan-Tyee intertie connects the Swan Lake power system in Ketchikan with the systems in Wrangell and Petersburg. There are a number of local interties that connect small communities, allowing them to share excess power.

The largest hydroelectric facility currently operating in Southeast Alaska is the Snettisham Hydroelectric project, located about 30 miles southeast of Juneau (Alaska Industrial Development and Export Authority 2016). The US Corps of Engineers built Snettisham in 1979 and sold the facility to the State of Alaska in 1998. Today, AELP operates Snettisham under contract with the Alaska Industrial Development and Export Authority (AIDEA), a public corporation of the State of Alaska that is legislatively mandated to promote growth and progress in Alaska. Snettisham generates 80% of the power used by Juneau and Douglas, with a capacity of 78 megawatts. In comparison, the Hoover Dam has a capacity of 2080 megawatts, but serves the power needs of some of the most densely populated areas of the western US.

Two of the facilities mentioned in Table 7-2 (the Black Bear Lake facility on Prince of Wales Island, and the Goat Lake project near Haines and Skagway), are certified as Low Impact by the Low Impact Hydropower Institute. The Institute's certification program assesses a facility based on standards for river flow, water quality, fish passage and protection, watershed protection, threatened and endangered species protection, cultural resource protection, and recreation (Low Impact Hydropower Institute 2015).

Logging Roads

In the logging industry's early days in Southeast Alaska, there was little incentive to build roads in such a remote and challenging terrain. Instead, during the late 1800s and early 1900s, loggers accessed timber via the coastline, and felled giant trees directly into the water, where boats then tugged the logs to sawmills (Sisk 2007c). It was not until World War II, and the accompanying demand for Sitka spruce, that loggers began to require roads in order to access the timber beyond easy coastal reach (Sisk 2007c).

Even early on as people began constructing roads in the Tongass seeking materials for sawmills, it was difficult to locate and access trees that were large enough for lumber processing. The USFS and the timber industry instead began turning their attention toward pulp harvest (Sisk 2007c), in which smaller and excessively branching trees are reduced to pulp for paper and other products.

In the 1950s, the USFS drew up contracts for two pulp mill operations, one in Sitka and one in Ketchikan. The agency sold a third area of pulp timber near Wrangell, but no pulp mill materialized there. The two pulp

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mills at Sitka and Ketchikan began building logging roads in order to access the raw timber.

Under their contracts, the pulp mills were responsible for road building costs. But the contracts also provided for reimbursement in the form of credits against the payment for timber (Sisk 2007c). The USFS essentially used road building as a form of currency in timber sales. Southeast's two pulp mills operated for close to 50 years, each finally closing permanently in the 1990s. But the pulp mill legacy remains written on the landscape in the form of logging roads.

Road building in the difficult terrain and climate is more expensive than almost anywhere else in the world where timber is produced. In 2008, road building cost $185,000 per mile in the Tongass, with maintenance and repair costs estimated at $50,000 per mile (US Forest Service 2008b). Prior to pulp mill operation in the 1950s, logging roads were rare in Southeast. By 2008, there were 4,941 mi (7,952 km) of roads within the National Forest, and 3,906 mi (6,286 km) of non-USFS roads in Southeast (US Forest Service 2008b). Once these publically funded roads are built, local use makes their closure or curtailment politically difficult (Person and Brinkman 2013), thereby making their impact on the landscape long-lasting.

CONSERVATION ISSUES

Airports

Airports provide an essential transportation service for communities in Southeast Alaska, but they also can have, sometimes literally, impacts on birds.

The Juneau Airport was built in the Mendenhall River wetlands because of the scarcity of flat ground in the city. The open lands and tidal flats around the airport provide habitat for many birds and the trails there are a favorite place for local birders. A major safety concern for the airport, both on land and floatplane airstrips, are bird strikes. If a plane runs into a large bird—such as a Bald Eagle (*Haliaeetus leucocephalus*), Common Raven (*Corvus corax*), goose, large gull, or duck—it can be fatal for the bird and very hazardous for the plane.

A report from Juneau Audubon discusses various methods for reducing risks of bird strikes. Knowledge of bird behavior is crucial. Hazing waterfowl, for instance, sometimes scares the birds into circling, crossing the runway multiple times, and possibly increasing the hazard temporarily (Carstensen and Armstrong 2004).

At the Juneau airport, clearing a segment of trees surrounding a stream to try to open the view for the control tower and to remove habitat for Great Blue Herons, waterfowl, and Bald Eagles had the opposite effict of drawing larger birds to the suddenly more open habitat. These larger birds are not as manoueverable as smaller birds, therefore tend to avoid tight spaces such as dense forest where they can't see predators and have trouble taking flight. In hindsight, the report suggests that an alternative plan that had been discarded, of simply topping the trees but leaving them standing, could have been more effective. Removing the tops of the trees would open the sight line for the tower, but still provided habitat unappealing for larger birds (Armstrong et al. 2009).

The report states that foraging habitat is the most attractive to birds, and that it's easier to deter birds from nesting or roosting habitat than feeding areas. A bird can abandon a nest or roost, but it always needs to eat. By that logic, creating the least attractive habitat for "hazard" birds closest to the runway and very attractive habitat further away might be a better strategy for dealing with birds. For example, planting evergreen shrubs that dissuade large birds close to the runway and using gravel instead of grass with seeds would make the runway more unappealing to waterfowl. A combination of allowing waterfowl hunting and also closing areas for hunting to draw waterfowl away from airport hazard areas could also be a tool (Armstrong et al. 2009).

Overall, these strategies for reducing risks of bird strikes are not one-size-fits all, but rely on knowledge of local ecology and bird behavior in conjuction with the safety needs of the particular airport.

Marine Vessels

As cruise ship travel increases in Southeast Alaska, concerns over potential side effects of the sheer volume of visitors has reared up. Specifically, how and where do cruise ships, which can hold several thousand people, dispose of wastewater? State waters extend three miles off Alaska's coast, then beyond that the jurisdiction changes to federal waters. Cruise ship wastewater, depending on how throughly treated it is, can hold varying levels of heavy metals, such as copper and zinc, and ammonia that can be harmful to marine life. Copper, for example, may soak out of shipboard plumbing, and can harm a salmon's ability to navigate to spawning streams. Ammonia, a component of human waste, can be fatal for marine life (Demer 2014).

In 2006, several incidents of cruise ships releasing pollutants in Juneau and other places spurred a voter initiative calling for strict water quality regulation. The initiative would have required that treated wastewater had to pass water quality standards that it would not harm marine life at the point of discharge, but the regulations were never implemented (Demer 2014). A new state law in 2013 overrode the voter initiative, allowing cruise ships to discharge treated water in Alaska state waters or at dock. The idea was that treated wastewater would be diluted in mixing zones. Opponents say the law sacrifices water quality, while proponents say that wastewater treatment technology is high enough to eliminate concerns about water quality. Tests for water quality are not required at the site of dumping, however, but within 90 yd (82 m) of the source. As of the summer of 2015, 18 cruise ships had permits to dump wastewater either at the dock or in Alaska waters (Schoenfeld 2015).

Cruise ships have to record when they discharge wastewater, but don't have to provide notice to nearby fishermen or other marine area users. Conservation groups suggest that a good step forward would be to ban the discharges in sensitive habitat, such as fish and wildlife refuges and sanctuaries. At the very least cruise ships should provide notice to other users nearby when they will be discharging wastewater (Demer 2014).

Another hazard for marine wildlife is underwater noise produced by vessel engines. A National Park Service study in the marine soundscape of Glacier Bay gives a good set of recommendations for managing underwater noise pollution (Gabriele et al. 2011). Many marine mammals such as whales rely on sound for communication within their social groups, for locating prey, detecting predators, and for navigation. Noise from ships and private vessels can create a background din that is damaging to marine mammals, which are unable to avoid exposure. While removing vessels from an area is the only way to completely solve the problem, the study determined that a surprisingly simple step could reduce harmful noise pollution. Slower vessel speeds, and therefore lower decibel levels, made a surprising amount of difference. A marine mammal would have to listen to a cruise ships moving at 13 knots for 7.5 times longer than a ship moving at 20 knots to reach the same level of noise exposure. Slower vessel speeds in important marine mammal habitat could provide a good guidline for minimizing harmful effects of marine vessel traffic (Gabriele et al. 2011).

Hydropower

Small hydropower projects have been a part of Southeast power generation since the gold rush. Rather than massive dam projects like on some Lower 48 rivers, dispersing these smaller projects, using mountainous terrain and lakes to assist in water flow, has less ecological impact than damming large river systems.

The Snettisham project, which provides about 65% of the power for Juneau's AELP, is an example of using terrain for lowering ecological impact. Instead of a large dam, this project consists of two mountain lakes and an 8,400-foot tunnel that brings water from the lakes to the hydropower turbines. The natural elevation drop provides the water current for the turbines. A 44-mi (71-km) transmission line delivers the power to Juneau. This facility started producing power in 1972 from Long Lake, and in 1990 the nearby Crater Lake facility added to the project's power generation. The excess power produced by this and other Juneau hydropower is sold both to the Greens Greek mine on

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TABLE 7-2 List of hydroelectric projects powering communities in Southeast Alaska (Renewable Energy Alaska Project 2016).

Community	Owner/Operator	Hydro Project Name	Capacity (megawatts)*	Notes
Juneau	AELP	Snettisham	78 MW	Supplies 80% of the electricity demands in Juneau and the surrounding area.
		Annex Creek	3.6 MW	Established in 1915 by the Gastineau Alaska Engineers; automated in 1977. Supplies 10% of Juneau's power.
		Salmon Creek	6.7 MW	Hydro facility first established at the site in 1913, but the infrastructure present today was constructed in 1984. Supplies 10% of Juneau's power.
		Gold Creek	1.6 MW	Seasonal run-of-the-river facility built in 1914 in downtown Juneau.
		Lake Dorothy	14.3 MW	Also supplies energy directly to Princess Cruise Lines and the Greens Creek Mining Company.
Ketchikan	Ketchikan Public Utilities	Silvis Lake	2.1 MW	Built in 1968.
		Beaver Falls	5.4 MW	Three generators built 1947–1954.
		Ketchikan Lakes	4.2 MW	Three generators built 1923–1957.
		Whitman Lake	4.6 MW	Completed in 2014.
	SEAPA	Swan Lake	22.4 MW	Connected to the Lake Tyee facility in Wrangell/Petersburg via the Swan-Tyee intertie.
Wrangell	SEAPA	Tyee Lake	20 MW	40 miles southeast of Wrangell. Supplies electricity for Wrangell and Petersburg; connected to Swan Lake facility via Swan-Tyee intertie.
		Blind Slough	2 MW	Operating since the 1920s. Water flow sometimes used at nearby hatchery. Supplies 20% of Wrangell's power.
Petersburg	Petersburg Municipal Light and Power	Petersburg	2 MW	
		Blind Slough	2 MW	Operating since the 1920s. Water flow sometimes used at nearby hatchery.
	SEAPA	Tyee Lake	20 MW	Supplies electricity for Wrangell and Petersburg; connected to Swan Lake facility via the Swan-Tyee intertie.
Sitka	City and Borough of Sitka, Electric Department	Green Lake	18.6 MW	Fills the majority of the city's power.
		Blue Lake	18 MW	Recently expanded from a 6 MW capacity.
Metlakatla	Metlakatla Power and Light	Chester Lake	1 MW	
		Purple Lake	3.9 MW	
Haines	Alaska Power & Telephone	Goat Lake	4 MW	Natural lake used without a dam. Certified as a Low Impact facility.
		Kasidaya	0.3–3 MW	Capacity depends on the season.
		Lutak	0.3 MW	Run-of-the-river facility began operating in 2002.
Skagway	Alaska Power & Telephone	Goat Lake	4 MW	Natural lake used without a dam. Certified as a Low Impact facility.
		Dewey Lakes	0.9 MW	Run-of-the-river facility built in the early 1900s.
		Kasidaya	0.3–3 MW	Capacity depends on the season.
Prince of Wales	Alaska Power & Telephone	Black Bear Lake	4.5 MW	Certified as a Low Impact facility. Completed in 1995.
		South Fork Black Bear	2 MW	Run-of-the-river facility completed 2005. Operates as a backup supplementary electricity source.
Pelican	Pelican Utility Company	Pelican	0.7 MW	Meets nearly all of the small community's energy needs.
Gustavus	Alaska Power & Telephone	Falls Creek	0.4 MW	Meets close to 90% of residents' electricity needs.

*Capacity is the maximum energy per hour that a power plant can generate. Actual energy production depends on natural factors such as water flow and temperature.

John Schoen

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Admiralty Island, reducing the mine's use of diesel generators. Power is also sold to cruise ships when they are docked, reducing air pollution while the ships are in port (Alaska Industrial Development and Export Authority 2016).

As interties are developed between small hydropower facilities in the region, siting of transmission lines to avoid roadless areas, protected lands, or old-growth forest reserves should be taken into consideration. In the 2008 Tongass Land Management Plan (TLMP), several land use designation categories are considered transportation and utility system "avoidance areas," which are defined as areas where "Transportation and utility sites [TUS] or corridors may be located within this LUD [land use designation] only after an analysis of potential TUS corridors has been completed and no feasible alternatives exist outside this LUD." The LUD categories where the TUS avoidance areas apply include: Wilderness, Non-Wilderness National Monument, Research Natural Area, Special Interest Area, Remote Recreation, Municipal Watershed, Old-Growth Habitat, Land Use Designation II, Wild River, Scenic River, Recreational River, Experimental Forest, and some Minerals use areas. The TUS LUD does specify that powerlines should be buried or submereged where feasible (US Forest Service 2008d). Although utility corridors are not absolutely prohibited in these areas of the Tongass, every effort should be made to find alternative, less disruptive routes and follow these recommended land use guidelines whenever possible. As currently proposed, the 2016 TLMP amendment does not carry these standards forward. Such areas should be avoided by development regardless of whether the TLMP keeps the standards in place.

Melanie Smith

Float planes are a common form of transportation in the region.

Logging Roads

Ironically, the same qualities that make road building costly in the Tongass are the same attributes that are lost when another road conquers this ruggedly beautiful forest. Roads that cross forest streams may hamper anadromous fish movements. There is some indication that current bridge building standards do offer adequate fish passage, but older bridges may use culverts that are placed too high above the water level for migrating salmon to meaningfully access (Person and Brinkman 2013). Roads also offer easy access to hunters seeking legal and illegal harvest of wolves, bears, and deer.

Those wild areas that do remain in the Tongass National Forest may now retain their roadless character. In the last days of the Clinton administration, the Department of Agriculture promulgated the "Roadless Rule," which prevented new roads from being built in presently roadless areas within the Tongass and other national forests (US Forest Service 2001). The subsequent Bush administration delayed the rule's implementation and eventually negotiated with the State of Alaska to exempt the Tongass National Forest (US Forest Service 2003). However, in 2015, the Ninth Circuit Court of Appeals affirmed a lower court decision that the roadless rule does by law apply to the Tongass (Organized Village of Kake et al. v. USDA 2015, at 31). In March 2016, the US Supreme Court denied hearing an appeal from the lower court, leaving the rule in place that blocks new road building in the wild and roadless areas of the Tongass. Roads may, however, continue to appear in areas where roads already exist, and on land owned by other entities.

A high density of roads per square mile fragments the forest such that wildlife experience greater human traffic and less refuge in which to replenish their populations (Person and Brinkman 2013; Person and Russell 2008). Such a case was recently exhibited by the steep decline of the Prince of Wales Complex population of Alexander Archipelago wolves (*Canis lupus ligoni*). In 1994, there were an estimated 352 wolves in the Prince of Wales Island Complex (Person et al. 1996). In 2014, the Alaska Department of Fish and Game (ADFG) estimated there were 89 wolves remaining there (Alaska Department of Fish and Game 2015e). The drop from 352 wolves to 89 represents a 75% decline in the region's wolf population over 20 years. The direct take of wolves is the immediate issue facing the population. An estimated 87% of wolf mortality is human-caused through hunting, trapping, and illegal poaching (Person and Russell 2008). A recent Audubon Alaska (2015d) report determined much of the human-caused mortality can ultimately be indirectly attributed to six decades of aggressive old-growth clearcut logging and road-building on Prince of Wales and surrounding islands. The roads that are built to support the logging effort provide easy access points for poachers to enter the forest and kill wolves; the Prince of Wales Complex has over 4,200 mi (6,759 km) of roads. The report recommends that the Forest Service halt large-scale old-growth clearcut logging and road-building for the ongoing Big Thorne sale and end future large-scale old-growth sales in the Prince of Wales Complex. The Forest Service should also aggressively close and decommission existing logging roads to reduce human access to wolves.

Juneau Access Road

Juneau, the capital of Alaska, is only accessible by air or sea—there is no road connection to the mainland interstate system (Federal Highway Administration 2006). The Juneau Access Road, also called the Lynn Canal Highway, is a controversial proposed major infrastrucure project that would build a highway connecting Juneau to Skagway and the mainland road system, although it would still require a day-boat ferry connection to complete the route (Moritz 2015).

Discussion of the road project began before 1972, but the state didn't acquire funding for the first feasibility study until 1987. In 2006, the Alaska Department of Transportation and Public Facilities' Environmental Impact Statement (EIS) announced the currently contested route that involves about 50 mi (80 km) of highway along the steep east side of Lynn Canal to the Katzehin River, where it would connect with a ferry terminal about 18 mi (29 km) south of Skagway. The ferry would take vehicles the rest of the way to Haines and Skagway (Alaska Department of Transportation and Public Facilities 2014; Wikipedia 2016a, b). In 2009 a US Distict Court decision, upheld in 2011 by the US Court of Appeals for the Ninth Circuit, ruled that the decision was invalid because it did not consider any alternatives that improved transportation using existing ferries. The State began a Supplemental EIS, which was still not released as of May 2016 (Alaska Department of Transportation and Public Facilities Southcoast Region 2016).

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Lynn Canal is a steep-sided fjord. There are more than forty avalanche chutes along the proposed route (Alaska Department of Transportation and Public Facilities 2014). Possible ecological impacts include loss of wetlands and old-growth forest, including reduction of brown bear habitat and Bald Eagle nesting habitat. The preferred alternative in the 2014 Draft Supplementa EIS would cause the loss of about 61 ac (25 ha) of wetlands and about 32 ac (13 ha) of intertidal and subtidal habitat. The road bed would affect groundwater flow, potentially altering wetland function. The preferred alternative would affect more than 400 ac (162 ha) of old-growth forest and the road would fragment habitat by dividing the forest into inland and coastal sides. The route crosses along Berners Bay, and would cut through USFS LUD II areas, the roadless area category set forth in the Tongass Timber Reform Act of 1990. Building the road across this area requires the governor to designate the route an essential transportation corridor (Alaska Department of Transportation and Public Facilities 2014).

According to the Draft Supplemental EIS, the road “would substantially increase access to the east Lynn Canal coastline for recreation and tourism. Improved access to forest land is expected to increase use and thus the need for management and monitoring” (Alaska Department of Transportation and Public Facilities 2014). Increased access could have various affects, include increased human hunting and fishing pressure on wildlife, potential wildlife-vehicle collisions, and making animal movements from upland habitat to the coastline more hazardous. Mammals potentially affected by cutting off coastal access include mountain goat, moose, black bear, and possibly brown bear (Alaska Department of Transportation and Public Facilities 2014).

The sound from explosive charges used to release avalanche danger could be disturbing to wildlife, including flushing Bald Eagles from nests and possibly causing them to abandon the nest. Up to 46 Bald Eagle nests fall within a half mile (1 km) of the avalache blasting zone, although in a normal snow year not all of those nests would be affected. Avalanche control efforts could cause some mountain goat mortality because the animals sometimes forage in avalanche chutes in winter. Since the 2006 road plan, the preferred alternative route was adjusted to alleviate some of the effects on nesting Bald Eagles and Steller sea lions at haulouts (Alaska Department of Transportation and Public Facilities 2014).

Haines Highway Expansion

Audubon was instrumental in helping establish the Alaska Chilkat Bald Eagle Preserve in 1982, and it is currently a designated Important Bird Area. The Chilkat River is internationally important for Bald Eagles and other fish and wildlife resources. From an ornithological perspective alone, the Preserve is home for 200–400 Bald Eagles year-round, and in some years, hosts close to 4,000 birds—the densest concentration of Bald Eagles in the world (Audubon Alaska 2015b).

Since the Preserve’s establishment, Audubon Alaska and many other stakeholders have worked with various State and Federal agencies on issues threatening the integrity of the Preserve. Perhaps the most controversial issue over the past years has been addressing impacts that commercial jet boat tours have in the Preserve, especially with respect to spawning and out-migrating young salmon, as well as bank erosion in salmon habitat. In recent years the Haines Highway expansion project has generated extensive comments about potential effects on the Preserve (Audubon Alaska 2015b). The proposed highway changes within the Preserve would remove eagle roosting trees; allow an unspecified amount of disturbance to nesting, perching, feeding, and roosting eagles; impact salmon spawning habitat in the majority of the tributaries to the Chilkat River that provide salmon habitat; and affect wetlands that provide fish passage and rearing habitat (Audubon Alaska 2016). Mining companies like Constantine Metal Resources Ltd. are developing prospects around Haines which, if permitted, will result in significant additional truck traffic along the highway to Haines and may compromise water quality inside the Preserve.

The many types of human development in Southeast Alaska deliver both opportunity and impact. Infrastructure allows us to access communities, bring in goods and resources, obtain energy, travel to wild places, and earn income. But with these developments come a responsibility to manage wisely. Related issues are varied and include pollution, aircraft and ship noise, fish passage, habitat fragmentation, game poaching, avalanche danger, and degradation of adjacent conservation lands. Even in a landscape as rugged as Southeast Alaska, oftentimes our ability to develop and change landscapes exceeds our knowledge of or ability to mitigate associated impacts. As Southeast Alaskans move forward with development of the region they should do so slowly and wisely, avoiding many of the mistakes made in other parts of Alaska and the Lower 48.

MAPPING METHODS

This map depicts the following datasets:

1. Air service, using airport and heliport location data from FAA (1995), classified into primary airports and other commerical air service based the map of Southeast Alaska airports presented on State-Maps.org (2015).
2. Cruise ship ports, digitized by Audubon Alaska (2015c), based on cruise ship itinerary and ship size information summarized from AlaskaCruises.com (2015) and routes and docks visible on hybrid imagery from ESRI/Bing Maps (2015).
3. Existing hydroelectric power sites and energy tie lines, as of 2009, from AIDEA, acquired by The Nature Conservancy (TNC) (Alaska Industrial Development and Export Authority 2009; The Nature Conservancy: Alaska Field Office 2011).
4. Dam locations, from the National Inventory of Dams, developed by the US Army Corps of Engineers and the Federal Emergency Management Agency (The Nature Conservancy: Alaska Field Office 2011; US Army Corps of Engineers 1999).
5. Open roads including:
    a. Southeast Alaska’s forest system roads, from the USFS (Southeast Alaska GIS Library 2012).
    b. Southeast Alaska’s non-forest system roads from Alaska Department of Natural Resources (Southeast Alaska GIS Library 2011).
    c. British Columbia’s Digital Road Atlas, the authoritative layer for road data in British Columbia (GeoBC 2004).
6. The Alaska Marine Highway system, digitized at a scale of 1:750,000 by Audubon Alaska (2015a), based on routes shown on hybrid imagery from ESRI/Bing Maps (2015) and vessel traffic patterns data from The Nature Conservancy and Marine Exchange of Alaska (2011).
7. Shipping intensity, analyzed by TNC from Marine Exchange of Alaska data in 2009. This analysis used locations from all tracked vessels, conducting a point density analysis with a 1 km search radius. (The Nature Conservancy and Marine Exchange of Alaska 2011; The Nature Conservancy: Alaska Field Office 2011).

MAP DATA SOURCES

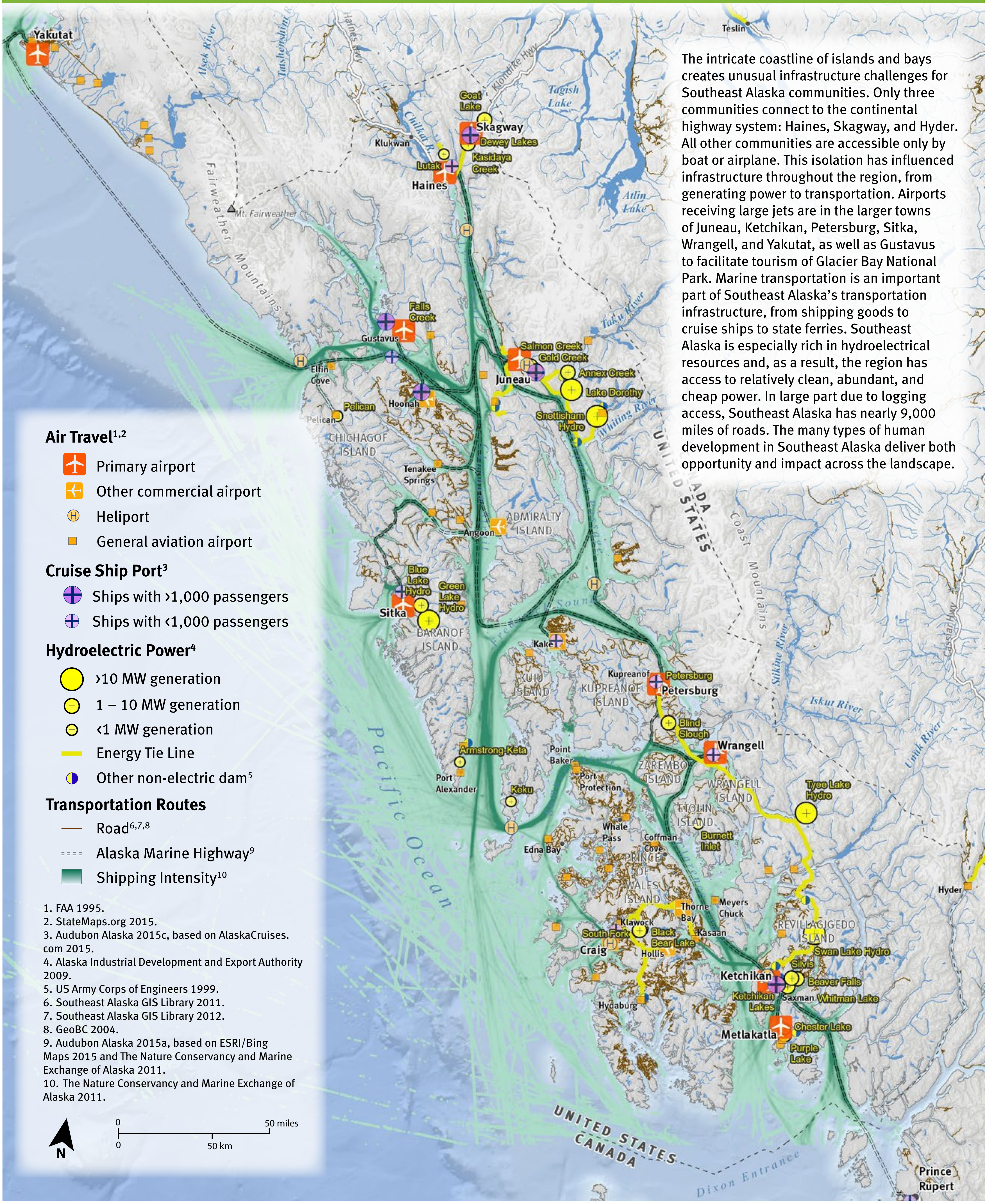
- Air service: FAA (1995) and State-Maps.org (2015)
- Cruise ship ports: Audubon Alaska (2015c), based on AlaskaCruises.com (2015)
- Hydropower sites and energy tie lines: Alaska Industrial Development and Export Authority (2009)
- Dam locations: US Army Corps of Engineers (1999)
- Roads: Southeast Alaska GIS Library (2011), Southeast Alaska GIS Library (2012), GeoBC (2004)
- Alaska Marine Highway: Audubon Alaska (2015a), based on ESRI/Bing Maps (2015), and The Nature Conservancy and Marine Exchange of Alaska (2011)
- Shipping intensity: The Nature Conservancy and Marine Exchange of Alaska (2011).

Transportation and Energy Infrastructure

Audubon ALASKA

The Nature Conservancy

The intricate coastline of islands and bays creates unusual infrastructure challenges for Southeast Alaska communities. Only three communities connect to the continental highway system: Haines, Skagway, and Hyder. All other communities are accessible only by boat or airplane. This isolation has influenced infrastructure throughout the region, from generating power to transportation. Airports receiving large jets are in the larger towns of Juneau, Ketchikan, Petersburg, Sitka, Wrangell, and Yakutat, as well as Gustavus to facilitate tourism of Glacier Bay National Park. Marine transportation is an important part of Southeast Alaska's transportation infrastructure, from shipping goods to cruise ships to state ferries. Southeast Alaska is especially rich in hydroelectrical resources and, as a result, the region has access to relatively clean, abundant, and cheap power. In large part due to logging access, Southeast Alaska has nearly 9,000 miles of roads. The many types of human development in Southeast Alaska deliver both opportunity and impact across the landscape.



1. FAA 1995.
2. StateMaps.org 2015.
3. Audubon Alaska 2015c, based on AlaskaCruises.com 2015.
4. Alaska Industrial Development and Export Authority 2009.
5. US Army Corps of Engineers 1999.
6. Southeast Alaska GIS Library 2011.
7. Southeast Alaska GIS Library 2012.
8. GeoBC 2004.
9. Audubon Alaska 2015a, based on ESRI/Bing Maps 2015 and The Nature Conservancy and Marine Exchange of Alaska 2011.
10. The Nature Conservancy and Marine Exchange of Alaska 2011.

Map 7.2: Transportation and Energy Infrastructure

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COMMUNITY SUBSISTENCE USE

Excerpted from John Sisk (2007)
Revised by Nils Warnock

The 1980 Alaska National Interest Lands Conservation Act (ANILCA) identified subsistence as a priority use of federal lands in Alaska. ANILCA defines subsistence as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife…; for barter, or sharing for personal or family consumption; and for customary trade." Significantly, ANILCA links subsistence to rural Alaska residency, without ethnic or other distinction. This inclusive definition fits the nature of subsistence harvests in Southeast, where Tlingit, Haida, Tsimshian people, and other Alaska citizens all depend on harvesting the region's bounty for their direct personal and family use.

In 1978, the State of Alaska passed its first subsistence statute (Alaska Statute 1978), which gave "priority" to subsistence uses of fish and game resources over other uses, with all Alaska residents eligible to participate. In contrast, federal passage of Title VIII of ANILCA gave a subsistence priority to rural residents only. The conflict in subsistence eligibility rules led to two parallel sets of management regulations, beginning in 1990 with the federal takeover of subsistence management on federal lands and marine mammals (Huntington 1992) and state management of state and private lands. ADFG Title 05 Regulations outline the State of Alaska subsistence statutes. Subsistence use includes the customary and traditional uses of fish and game in rural areas of Alaska (Alaska Department of Fish and Game 2014). Complex and varied subsistence regulations continue to be a source of debate.

The rainforest ecosystem of Southeast is rich in wildlife, fish, and other renewable resources that are used by local hunters, fishermen, and gatherers. These subsistence harvests constitute a significant portion of the food consumed by rural residents, and collectively the harvests represent one of the most fundamentally important uses of natural resources. The 17-million ac (6.9-million-ha) Tongass National Forest encompasses approximately 80% or more of the land area of Southeast, and a wide variety of subsistence activities takes place in the Tongass. Glacier Bay National Park and Preserve occupies an additional 3.3 million ac (1.3 million ha) of federal land and marine waters in the region. Only limited and largely ceremonial use of subsistence resources occurs within the National Park portion of Glacier Bay, although significant fishing and some hunting occur legally in the 57,000 ac (23,000 ha) designated as a National Park Preserve. Because of the extensive area and the richness of biological resources in the Tongass National Forest, the vast majority of subsistence harvests in Southeast occur there or on the immediately adjacent tidal lands.

HISTORIC NATIVE SUBSISTENCE

The Tlingit, Haida, and Tsimshian people have the longest subsistence relationship with Southeast Alaska, and have long held traditional laws and customs mandating the conservation and perpetuation of subsistence resources (Voluck 1999). The Haida Nation is centered on the Queen Charlotte Islands (Haida Gwaii) of northern British Columbia; the northern or "Kaigani" Haida people have lived in Alaska on Prince of Wales Island since before European contact (MacDonald 2001). A major portion of Southeast was the ancestral home of the Tlingit people, today the most numerous Native residents of the region. The intact remains of Tlingit fishing structures hewn from wood have been carbon-dated to more than 3,000 years ago on Admiralty Island, a testament to the traditions of Native subsistence in Southeast (Newton and Moss 1984). Relative newcomers to Alaska, since 1887, Tsimshian people have lived on Annette Island in southern Southeast Alaska (Annette Island School District 2005).

Sheldon Museum and Cultural Center

Subsistence fishing using a gill net.

CONTEMPORARY SUBSISTENCE

The majority of rural Southeast Alaska households continue to subsistence harvest fish and game to this day (Alaska Department of Fish and Game 2014). Annual take of wild food by Southeast residents averages around 200 lb per person (91 kg) (Alaska Department of Fish and Game 2000, 2014). In contrast, annual per capita harvests of rural communities range from 200 lb (91 kg) to 400 lb (181 kg) (Wolfe 2004). Annual estimates of the cost of replacing the wild food harvested by rural Southeast residents with retail purchases of equivalent food run from $22–$44 million (Alaska Department of Fish and Game 2000, 2014; Flanders et al. 1998). People harvest many species of animals and plants in Southeast, but deer (*Odocoileus hemionus sitkensis*), salmon (*Oncorhynchus spp.*), and halibut (*Hippoglossus stenolepis*) are particularly and consistently important to rural communities and Native people throughout the region (Naves et al. 2010; Wolfe 2004).

MAMMALS

Nearly half of rural Southeast residents harvest game and almost 80% use the meat and other animal products (Alaska Department of Fish and Game 2014). Sitka black-tailed deer represent the most important subsistence food in Southeast, aside from fish. During the 20 years from 1983 to 2003, an average annual harvest of 12,361 deer was taken by an average of 7,994 hunters (Straugh 2004). Deer harvest levels vary substantially by rural community. The highest harvest rates occur on Admiralty, Baranof, and Chichagof islands (ABC islands) and Prince of Wales Island (US Forest Service 2008c). Residents of the rural communities of Edna Bay, Port Alexander, Pelican, Tenakee Springs, Hoonah, and Angoon harvested an average of 250 lb (114 kg) per household in 1987 (Kruse et al. 1988).

Other mammals are not so widely distributed as deer, but are also important. Moose (*Alces alces*) are hunted on the mainland, particularly in the large valleys carved by transboundary rivers such as the Taku and the Stikine. The towering cliffs and ridges alongside the great Taku and the Stikine river valleys are habitat for mountain goats (*Oreamnos americanus*). Tlingit weavers use mountain goat fur as the source of fiber for their beautiful and famous Chilkat and Ravens Tail blankets. Likewise, wolves (*Canis lupus*) are harvested in Southeast and their fur used mainly to trim clothing, blankets, and ceremonial objects such as masks (Turek et al. 2008). Hunters harvested the majority (72–83%) of wolves from boats, and the percentage of households harvesting wolves in four Southeast communities ranged from 1–10% (Turek et al. 2008).

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Black bears (*Ursus americanus*) and brown bears (*U. arctos*) are abundant and widely distributed in Southeast Alaska (Flanders et al. 1998). Both bear species inhabit the mainland forests, but they are segregated on the islands. Although the brown bear is hunted by sportsmen as a trophy animal, most subsistence bear hunting focuses on the smaller black bear as a food resource.

Residents of Southeast also utilize various marine mammals. Native Alaskans are exempted from the Marine Mammal Protection Act for subsistence use of marine mammals. Native people harvest sea otters (*Enhydra lutris*) and use the fur for clothing and other handicrafts. The mean reported annual subsistence take of sea otters in Southeast from 2006–2010 was 447 animals (US Forest Service 2014). The harvest of pinnipeds in Southeast is more widespread than the sea otter harvest, but has been declining since the 1990s (Wolfe et al. 2013). The vast majority of seals captured are harbor seals (*Phoca vitulina*), with annual take in Southeast ranging from close to 1,900 seals harvested in 1995, to 595 seals harvested in 2012. In recent years (2005–2012) the largest numbers of harbor seals were taken by the Yakutat community (Wolfe et al. 2013). Hunters take a few Steller sea lions (*Eumetopias jubatus*) in Southeast as well (Wolfe et al. 2013).

FISH

Eighty percent of rural Southeast households harvest subsistence fish (Alaska Department of Fish and Game 2014). In the Tlingit villages of Angoon and Hoonah, fish represented about 55%, by weight, of the annual subsistence harvests of residents. The mean subsistence harvest of salmon for personal use in Southeast from 1996–2006 was 67,703 salmon per year, of which 83% were sockeye (*Oncorhynchus nerka*), 6% pink (*O. gorbuscha*), 5% chum (*O. keta*), 4% coho (*O. kisutch*), and 2% Chinook salmon (*O. tshawytscha*) (Naves et al. 2010). Chinook and coho salmon have few formal subsistence fisheries and instead are obtained through participation in commercial and sport fisheries, as well as through incidental take when subsistence fishing for other species (Fall et al. 2003).

Subsistence fishing for halibut has a long history in Southeast, as evidenced by the carved halibut hooks used by Native people for centuries. In 2003, the federal government authorized a formal subsistence halibut fishery. Each year between 2003 and 2006, more than 3,000 Southeast subsistence fishermen landed greater than 600,000 lb (272,000 kg) of halibut (Fall et al. 2004; Fall et al. 2007).

Other fish are also important. Sitka Sound boasts a large herring (*Clupea pallasii*) spawn in early spring, and herring roe is a prized subsistence food. The annual harvest of herring spawn by subsistence users in Sitka Sound ranged from 72,000–381,000 lb (32,700–173,000 kg) a year between 2002 and 2014 (Sill and Lemons 2015). Herring roe harvest per capita was nearly 15 lb (6.8 kg). In the spring, eulachon (*Thaleichtys pacificus*) smelt, also called hooligan, swim up select large mainland rivers by the millions. Hooligan and their oil are prized foods in many Native families and villages (Turek 2009).

Other animals - Octopi (*Octopus dofleini*) are special delicacies and are most abundant on the outer ocean coasts, as are abalone (*Haliotis kamtschatkana*). Subsistence gatherers may find bird eggs on rocky, ocean islands and near glaciers where seabirds congregate to breed. Dungeness (*Cancer magister*), tanner (*Chionoecetes spp.*), and king crab (*Paralithodes spp.*) are harvested from specific marine habitats.

Plants - Plant harvests also make up an important component of the subsistence lifestyle. Gatherers may pick and preserve various delicious berries. Some of the most popular berries are blueberries (*Vaccinium spp*.), huckleberries (*V. parvifolium*), nagoon berries (*Rubus arcticus*), highbush (*Virunum edule*) and lowbush cranberries (*Oxycoccus Oxycoccos*), as well as currants (*Ribes spp.*). Kelp and seaweed are gathered and dried for use in cooking and special preparations. Sea vegetables are also rich in vitamins and minerals, and make a wonderful seasoning. Spruce (*Picea sitchensis)* roots and red cedar (*Thuja plicata*) bark are gathered for basketry. Subsistence harvesters may also collect plants such as devil's club (*Oplopanax horridus*) for their medicinal properties.

Sheldon Museum and Cultural Center

A Tlingit man netting eulachon (hooligan), 1927. The canoe is filled to almost overflowing with fish.

CONSERVATION ISSUES

Subsistence harvesting success is sensitive to the deterioration or loss of fish and wildlife habitat, changes in accessibility, and increased resource competition. The state of Alaska identified logging, road construction, and mining as the development disturbances most likely to affect subsistence use in Southeast (Flanders et al. 1998). Harvest of old-growth forest habitat significantly affects the productivity of subsistence game harvest—in particular, deer. Old-growth forests constitute important deer winter habitat (Kirchhoff and Schoen 1987; Leopold and Barrett 1972; Schoen and Kirchhoff 1990; Wallmo and Schoen 1980). Because natural deer mortality is highest in winter, the quality of winter habitat can be a limiting factor. In areas where logging has diminished important forest habitat, severe winters with deep snows significantly reduce deer populations (Person and Brinkman 2013). Subsistence deer hunters have also noted that within a few years after a clearcut, regrowth tends to make the areas impassable (Galginaitus 2004 cited in US Forest Service 2008c).

Construction of roads in Southeast, mainly driven by logging, both aids and hinders subsistence efforts. Roads pose risks to salmon migration, spawning, and rearing habitat in freshwater streams. Before 1954, Southeast had only a few, scattered roads. The Tongass now has about 5,000 mi (8,000 km) of roads with new construction of more than 25 mi (40 km) a year on average (1997–2005) (US Forest Service 2008c). This expansive road network poses a major maintenance challenge. Some roads need to be restored to minimize

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erosion damage to soils and salmon streams. Stream crossings need to be removed or improved to ensure they do not block salmon passage. An ADFG stream inventory suggested one to two thirds of stream crossings in Southeast need remedial work to ensure fish passage (Flanders and Cariello 2000).

Roads can also change access to established subsistence harvest areas, with complex results (US Forest Service 2008c; Wolfe and Walker 1987). Easy access to important hunting and fishing areas might appear to benefit the subsistence lifestyle, but it can also result in increased competition for prime fish streams or wildlife habitat areas. Possible impacts include displacement of subsistence hunters, reduced harvests by both subsistence and visiting hunters, and decline in deer populations. On Prince of Wales Island, the Alexander Archipelago wolf population has precipitously declined in recent years. An estimated 87% of the wolf mortality was caused by a combination of legal and illegal hunting and trapping (Person and Russell 2008), facilitated by increased hunter access along roads built for logging (Person and Brinkman 2013).

During preparation of the 1997 revision of the Tongass National Forest Land and Resource Management Plan (TLMP) (US Forest Service 1997a), the USFS cooperated with the ADFG to develop a region-wide assessment of rural subsistence harvest patterns and the use intensity in important places within the Tongass (Kruse et al. 1988; US Forest Service 1997b). In comments on the 1997 TLMP, the State of Alaska used an assessment of fish and game resources to identify the watersheds that are most important for meeting the harvest needs of local communities and rural residents. (Flanders et al. 1998). That assessment identified the watersheds with the highest "community use values" and ranked watersheds for sensitivity to disturbance. The subsistence use areas of the ABC and Prince of Wales islands were ranked as having some of the highest sensitivities to disturbance in the Southeast Alaska (Flanders et al. 1998).

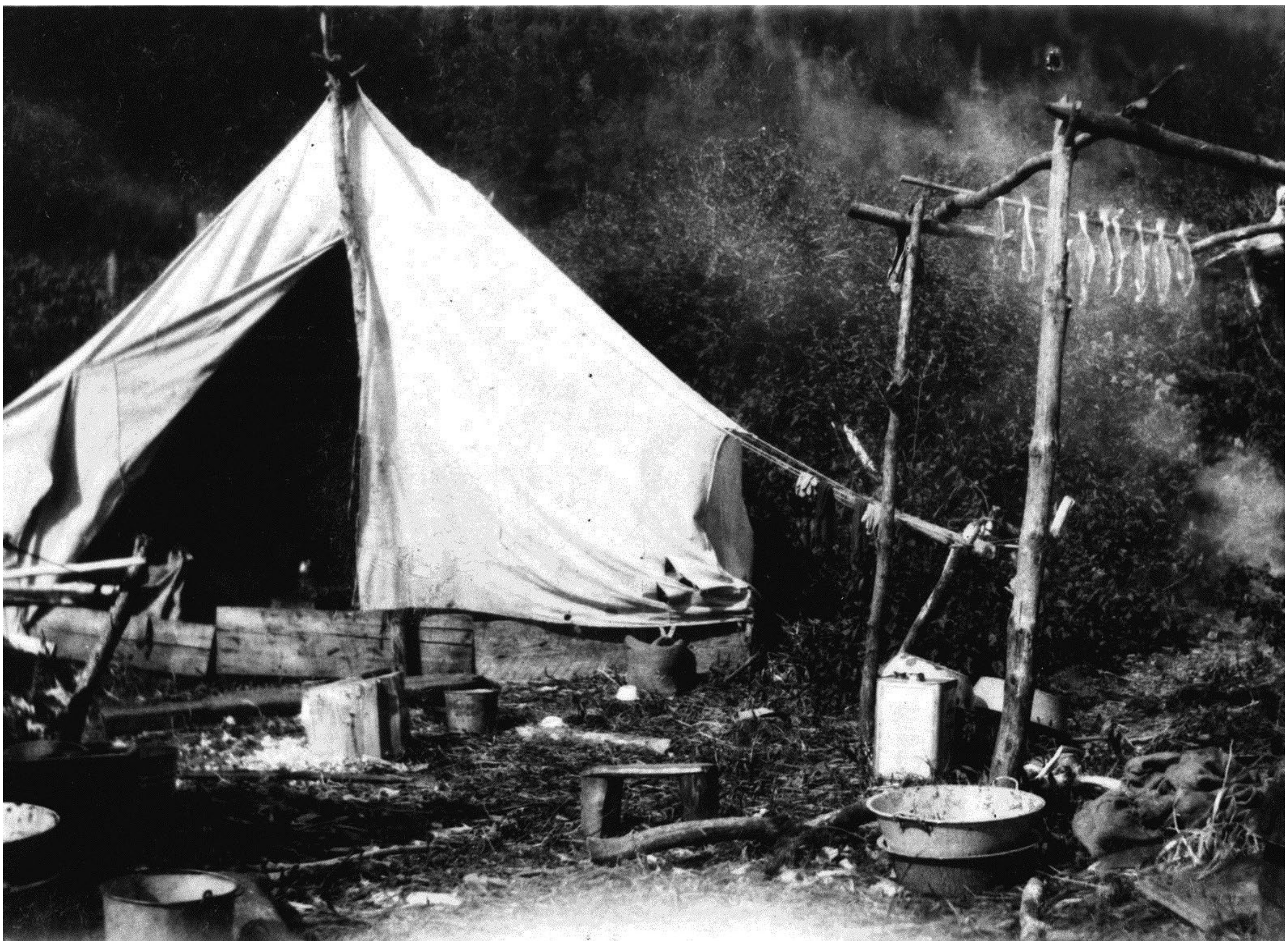
MAPPING METHODS

ADFG compiled information on fish and wildlife harvest by community. The mapping focused on salmon, bear, deer, and forest vegetation (Flanders et al. 1998). Watershed units were overlayed to account for the number of communities using an area for subsistence. The agency combined community use areas with additional data and expert knowledge on areas of high productivity for old-growth forest, fish, and wildlife to produce a prioritized list of community use values by watershed (VCU) (Flanders et al. 1998).

Pie charts representing the composition and total take of subsistence resources were compiled by community from ADFG's subsistence survey data (2015c). For each community and each resource (birds and eggs, fish, land mammals, marine invertebrates, marine mammals, and vegetation), we selected most recent study, then joined Estimated Pounds Harvested to community location.

MAP DATA SOURCES

- Community use and priority areas: Flanders et al. (1998)
- Harvest by community: Alaska Department of Fish and Game (2015c).



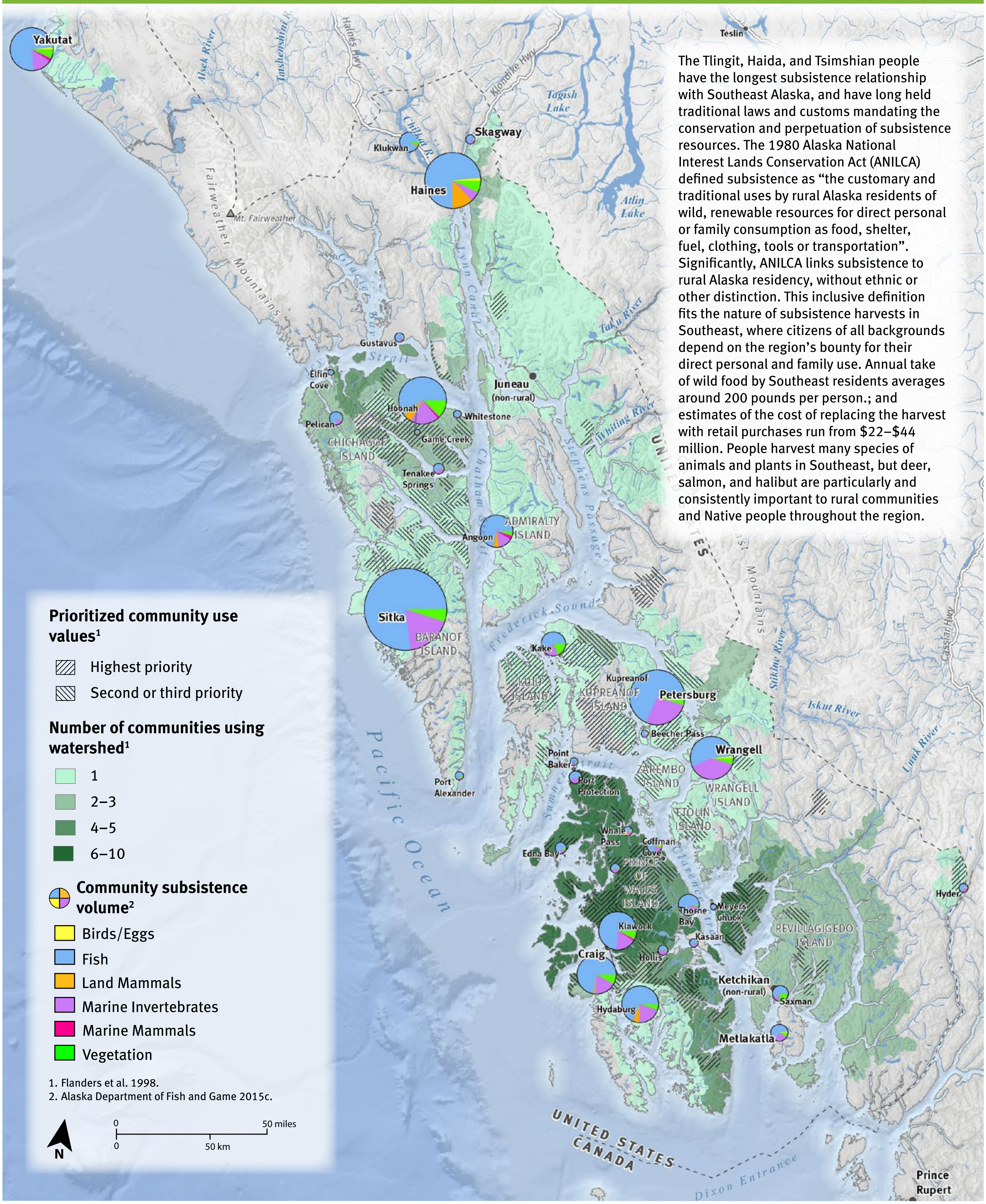
Sheldon Museum and Cultural Center

A 1920s Tlingit eulachon fish camp tent and fish-smoking rack.

Community Subsistence Use

Audubon ALASKA

The Tlingit, Haida, and Tsimshian people have the longest subsistence relationship with Southeast Alaska, and have long held traditional laws and customs mandating the conservation and perpetuation of subsistence resources. The 1980 Alaska National Interest Lands Conservation Act (ANILCA) defined subsistence as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools or transportation". Significantly, ANILCA links subsistence to rural Alaska residency, without ethnic or other distinction. This inclusive definition fits the nature of subsistence harvests in Southeast, where citizens of all backgrounds depend on the region's bounty for their direct personal and family use. Annual take of wild food by Southeast residents averages around 200 pounds per person.; and estimates of the cost of replacing the harvest with retail purchases run from $22–$44 million. People harvest many species of animals and plants in Southeast, but deer, salmon, and halibut are particularly and consistently important to rural communities and Native people throughout the region.



Map 7.3: Community Subsistence Use

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TIMBER

Benjamin Sullender and Melanie Smith

The complex geography of Southeast Alaska creates a fragmented mosaic of forests, constrained by a low timberline (approximately 2,500–3,000 feet, depending on aspect and latitude) and interrupted by steep slopes, glaciers, and wet muskeg bogs (Sisk 2007a). Forests are composed primarily of Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) (Hutchison and LaBau 1975). Within the Tongass, broad-scale disturbances such as fire are rare. Canopy gap generation instead stems primarily from windthrow (Kramer et al. 2001), and to a smaller extent from disease, insect damage, avalanches, and occasional flooding (Alaback et al. 2013; Ott and Juday 2002). As a result of these spatially limited processes, old-growth in the Tongass is heterogeneous, and multi-storied. Old-growth stands may include snags (standing dead or dying trees), saplings, pole timber, centuries-old trees, and layers of understory vegetation, exhibiting substantial diversity in vertical canopy structure (Alaback et al. 2013).

Historically, indigenous usage of Southeast Alaska's forests was typically limited to single-tree harvest for immediate needs (Crone and Mehrkens 2013). In the late 1800s and early 1900s, Southeast Alaska's forests were not officially managed. Instead, logging was primarily composed of localized harvest to support the immediate timber needs of the fishing and mining industries (Sisk 2007c). After the Tongass was officially designated as a national forest in the early 1900s, the United States Forest Service (USFS) began auctioning tracts of timber for harvest. However, the contemporary regulatory and economic environment forestalled significant investment by the timber industry. Operating costs were high due to difficult terrain, lack of transporation infrastructure, and remoteness, which presented an obstacle to supporting a workforce and accessing markets for forest products (Crone and Mehrkens 2013). Timber companies were hesitant to commit financing to build the requisite infrastructure and harvest in an unknown landscape, given the examples of failed sales, cancelled contracts, and small sawmills that rapidly went of out business (Rakestraw 1981).

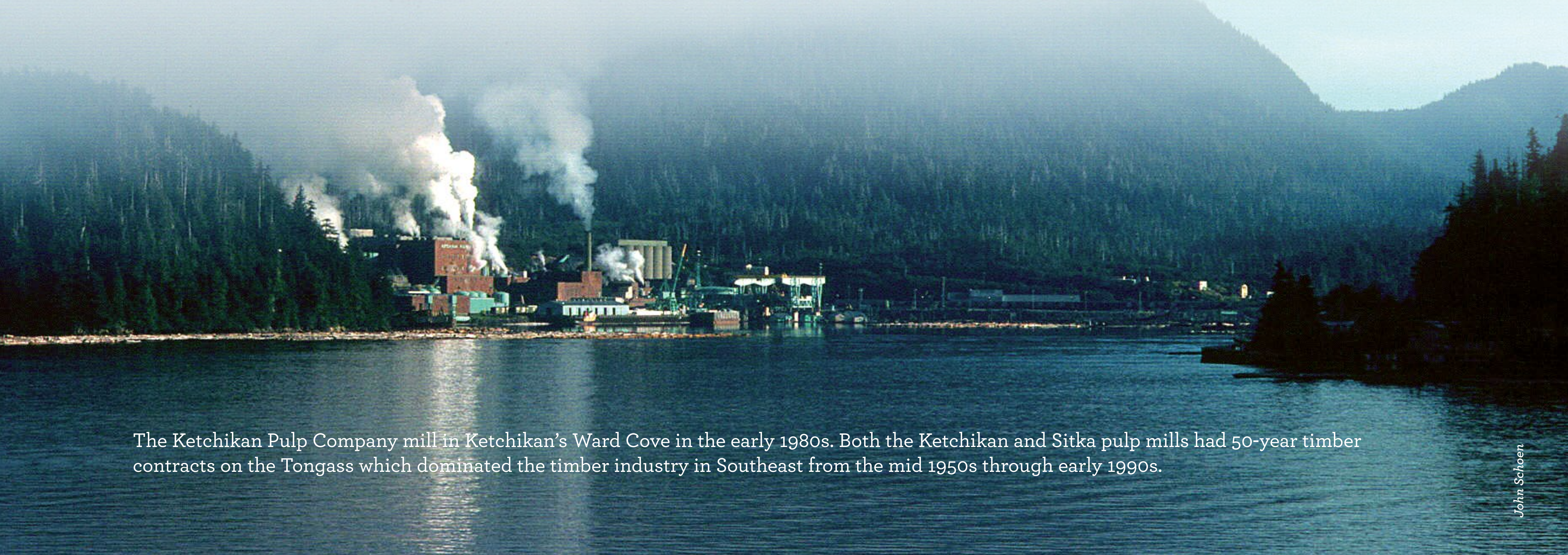
As the 20th century progressed, calls strengthened to leverage Alaska's natural resources as a pathway toward widespread economic development. The prevailing political belief at the time, fostered by proponents of aggressive logging such as Regional Forester, and later Territorial Governer, Frank Heintzleman, was that the Tongass' wealth of timber could be the centerpiece of a regional development plan (Nie 2006). Partially due to a post-World War II boom in demand for forest products, efforts to establish a timber industry came to fruition with the Tongass Timber Act of 1947 (Beier et al. 2009). (Note that this controversial act was later legally challenged, albeit unsuccessfully, and was considered by many an unfair confiscation of indigenous lands.)

Rather than exporting unprocessed round logs, the early days of the Tongass timber industry focused on providing wood pulp and fiber (Crone and Mehrkens 2013). The Tongass Timber Act catalyzed wood pulp production by providing credits for logging road construction, a guaranteed supply of timber, and extending logging contracts to an unprecedented 50 years (Sisk 2007c). Two timber operations constructed major sawmills in Ketchikan (which began operations in 1954) and Sitka (in 1959); these sawmills would dominate the industry for the next several decades (Nie 2006). This domination was the product of decades of collusive business practices which led to antitrust convictions for the mills. The convictions resulted in Congress unilaterally modifying the long-term contracts in the 1990 Tongass Timber Reform Act (TTRA) to protect and wisely manage Tongass resources and promote fair competition within the Tongass industry.

In 1971, Congress passed a landmark bill known as the Alaska Native Claims Settlement Act (ANCSA). In Southeast Alaska, the law created a regional corporation (Sealaska) and 12 village and urban corporations and authorized these Alaska Native corporations to select 550,000 acres of land (Sisk 2007c). The corporations preferentially selected high-value timber lands from geographically restricted selection boxes offered through the Congression action. Native Corporation practices on these selected lands have focused primarily on aggressive logging (Nie 2006).

The Tongass timber industry received a somewhat unexpected boost with the 1980 passage of the Alaska National Interest Lands Conservation Act (ANILCA), which set aside a huge tract of the Tongass as wilderness. However, during legislative negotiations, ANILCA's Section 705 concurrently established an automatic $40 million annual timber appropriation subsidies and a mandate to provide 4.5 billion board feet of timber per decade (Beier et al. 2009). With the subsidies in place and Native corporation logging operations ramping up, logging acitivity in Southeast Alaska peaked, providing about 4,000 jobs in 1990 (Crone and Mehrkens 2013).

Throughout the 20th century, the USFS worked closely with the timber industry to encourage economic growth. At one point, 95% of the forest was slated for logging (Sisk 2007c). The USFS' remarkable embrace of industrial forestry was rooted in contemporary support for clearcut logging practices, in which every standing tree is cut from a selected area. Although the denuded landscape results in increased light penetration that, in turn, encourages rapid regrowth, clearcutting fundamentally shifts regional ecology by creating thick stand impenetrable to sunlight thereby reducing structural diversity (Alaback 1984), with cascading implications for wildlife (Sisk 2007a) and especially old-growth-obligate flora and fauna (e.g. Shanley et al. 2013).



The Ketchikan Pulp Company mill in Ketchikan's Ward Cove in the early 1980s. Both the Ketchikan and Sitka pulp mills had 50-year timber contracts on the Tongass which dominated the timber industry in Southeast from the mid 1950s through early 1990s.

John Schoen

TIMBER
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John Schoen

Clearcut on northeast Chichagof Island.


John Schoen

Forest regrowth 60 years after clearcut.

Whereas a naturally functioning temperate rainforest provides a variety of habitats in the same patch due to heterogeneity, post-clearcut regrowth follows three main stages: early productivity, stem exclusion, and maturity. Within 20 years of logging, forage biomass for herbivores such as Sitka black-tailed deer (*Odocoileus hemionus sitkensis)* reaches peak abundance, albeit at a lower quality than in mature stands (Person and Brinkman 2013). After about 25 years, regrowth reaches a stage known as stem exclusion. In this stage, even-aged trees create a dense canopy that shades out the understory, essentially eliminating available forage (Alaback 1980). Depending on environmental factors such as soil quality and exposure to disturbances, the stem exclusion stage can last over 150 years, with some tree stands requiring 250 or more years to acheive the vertical canopy structure typical of productive old-growth forests (Alaback and Tappeiner 1984).

In addition to promoting clearcutting, Tongass logging has typically followed the practice of "high-grading," or preferentially targeting large-tree stands (Sisk 2007c). Large old-growth trees represent high timber value, and loggers target these patches of forest disproportionately to their abundance (Albert and Schoen 2013).

Gradually, the scientific community and the public acknowledged these ecological realities and the USFS refocused its overall mission. Such incremental progress culminated in regulatory reform in the 1970s and 1980s (Beier et al. 2009), capped by the passage of the TTRA in 1990. The TTRA halted the Forest Service's "timber-first" approach to Tongass management regardless of market demand, impact on other multiple uses, or cost to taxpayers. Later in the 1990s, global demand for timber products collapsed and higher operating costs put the Alaskan timber industry at a competitive disadvantage for a receding market share (Crone and Mehrkens 2013). In the face of declining pulp market, rising costs, and insurmountable competition, the pulp mills in Sitka (in 1994) and Ketchickan (in 1997) terminated their contracts and closed (Beier et al. 2009).

The 1997 Tongass Land Management Plan (TLMP) further shifted the agency away from its "timber first" approach and helped formalize the USFS multiple use mandate (Nie 2006). The 1997 TLMP called for the establishment of old-growth reserves, riparian and beach-fringe buffers, wildlife conservation measures, and ecosystem-based management (Beier et al. 2008). The TLMP Old-growth Conservation Strategy was an big improvement for habitat conservation across the Tongass; yet the Strategy was considered inadequate by many, including the Peer Review Committee of scientists established in 1993 by the Pacific Northwest Research Station of the Forest Service. The committee issued a joint statement in 1997, stating that the new plan relies on "an inadequate reserve system" and "ignores the adverse consequences of fragmenting habitat". The conservation measures have since been the subject of multiple conservation and viability studies concerned with gaps in the TLMP strategy (Cook et al. 2006; Lindenmayer et al. 2006; Person and Brinkman 2013; Person and Logan 2012; Schoen and Dovichin 2007; Smith 2013; Smith and Person 2007).

The Audubon-TNC Conservation Assessment (Albert and Schoen 2007) addressed the gaps in the Tongass reserve network with identification of watershed-scale reserves (Lertzman and MacKinnon 2013) for conservation and restoration. Together with the TLMP old-growth conservation measures, the Audubon-TNC approach would ensure ecological integrity by protecting the core areas of the Forest in perpetuity. To date, those core watersheds have not been permanently protected. However, the 2008 TLMP postponed logging in many higher value watersheds under the Tongass Timber Sale Program Adaptive Management Strategy. Subsequently a smaller, closely related proposal identified the Tongass 77 (T77), a set of watersheds that best protect salmon and other values, as identified by local fishermen and Trout Unlimited with support from Audubon Alaska, based on the assessment work by Audubon and TNC.

In 2010, a major ideological shift occurred within the Forest Service when the Regional Forester announced that the Tongass National Forest would transition away from old-growth logging toward a sustainable, second-growth industry. Yet in years following, old-growth logging continued, and the highly controversial Big Thorne Timber Sale—the largest old-growth sale in a decade—was an indication to many that the Forest Service was dragging its feet. This led to a call for an amendment to the TLMP to codify the transition out of old-growth logging.

The proposed 2015 TLMP Plan Amendment set aside old-growth timber in the Audubon-TNC and T77 conservation priority watersheds from large-scale clearcut logging. Yet the proposed plan allows entry for second-growth logging into all timber-suitable lands previously logged. Those areas slated for clearcutting include second-growth in the same Audubon-TNC and T77 priority watersheds, as well as the beach fringe and riparian buffers, and old-growth habitat reserves that make up the TLMP Old-growth Conservation Strategy. Importantly, the plan also ramps up the level of old-growth logging at levels higher than the last decade. These concerns will be central to evaluating the success of this ongoing TLMP amendment process.

Economic realities, including persistent high operating costs for industry, may preclude the promised shift from old-growth to second-growth logging (Crone and Mehrkens 2013), or cause the industry to close their remaining operations, although others believe that the time is right for an industry shift to second-growth in as few as five years (Mater 2014). Some are calling for an end to old-growth clearcutting altogether, citing ecological impacts, high timber subsidy at cost to taxpayers (about $200,000 per timber job on the Tongass), and maintaining a globally significant carbon stock in light of recent US commitments at the global climate talks in Paris. It remains to be seen whether the USFS will truly transition to a timber industry based on logging of second-growth as has been achieved in the Lower 48 States, or whether the transition to end old-growth clearcut logging entails an end to the timber-based economy altogether.

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CONSERVATION ISSUES

The heavy exploitation of rare large-tree stands on the Tongass has long been a concern of wildlife biologists. Those concerns were affirmed by a congressionally appointed blue-ribbon panel of scientific peer reviewers (Powell 1997) and reflected in a national position statement on management of old-growth forests on the Pacific coast of North America (The Wildlife Society 2007). In the 1990 Tongass Timber Reform Act, Congress acted to ban the highgrading of large-tree stands of old growth. Still, highgrading continues to be an ongoing concern on the Forest today (Albert and Schoen 2013). For example, yellow cedar (*Cupressus nootkatensis*), a species in serious decline across the region (Hennon et al. 2012), is targeted by industry as it is especially valuable in today's markets, with a stumpage value in 2005 that was five times higher than the next most valuable species (Beier 2011).

Currently the State of Alaska maintains a timber base of 42,000 acres in northern Southeast Alaska near Haines and 44,000 acres in southern Southeast Alaska on several major islands (Alaska Department of Natural Resources Division of Forestry 2015, 2016). Sealaska Corporation owns 290,000 acres of land that is subject to clearcut logging. State and Native Corporation timber programs contribute to environmental degradation, often with greater impact to the resource due to fewer ecological standards and guidelines for operating than required on federal lands. The cumulative impact of these timber sales must be considered by the USFS in their own planning and project implementation.

Log transfer facilities have localized impacts of concern for the marine environment. The timber industry stores masses of logs in protected, often productive, waters before towing them in rafts to a mill. The resulting bark loss damages the benthic habitat in those areas. The Alaska Department of Environmental Conservation has listed several areas as impaired waters due to log storage effects, including Ward Cove in Ketchikan, Thorne Bay on Prince of Wales Island, Silver Bay near Sitka, and East Port Frederick on northeast Chichagof Island (Alaska Department of Environmental Conservation 2010).

Until clearcutting is discontinued in the Tongass, succession debt (in which early post-harvest productivity disguises the negative impacts of subsequent stem-exclusion) will continue to accumulate (Person and Brinkman 2013). As more logged stands reach stem exclusion stages, wildlife habitat capability will decline, even if future logging is halted.

Beyond impacts to individual stands, more pervasive forces also affect Tongass timber lands. Subsidized development of infrastructure has left a network of logging roads that fragments remaining habitat and increases mortality risk for wildlife (Person and Brinkman 2013; Sisk 2007c; US Fish and Wildlife Service 2016). The recent sharp decline in Alexander Archipelago wolves (*Canis lupus ligoni*) on the heavily logged Prince of Wales Island is an example of how intense logging and high road densities can lead toward extirpation of populations if not properly managed (Audubon Alaska 2015d; US Fish and Wildlife Service 2016).

Audubon strongly recommends an end to old-growth clearcut logging in the Tongass National Forest. Alternative forest management could include logging of second-growth stands outside of conservation lands (TLMP Old-growth Conservation areas, Audubon-TNC conservation priority watersheds, and T77 watersheds), and small old-growth sales totaling less than 5 million board feet annually.

MAPPING METHODS

The uncut suitable timber dataset was developed by the Tongass National Forest for their 2008 Plan. This is based on a forest-wide planning layer which represents suitable timber before on-the-ground stand exams are conducted. The TNF refers to "tentatively suitable" timber which indicates lands that are biologically productive, have shallow slopes, operable soil types, etc., and "suitable" refers to lands where timber is also allowed based on land use designations. This layer depicts suitable old-growth timber that has not been previously harvested. The suitability of previously harvested lands is in flux during 2016 due to pending decisions about the TLMP amendment.

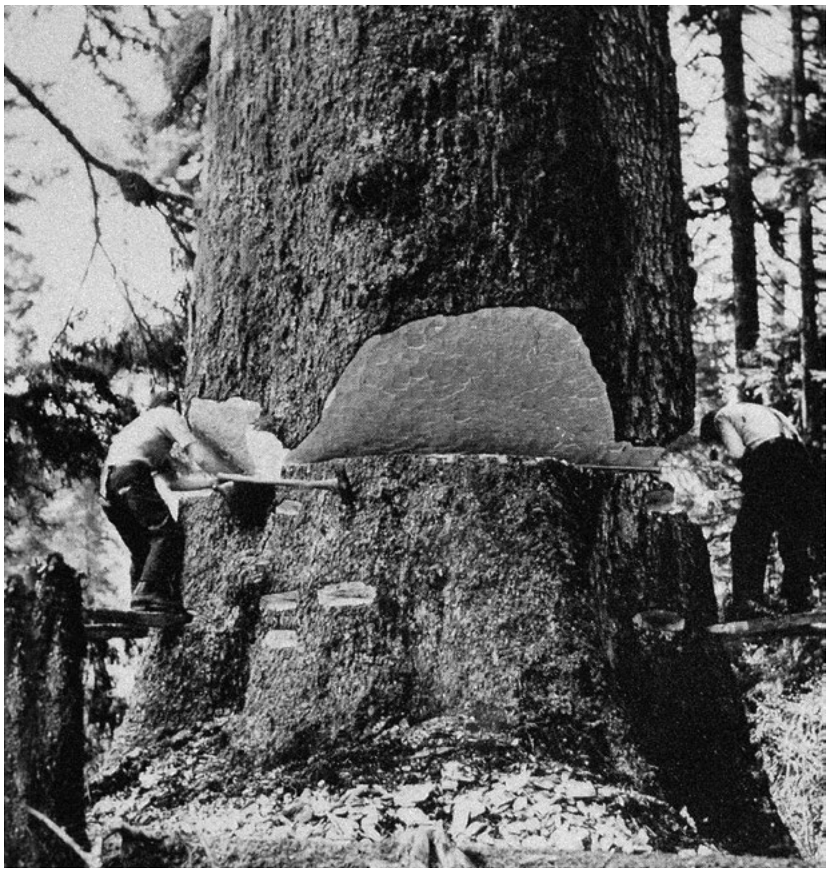
Previously logged timber comes from two datasets. The transboundary land cover classification was put together by Audubon Alaska et al. (2012) which involved collaboration between Alaskan and Canadian government agencies (e.g. US Forest Service, National Park Service, US Fish and Wildlife Service, and 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. This layer is current across all ownerships as of 2012. The second layer was provided by the US Forest Service depicting timber harvest activity on TNF lands which is current through early 2016.

Marine Access Log Transfer Facility (LTF) sites were digitized by the USFS from known coordinates or using digital ortho photographs as backdrops for location of features. Points are included for historical LTFs that are no longer in existence. The LTF cover is updated as needed when new LTFs are built or proposed for timber sale support or non-operational LTFs are disposed of. This dataset is current as of 2004.

Ownership is depicted for USFS, Native Corporation, and State of Alaska lands. Together, these three entities permit the vast majority of timber operations in Southeast Alaska. Ownership is based on USFS and Alaska Department of Natural Resources datasets.

MAP DATA SOURCES

- Logged forestland: Audubon Alaska et al. (2012), US Forest Service (2016c)
- Suitable timber: US Forest Service (2008a)
- Log transfer facilities: US Forest Service Tongass National Forest (2002)
- Ownership: US Forest Service (2016b), Alaska Department of Natural Resources: Information Resource Management (2015).

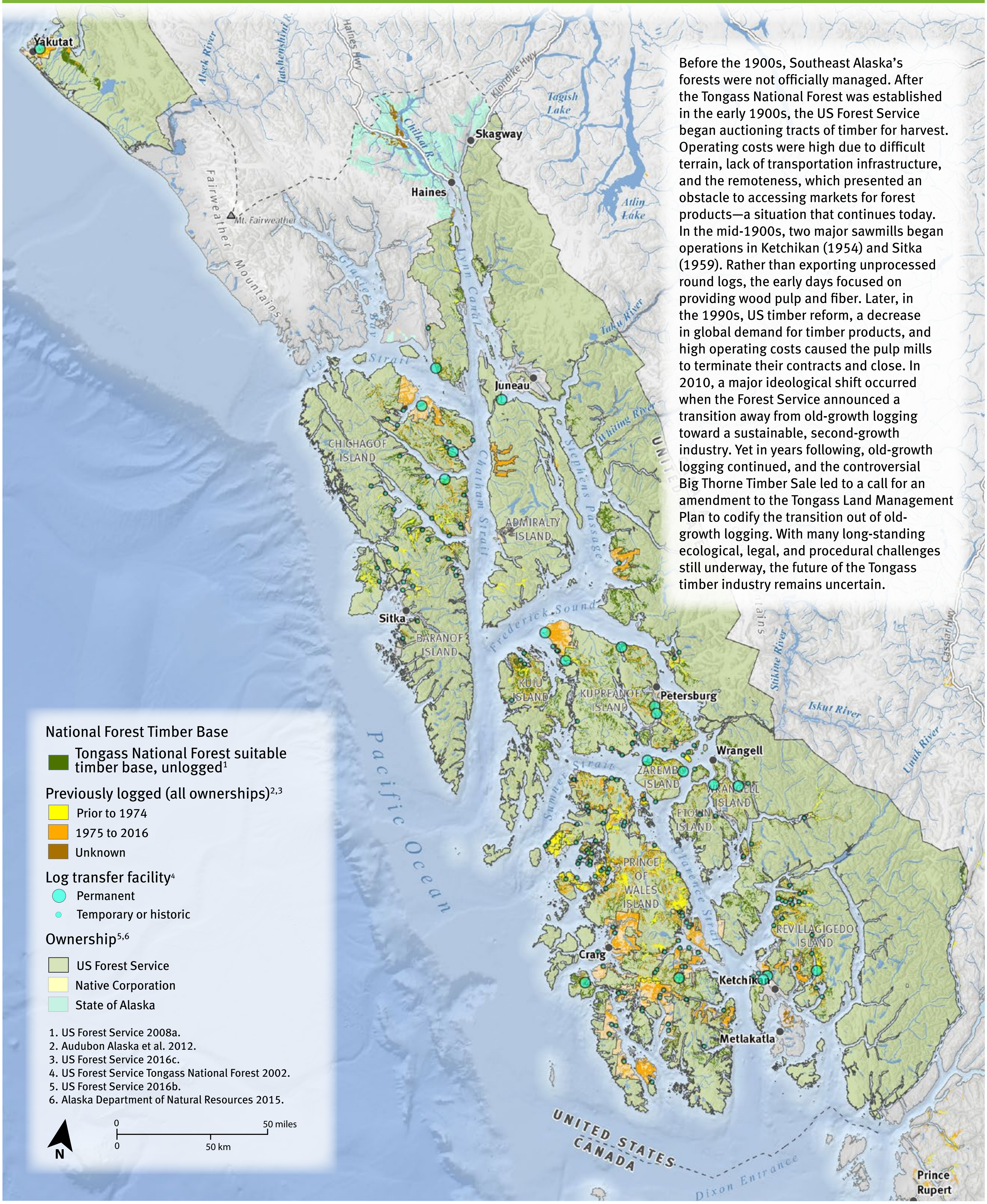


US Forest Service

Hand loggers using spring boards to stand on and axes and hand saws to cut a large old-growth Sitka spruce in the southern Tongass circa 1900. The biggest, best quality, and most accessible trees were cut first throughout the forest.

Timber

Before the 1900s, Southeast Alaska's forests were not officially managed. After the Tongass National Forest was established in the early 1900s, the US Forest Service began auctioning tracts of timber for harvest. Operating costs were high due to difficult terrain, lack of transportation infrastructure, and the remoteness, which presented an obstacle to accessing markets for forest products—a situation that continues today. In the mid-1900s, two major sawmills began operations in Ketchikan (1954) and Sitka (1959). Rather than exporting unprocessed round logs, the early days focused on providing wood pulp and fiber. Later, in the 1990s, US timber reform, a decrease in global demand for timber products, and high operating costs caused the pulp mills to terminate their contracts and close. In 2010, a major ideological shift occurred when the Forest Service announced a transition away from old-growth logging toward a sustainable, second-growth industry. Yet in years following, old-growth logging continued, and the controversial Big Thorne Timber Sale led to a call for an amendment to the Tongass Land Management Plan to codify the transition out of old-growth logging. With many long-standing ecological, legal, and procedural challenges still underway, the future of the Tongass timber industry remains uncertain.



Map 7.4: Timber

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METALS MINING

Beth Peluso

Mining, especially for gold, has played a large part in Southeast Alaska's history. The industry spurred settlements, some of which grew into today's communities and some of which faded away. Mining for metals continues to play a role in Alaska's economy today.

MINING HISTORY

(Passages in this section are excerpted from Sisk (2007b) and revised by Beth Peluso.)

The first mineral location in Southeast was a copper claim in 1867 (Kaufman 1958; Roppel 1991), the same year that the United States purchased Alaska from Russia. Charles V. Baranovich staked the copper claim on Prince of Wales Island near the Haida Indian village of Kasaan. As a result, the Niblack area in Moira Sound saw significant copper mining and construction of ore trans-shipment facilities. Nearly all of these copper deposits were played out by 1908 (Roppel 1991).

Southeast Alaska also has a rich history of gold mining. In 1869, Max Silva discovered placer gold at Windham Bay, south of Juneau; that area produced gold for several years (Kaufman 1958). In 1872, silver and gold were found near Sitka at Silver Bay, and in 1879, a stamp mill briefly operated there (Kaufman 1958; US Department of the Interior 1999).

In 1880, Tlingit Chief Kowee led Joe Juneau and Richard Harris to Gold Creek and into the Silver Bow Basin, near present-day Juneau (Juneau Empire staff 2009). The miners returned with a large amount of gold ore, prompting Juneau's gold rush.

Throughout the Juneau gold mining years, staked claims and mining ventures ranged from Taku Inlet north to Lions Head Mountain on Berners Bay. Although many ventures produced gold and silver, none rose to the stature of the Alaska Juneau (AJ), Alaska Gastineau, and Treadwell complexes. Several Lions Head claims were consolidated into what became the Kensington claims, currently owned by Coeur d'Alene Mines (Stone and Stone 1980).

The Juneau and Harris discoveries led to the establishment of the Alaska Juneau Mining Company, which, over the lifespan of the mine, produced more than $80 million (nominal value) in gold, silver, and lead ores. In 1881, John Treadwell began development of a complex of mines across Gastineau Channel from the Alaska Juneau (AJ) Mine. The Treadwell mine produced more than $67 million in gold and silver during its lifetime. (Kaufman 1958; Stone and Stone 1980).

During the glory days of the boom, many steamships tied up at the numerous piers in Gastineau Channel, offloading supplies and loading gold ore from the AJ and Treadwell mines, the Alaska Gastineau mine at Thane, and the Silver Queen mine in Sheep Creek Basin (Roppel 1991; Stone and Stone 1980). The Silver Queen, Perseverance, and Silverbow Basin mines (all at Juneau) were consolidated into the Alaska Gastineau mine in 1911 (Stone and Stone 1980).

Juneau's major mining era wound down by the 1940s due to a combination of mine collapses and the demand for soldiers during World War II. Three of the four Treadwell underground mines collapsed and flooded in 1917, and the mine limped along for only five more years before closing (Juneau Empire staff 2009).

US Geological Survey

Gastineau Mining Company mill at Juneau, 1913.

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TABLE 7-3 Significant historically producing mines in Southeast Alaska.

Mine Name	Owner	Location	Materials Mined	Size	Activity
Alaska Gastineau Mine		Thane (near Juneau)	Gold		1912–1921 Silver Queen, Perseverance, and Silverbow Basin mines consolidated into this one in 1911; closed due to cave-ins.
Alaska Juneau (AJ)	Alaska Juneau Mining Company	Juneau	Gold, silver, lead	$80 million over life of the mine.	1897–1944 closure of nonessential mines to free men up the war effort.
Bokan Mountain	Ucore (currently)	Prince of Wales Island	Uranium	95,000 tons of uranium oxide ore extracted	1955–1971 mine closed when it played out; now in exploration phase by Ucore for rare earth elements.
Iyoukeen Cove area (small mines)	Kaiser Gypsum Company, formerly owned by Pacific Coast Gypsum	Chichagof Island	Gypsum	500,000 tons during life of the mines	1902–1926; 1950s.
Klag Bay and Kimshan Cove areas (small mines)		Chichagof Island	Gold		1905, 1942.
marble quarries (small mines)		West coast of Prince of Wales Island	Marble		1895–1932.
Niblack	Heatherdale	Prince of Wales Island	Copper, gold, silver, zinc		Copper played out in 1908; in 2009 Heatherdale started underground exploration.
Silver Bay		Sitka	Gold, silver		1872.
Treadwell Mine	John Treadwell (founder)	Douglas Island across from Juneau	Gold, silver	$67 million over life of the mine	3 of the 4 mines collapsed in 1917; mine closed in 1922.
Windham Bay	Max Silva	South of Juneau	Placer gold		1869 gold discovered; produced gold for several years.
Yakobi Island area (small mines)		Near Chichagof Island	Gold		1924–1939.

TABLE 7-4 Significant currently producing mines in Southeast Alaska.

Mine Name	Owner	Location	Materials Mined	Size	Activity
Greens Creek	Noranda started mine; now owned by Hecla Mining Company	Admiralty Island	Gold, lead, zinc silver	Largest silver mine in US; in 2014 produced 7.8 million ounces of silver	1989 to present.
Kensington	Coeur d'Alene Mines (Coeur Alaska)	Berners Bay, north of Juneau	Gold	In 2013 produced nearly 115,000 ounces of gold	Current mining began in 2010; in 2015 the company announced mine expansion.

TABLE 7-5 Exploration phase mines in Southeast Alaska.

Mine Name	Owner	Location	Potential Materials	Exploration Activity
Bokan Mountain	Ucore	Southern Prince of Wales Island	Rare earth minerals (Dysprosium, Terbium, and Yttrium)	Exploration restarted 2011 to present.
Herbert Glacier Mine	Houston Oil and Mineral initially; currently Quaterra Resources Inc. (Vancouver, BC)	18 miles north of Juneau	Gold, silver, copper, zinc, tungsten	Conducted some exploratory drilling beginning in 2010, but the mine remains in the early stages of exploration.
Niblack	Heatherdale	Prince of Wales Island	Copper, gold, silver, zinc	Copper played out in 1908; in 2009 Heatherdale started more exploration; operation currently suspended.
Palmer Mine	Constantine Metals and Dowa Metals and Mining (Japan)	North of Haines	Copper, zinc, gold, silver	2010 to present; mid-stage exploration.
Port Snettisham Iron Ore Project	Arrowstar (Vancouver, BC)	Port Snettisham (south of Juneau)	Iron, initially gold	Ore first reported in 1897; in 2014 Arrowstar relinquished older claims, keeping only newer ones.

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The Alaska Gastineau mine closed in 1921 because cave-ins and the intrusion of water into the mine made the ore unprofitable to mill. Gradually, the Alaska Juneau Mining Company acquired the shuttered mines around it; by 1934, the firm owned most of the immediate Juneau gold properties (Stone and Stone 1980).

Production at the AJ Mine peaked in the late 1930s, and 1941 was the mine's last profitable year. In 1942, the federal War Production Board closed all nonessential mines to free men up for the war effort. The AJ Mine closed permanently in 1944 (Stone and Stone 1980).

In addition to the larger mines, a variety of smaller mines historically operated throughout Southeast. Marble quarries operated on islands on the west coast of Prince of Wales Island from 1895 through 1932. Alaska marble was used in buildings from California and Nevada across the United States (Roppel 1991). Some 500,000 tons of gypsum were mined from the Iyoukeen Cove area on Chichagof Island between 1902 and 1926 (Kaufman 1958; Roppel 1991; US Department of the Interior 1999). Several small gold mines operated on west Chichagof Island at Klag Bay and Kimshan Cove from 1905 and 1942, and on adjacent Yakobi Island from 1924–39 (US Department of the Interior 1999). None of these mines are in operation today.

In the 1950s, a boom in uranium mining led to significant exploration throughout Southeast. Aerial detection of geologic radioactivity identified a deposit on Bokan Mountain on southern Prince of Wales Island in 1955. Between 1955 and 1971 the mine yielded nearly 95,000 tons of uranium oxide ore before the mine was played out and closed (Roppel 1991; US Geological Survey 1996).

In 1973, the Noranda Mining Company discovered a significant silver deposit on Admiralty Island in the Greens Creek watershed. Ironically, the Greens Creek deposit was also within an area that had been proposed to Congress for Wilderness designation (Kootznoowoo Wilderness). To address this, Congress set forth specific requirements and procedures in the 1980 ANILCA whereby the mine might be developed in a nonwilderness portion of an area otherwise considered Wilderness and having a national monument land designation. The Greens Creek silver was extremely high grade and valuable, and after extensive planning and review, development commenced. The Noranda Mining Company brought the mine on-line in 1989 and it continues to operate today (Bradner 2015; US Forest Service 1997a). See Table 7-3 for a summary of historic mines in Southeast.

MINING TODAY

The only two major mines currently operating in Southeast Alaska are Greens Creek Mine on Admiralty Island and Kensington Mine along the east side of Lynn Canal near Berners Bay north of Juneau, summarized in Table 7-4.

Greens Creek is owned and operated by the Hecla Mining Company (Bradner 2015). It is the largest silver mine in the United States; in 2014 it produced 7.8 million ounces (243,000 kg) of silver. Greens Creek also produces gold, lead, and zinc (Hecla Mining Company 2015).

Since the 1980s, Coeur d'Alene Mines, operating as Coeur Alaska, endeavored to reopen the Kensington gold mine at Lions Head Mountain in Berners Bay, just north of Juneau (Sisk 2007b). From 2005 through 2009, local conservation organizations and Coeur were involved in court battles about the corporation's mine waste disposal plans (see the Conservation Issues below). The Kensington Mine moved into production in 2010. In 2013, the mine produced nearly 115,000 ounces (3,600 kg) of gold, reportedly up 40% from 2012. At the end of 2014, Coeur Alaska identified proven and probable gold reserves in excess of 600,000 ounces (19,000 kg) at Kensington (Coeur Mining Inc. 2015). In 2015, Coeur Alaska announced the mine will expand into the neighboring Jualin deposit, increasing the mine's gold output (Bradner 2015).

As mining technology advances, companies sometimes revisit mining claims previously "played out" for renewed exploration. The Niblack area on Prince of Wales Island has recently experienced renewed interest in additional minerals. Since 2009, a Canadian company, Heatherdale, has been involved in exploration of the Niblack Mine for copper, gold, silver, and zinc.

John Schoen

The Greens Creek Mine on northern Admiralty Island is located within the Admiralty Island National Monument but lies outside the Kootznoowoo Wilderness. This mine is the largest silver mine in North America and also produces gold, lead, and zinc.

On southern Prince of Wales Island, Ucore corporation returned to the Bokan Mountain area previously mined for uranium, now in search of rare earth elements (Ucore 2016). Although prices for rare earth elements have dropped since 2011, as of 2015 Ucore seems to be slowly moving forward toward permitting.

Constantine Metals and its partner, Dowa Metals and Mining Co. of Japan, started exploration of the Palmer Mine north of Haines in 2010 (Constantine Metal Resources Ltd. 2016). The Volcanogenic Massive Sulphide (VMS) project is targeting copper, zinc, gold, and silver. This project has major expansion potential, in part due to its location near a major Alaska highway with year-round deep-sea port access for shipping to Asian markets (Constantine Metal Resources Ltd. 2016).

The Vancouver, B.C. corporation Arrowstar is the current project operator for the Port Snettisham Iron Ore project. Marine navigators were the first people to detect iron deposits near Port Snettisham because compasses "went crazy." Gold and iron ore were first reported in 1897. In 2013, the corporation added additional claims to expand the project. In September 2014, Arrowstar announced it was relinquishing the older claims and keeping only the newer claims (Arrowstar Resources Ltd 2015). Although the corporation did not state a reason, the change was likely due to low market prices (Archibald 2015).

The Herbert Glacier Mine is in early stages of exploration. The retreat of the Herbert Glacier, 18 miles north of Juneau, relatively recently exposed this deposit of gold, silver, copper, zinc, and tungsten. (Miller 2012); (Ground Truth Trekking 2015). Houston Oil and Mineral discovered the newly revealed mineral veins in 1986. Quaterra Resources Inc. picked up the project in 2007, forming a partnership with another Vancouver corporation, Grande Portage Resources Ltd. in 2010 (Lasley 2012). They conducted some exploratory drilling beginning in 2010, but the mine remains in the early stages of exploration (Ground Truth Trekking 2015); (Archibald 2015).

Exploration phase mines in Southeast Alaska are summarized in Table 7-5.

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Transboundary Mines

Several large Southeast Alaska rivers spring from headwaters across the border in British Columbia. About ten active mines in the Stikine, Taku, and Unuk River watersheds are in various stages of permitting and development in Cananda and could pose a threat to Alaska. In July 2014, BC Hydro completed the Northwest Transmission Line, which extended the British Columbia power grid 213 miles (344 km) north. The available power has added incentive for the boom of proposed mines in northwestern British Columbia. The Red Chris mine, at the confluence of the Iskut and Stikine Rivers, was one of the first mines to take advantage of the new power source (BC Hydro 2014). According to the B.C. Ministry of Energy and Mines, as of July 2015, there are about 10 "advanced project" mines in the region (Lavoie 2015). Eight mines of most concern to Alaska are listed in Table 7-6.

CONSERVATION ISSUES

Alaska Mines

Some types of mining use chemicals to separate ore, and some types of rock itself generate acid mine drainage, both of which often create concerns about effects on water quality, fish, and wildlife. The type of mining and the method of waste disposal have generated conflicts with communities throughout Alaska's history. Acid mine drainage occurs mainly when water oxidizes with sulfide minerals, usually pyrite (or "fool's gold"), commonly found alongside desirable minerals. The result is sulfuric acid, which in addition to being harmful to aquatic life, dissolves heavy metals such as aresenic, copper, and lead. Acid mine drainage can occur naturally, but ores are usually inert when intact underground. The mining process of crushing ore and storing it above ground vastly increases the amount of acid generated, damaging water quality and harming aquatic life (Ground Truth Trekking 2015).

The ruins of the AJ Mine are still visible as several stories of dilapidated wooden buildings near downtown Juneau. Periodically there is a push to reopen the mine. Echo Bay Mining Company submitted a proposal to the Environmental Protection Agency in the late 1990s, but abandoned the plan in 1997, citing economic reasons (Environmental Protection Agency 1997). The City and Borough of Juneau owns rights to most of the AJ mine. In 2011, the City revisited the idea of reopening a smaller mine than the 1997 proposal. At a community hearing, there was no clear majority either in support or opposition to reopening the mine (Ground Truth Trekking 2015). So far, concerns about the AJ mine's potential to contaminate city drinking water, combined with concerns about increased traffic, noise, and the lack of sufficient electricity for the mine to operate are the major stumbling blocks that have prevented the mine from reopening. Of the comments submitted to the City and Borough of Juneau, over 80% were in opposition of reopening the AJ Mine (Guy Archibald, Southeast Alaska Conservation Council, personal communication).

Although the Greens Creek Gold Mine itself is outside the adjacent Wilderness area, the General Mining Act of 1872 allows the company to lease public lands for the purposes of milling operations including tailings storage. Half of the current tailings pile is in designated Wilderness. In 2013, Hecla Mining Company sought expansion further into Wilderness that would have resulted in the destruction of a salmon stream. Hecla's lease runs until 2096.

Section 505(a) of ANILCA requires the USFS to "maintain the habitats, to the maximum extent feasible, of anadromous fish and other foodfish, and to maintain the present and continued productivity of such habitat when such habitats are affected by mining activities on national forest lands in Alaska." There is significant local concern about the environmental effects of pollutant discharges from Greens Creek Mine into Hawk Inlet from pollutants that bioaccumulate, such as cadmium, copper, mercury, and lead. Along these lines, the USFS should increase the strength of their monitoring program to detect effects of mining on national forest lands, to support fish habitat as required under ANILCA, and avoid inducing impaired waterbodies.

In 1997, the US Forest Service approved a development plan for the Kensington Mine that required several provisions to minimize environmental impacts, including no cyanide processing, and requiring mine tailings be backfilled or impounded in a dry tailings facility. Coeur Alaska obtained the necessary permits, and development appeared to be imminent (Sisk 2007b; US Forest Service 1997b). In 2001, Coeur Alaska proposed an amended plan, in part due to falling gold prices. The company proposed moving facilities to the Berner's Bay side of Lions Head Mountain and depositing tailings into a lake. Marine terminals at Berners Bay would transport workers and equipment to the mine (Sisk 2007b; US Forest Service 2004).

The Kensington Mine plan to dump 4.5 million tons of tailings in the alpine Lower Slate Lake, killing all the fish in the lake, faced court challenges from local conservation organizations, such as the Southeast Alaska Conservation Council and Lynn Canal Conservation, that carried all the way to the federal Supreme Court. The point of contention was that the permits for dumping tailings in Lower Slate Lake came from the Army Corps of Engineers, classifying the tailings as "fill" instead of mine waste. The Environmental Protection Agency (EPA) said it was not the best alternative but did not oppose the permits. The groups contesting the permits said the EPA's permission violated the Clean Water Act, which prohibits discharge into a waterbody. In 2009, the Supreme Court decision sided with Coeur, allowing the Kensington Mine to move forward (Golden 2009).

Concerns at the Palamer VMS mine north of Haines include acid mine drainage leaking into the headwaters of the Chilkat River and threatening salmon spawning habitat. The Chilkat Indian Village, located at the confluence of the Klehini and Chilkat rivers, is opposed to the development. Furthermore, the river runs through the Alaska Chilkat Bald Eagle Preserve, a state preserve and Audubon Alaska Important Bird Area. Thousands of Bald Eagles (*Haliaeetus leucocephalus*) gather along the river for a late salmon run in early November; a threat to the salmon run would also put the eagles that flock to the reserve at risk.

Transboundary Mines

About ten active mines, in various stages of permitting and development, in the Stikine, Taku, and Unuk River watersheds in Cananda could pose a threat to Alaska fisheries downstream from acid mine drainage, hazardous materials in tailings that enter the river systems, or breaches in tailings impoundments (Archibald 2015). A summary of environmental concerns at eight major transboundary mines are summarized below (also see Table 7-6):

Brucejack: The mine's plan involves storing tailings underground or in Brucejack Lake. The Unuk River supports all five species of Pacific salmon and has the largest run of Chinook, or king, salmon (*Oncorhynchus tshawytscha*) in Southeast Alaska. Any leaching of toxic minerals into the watershed could have harmful effects on salmon runs (Wild Border Watersheds 2015).

Galore Creek: Environmental concerns for Southeast Alaska from this proposed open pit mine include contamination of the Stikine watershed and potential threat to salmon (Wild Border Watersheds 2015).

Kerr-Sulphurets-Mitchell (KSM): The mine plan includes underground mining and several massive open pit mines. The geology of the area has a high probability for generating acid mine drainage, so there are major concerns about water treatment and tailings of such a huge mine and the potential threat it poses to water quality and salmon in Southeast Alaska (Wild Border Watersheds 2015).

New Polaris: This mine is near the headwaters of the Taku River, which flows into the sea about ten miles south of Juneau. The Taku is one of the largest salmon spawning watersheds in the region, and with runs of nine anadromous fish species, is often considered the most important fish watershed in Southeast Alaska (Albert and Schoen 2007) (Griffiths 2014).

Red Chris: This open-pit mine is operated by the same corporation that operates the Mount Polley Mine that had a disastrous tailings dam failure in 2014, releasing 600 million cubic feet (17 million cubic meters) of wastewater and nearly 300 million cubic feet (8 million cubic meters) of tailings (Wild Border Watersheds 2015) (Government of British Columbia 2014). Alaska commercial fishermen, such as the Alaska Trollers Association, have voiced concern about the risk of toxic tailings from the Red Chris and other B.C. mines (Martin 2015).

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TABLE 7-6 Summary of transboundary mines of concern, located in British Columbia in watersheds upstream of Southeast Alaska (Canarc Resource Corp 2015; Galore Creek Mining Corporation 2015; Seabridge Gold 2015; Wild Border Watersheds 2015).

Mine Name	Owner	Location	Potential Materials	Status
Brucejack	Pretium Resources, Inc.	Lake-fill: the lake is at the headwaters of Sulphurets Creek, which flows into the Unuk River that lies within the Misty Fjords National Monument in Alaska	Gold, silver	The mine received its final permitting in 2015 and expects to begin production in 2017.
Galore Creek	The mine is owned equally by NovaGold Resources Inc. and Tech Resources Ltd., although as of 2015 NovaGold was seeking to sell its portion. The Galore Creek Mining Corporation manages the project	Between the Stikine and Iskut Rivers	Copper, gold, silver	The corporation published a prefeasibility study in 2011 and continues to do environmental baseline studies.
Kerr-Sulphurets-Mitchell (KSM)	Seabridge Gold Corporation	The mine lies along a tributary of the Unuk River, about 18 miles (30 km) from the US border and upstream from Misty Fjords National Monument	Gold, silver, copper, molybdenum	Touted as one of the largest undeveloped gold mining projects in the world, as of 2015, the mine is waiting for final permits before beginning construction.
New Polaris	Canarc acquired the mine in 1992	Tulsequah River upstream from the Taku River	Gold	Originally operated from 1937–1957, with a suspension in operation from 1942–1946 during World War II. Exploration restarted in 1988. In 2015, partner corporation Australian-based PanTerra Gold announced it could not commit to further exploration until the Dominican Republic government grants approval for processing the ore at its project facility in that country.
Red Chris	Imperial Metals	Stikine River Watershed	Copper, silver, gold	The mine has been given a temporary discharge permit to begin releasing into its tailings impoundment; if fully built, the mine would have a life of 28 years.
Red Mountain	IDM Mining Ltd.	Near Stewert BC within the Nass Wildlife Area and Nissa'a Territory within a transboundary watershed. Mine discharge will be in a river that enters Portland Canal just inside Canadian waters.	Gold, silver	The project is currently in both the federal and provincial environmental review process. The Canadians are currently coordinating with the State of Alaska, and plan to consult with Alaska Native representatives that have current, traditional, or cultural ties to Portland Canal.
Schaft Creek	Copper Fox Resources and Teck Resources	Headwaters of the Stikine River	Copper, gold, silver, and molybdenum	Proposed open-pit mine in pre-assessment stage in 2015; Teck announced the mine will pull out of the permitting process in 2016.
Tulsequah Chief (including Big Bull Mine)	Chieftain Metals Corporation	Located where the Tulsequah River flows into the Taku River.	Copper, gold, lead, silver, zinc	Previously in operation in the 1950s; currently permits have been issued to build the mine but operational hurdles make the project uncertain. Continues to leak acid mine drainage into the river in violation of its permits and non-compliance orders.

Red Mountain: An underground mine proposal in a transboundary watershed; however, all potential discharge from the project area would enter Portland Canal in Canadian marine waters.

Schaft Creek: Concerns include the millions of tons of tailings that would be stored in a lake and the possibility of acid mine drainage that would contaminate the Stikine watershed (Wild Border Watersheds 2015). On May 4, 2016, Teck Resources requested that the environmental study be terminated and the project withdrawn from further review.

Tulsequah Chief (including Big Bull Mine): The mine has been leaking sulfuric acid into the Tulsequah River since 1990. The Alaska section of the Taku River is about ten miles south of Juneau and is considered the biggest salmon watershed in Southeast Alaska (Griffiths 2014). The corporation briefly operated a water treatment plant to deal with the historical acid drainage, but stopped due to expense. The mine plan would store tailings in an impoundment next to the Tulsequah River (Wild Border Watersheds 2015). The Taku River Tlingit First Nation in Canada opposed reopening the mine because it lies in their traditional territory. The First Nation challenged the mine's operating status in 2102, but a 2015 decision denied the challege, allowing the mine to proceed (Lazenby 2015).

MAPPING METHODS

We utilized the US Geological Survey (USGS) Alaska Resource Data File (2008) to identify mines and prospects in Southeast Alaska. Based on the available data attributes, we reclassified the mines and prospects into status categories of active, inactive, or undetermined; production categories of yes, none, or undetermined; and size categories of small, medium, or large. On the map we grouped these categories into active mines (all sizes), active prospects, and inactive mines (all sizes). Next, we updated the USGS layer based on data presented online by Ground Truth Trekking (2015) to identify major activities in Southeast Alaska. Transboundary mines were from the ACE Conservation GIS Center (2015), and represented major activities and affected rivers in BC. State mining claims and leases were from the Alaska Department of Natural Resources (2006) via the Alaska State Geospatial Data Clearinghouse. Areas withdrawn from federal mineral entry were from the US Forest Service (2016a).

MAP DATA SOURCES

- Major activity: ACE Conservation GIS Center (2015), Ground Truth Trekking (2015)
- Other activity: US Geological Survey Mineral Resources Program: Western Region – Alaska Section (2008)
- Mineral rights: US Forest Service (2016a), Alaska Department of Natural Resources: Information Resource Management (2006)
- Ownership: US Forest Service (2016b), USDI National Park Service (2015), Alaska Department of Natural Resources: Information Resource Management (2015).

Metals Mining

Audubon ALASKA

Mining, especially for gold, has played a large part in Southeast Alaska's history. The industry spurred settlements, some of which grew into today's communities and some of which faded away. The first mineral location in Southeast was a copper claim in 1867, the same year that the United States purchased Alaska from Russia. In 1880, Tlingit Chief Kowee led Joe Juneau and Richard Harris to Gold Creek and into the Silver Bow Basin, near present-day Juneau. The miners returned with a large amount of gold ore, prompting Juneau's gold rush. Many hardrock mining operations have come and gone since. The only two major mines currently operating in Southeast Alaska are Greens Creek Silver Mine on Admiralty Island and Kensington Gold Mine near Berner's Bay. Greens Creek is the largest silver mine in the US. Several prospects in British Columbia, near the headwaters of major transboundary rivers in Southeast, are of concern for potential impacts to fish and wildlife.

Map 7.5: Metals Mining

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SPORT AND COMMERCIAL FISHING

Jim Adams and Susan Culliney

Whether commercial, recreational, or subsistence, fishing is culturally important to Southeast Alaska and forms a significant economic driver to the region. In 2013 and 2014, the Southeast Alaska seafood industry accounted for 20% of regional average monthly employment, which included 12,078 direct jobs and 6,600 full-time equivalent jobs (McDowell Group 2015b). Along with the visitor industry, it is one of the two largest private sectors in Southeast (Southeast Conference Report 2014). The Southeast Alaska salmon fishing industry contributed over $986 million to the economy in 2007, with the direct output generated by commercial fishing and processing of salmon estimated at $599.3 million (TCW Economics 2010).

The fisheries of Southeast Alaska are some of the finest and most intact in the world. Harvest enhancement procedures complement rather than replace Alaska's world-renowned natural fisheries. The state-run hatchery program aims to "increase salmon abundance and enhance fisheries, while protecting wild stocks" (Vercessi 2013b). Mariculture (a type of aquaculture that uses the natural nearshore environment to raise organisms like oysters, clams, and mussels) is also common in Southeast waters. Nearshore aquaculture of salmon and other finfish, however, is prohibited by the State of Alaska.

Southeast Alaska features numerous small natural fisheries for groundfish (e.g. rockfish, lingcod (*Ophiodon elongatus*), and Pacific cod (*Gadus macrocephalus*); shellfish (e.g. Dungeness crab (*Metacarcinus magister*), shrimp, scallop); and miscellaneous dive fisheries (for sea cucumber, sea urchins, and geoduck clams (*Panopea generosa*). Herring (*Clupea pallasii*) are also harvested in the winter as baitfish, and during the spring for their roe. But the salmon fisheries of Southeast are by far the most visible and economically important in the region.

Commercial salmon fishing in Southeast Alaska focuses primarily on the five species of salmon: king/Chinook (*Oncorhynchus tshawytscha*), red/sockeye (*O. nerka*), silver/coho (*O. kisutch*), pink/humpy (*O. gorbuscha*), and chum/dog (*O. keta*). Commercial salmon harvests began in the late 1870s; red salmon was the species most harvested until the early 1900s, when pink salmon began to dominate (Conrad and Davidson 2013). In the past 10 years pink salmon has made up three-quarters of Southeast's total salmon harvest (Conrad and Davidson 2013). According to a 2007 study, "Between 2003 and 2007, the commercial fishing harvest in Southeast Alaska annually ranged between 30 million and 70 million fish. Pink salmon accounted for about 74% of all salmon commercially caught in Southeast Alaska, followed by chum (18% of all salmon), sockeye (4% of all salmon), coho (2% of all salmon), and Chinook (0.7% of all salmon)" (TCW Economics 2010).

Commercial salmon fisheries in Alaska are limited entry, which limits the number of total vessel permits for different gear types. When averaged over the last ten years in Southeast Alaska, the percentages of harvest by gear type (including Yakutat) are: 75% by purse seine, 9% by drift gillnet, 9% by hatchery organizations, 4% by troll, 3% by Annette Island (a federally permitted hatchery on Native Alaskan reservation land), and 1% by set net (Conrad and Davidson 2013).

Each gear type results in different total harvest numbers and targets different types of salmon. In 2012, 235 purse seine permit holders caught 24.5 million of the 37 million salmon commercially harvested in the Southeast Alaska and Yakutat regions (Conrad and Davidson 2013). Purse seiners caught the vast majority of pinks and 39% of the chum harvested in the region; 445 drift gillnet permit holders harvested 5.2 million salmon, including over 3 million chum (28% of the harvest) and 498,000 sockeye—over half the sockeye harvested; 1,096 troll permit holders caught 209,000 of the 281,000 Chinook harvested in Southeast Alaska, as well as 1.2 million of the 2.1 million coho (Conrad and Davidson 2013). Another 3.5 million salmon were also harvested by non-profit, private hatcheries for cost-recovery purposes and are not included in the above gear numbers (Conrad and Davidson 2013).

The State of Alaska defines "ex-vessel value" as "the average price for an individual species, harvested by a specific gear, in a specific area" (Alaska Department of Fish and Game 2015d). For salmon species in 2015, when ex-vessel values are broken down by gear, the purse seine fishery gross earnings were $52.1 million, followed by the troll fishery earnings of $23.5 million, and the drift gillnet fishery earnings of $18.9 million (Alaska Department of Fish and Game 2016). When broken down by species, in 2012 chum brought in the highest earnings, followed by pink, silver, Chinook, and red (Conrad and Davidson 2013).

Salmon hatcheries play an important role in Southeast's salmon fisheries. In 2012, there were 17 active hatcheries in Southeast Alaska that provided a significant supplement to wild runs of salmon (Vercessi 2013a). Southeast hatcheries released over 615 million juvenile salmon made up of roughly 7.5 million Chinook, 15 million sockeye, 20 million coho, 101 million pink and 471 million chum in 2012 (Vercessi 2013a); however, returns are much smaller at around 1.5–3% for chum and pink salmon, and 8–12% for Chinook and coho salmon. Returning hatchery-produced salmon accounted for 27% of the salmon in the 2012 commercial common property fishery: 84% of the chum, 27% of the coho, 21% of the Chinook, 12% of the sockeye, and 1% of the pink salmon (Vercessi 2013a).

Power troller, Prince of Wales Island.

Nick Jans

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Southeast Alaska draws sport fishermen from around the globe to its world-class salmon runs. Recreational fishing includes the five species of salmon; halibut, rockfish, steelhead (*O. mykiss*), and Dolly Varden (*Salvelinus malma*); and rainbow, brook (*S. fontinalis*), and cutthroat trout (*S. clarkii*). In 2013, an estimated 109,571 people fished an estimated 546,050 sport angler-days in Southest Alaska (including Yakutat). The ten-year average is 108,769 anglers and 509,858 angler-days fished (Alaska Department of Fish and Game 2015b). The anglers primarily spent their time on saltwater, with an estimated 462,179 saltwater days and an estimated 83,871 freshwater days.

Silver (coho) salmon were the fish most frequently caught and harvested by sport anglers (with an estimated 485,851 fish caught and 339,585 harvested). Pacific halibut were the second most caught fish (an estimated 245,936 fish), with rockfish a close third (an estimated 213,604 fish caught). Among salmon, pink salmon were the second most caught (with an estimated 324,543 fish), with Chinook salmon coming in third (with an estimated 166,824 fish caught).

From 2004 to 2013, Dolly Varden led the trout and char fishery, with an estimated 56,778 caught and 10,859 harvested. An estimated 17,430 cutthroat trout, 9,005 rainbow trout, and 6,163 steelhead were also caught (Alaska Department of Fish and Game 2015b).

King (Chinook) Salmon

King salmon (also called Chinook) spawn in the streams and rivers that empty into the marine waters of Southeast. But compared to other salmon species, king salmon are more limited in their spawning habitat. Fewer than 40 watersheds in Southeast support spawning populations of king salmon, and most of the kings found in these rivers actually spawn in the Canadian portion of the watershed (Heard et al. 1995).

Hatcheries produce 21% of the king salmon harvested commercially in Southeast Alaska (Vercessi 2013a). Most wild, commercially caught king salmon in Southeast come from rivers in British Columbia, Washington, and Oregon (Orsi and Jaenicke 1996). The king salmon all-gear harvest quota is established according to guidelines contained in the US/Canada Pacific Salmon Treaty, which covers the years of 2009–2018 (Jones and Chadwick 2011). The Alaska Board of Fisheries subsequently allocates Alaska's share of the quota to the drift gillnet, set gillnet, seine, troll, and sport fisheries. The Board of Fisheries allocates approximately 7% of the quota to the net fisheries, and the remainder is split 80/20 between the troll and sport fisheries, respectively (Jones and Chadwick 2011). In 2012, trollers took 209,000 of the 281,000 king salmon harvested commercially in Southeast (Conrad and Davidson 2013). The 2014 ex-vessel value of the Chinook fishery in Southeast Alaska was $21.7 million (Alaska Department of Fish and Game 2015a) topping the 10-year average from 2002–2011 of $15.6 million (Conrad and Davidson 2013).

In 2013, sport fishers caught an estimated 166,824 king salmon and harvested 34% of them (56,392 fish), which was a drop from the estimated ten-year annual average of 68,258. Almost all king salmon caught recreationally were taken in saltwater (Alaska Department of Fish and Game 2015b). A 126 lb (57 kg) king salmon taken in a fish trap near Petersburg, Alaska in 1949 is the largest on record. The largest sport-caught king salmon was a 97 lb (44 kg) fish taken in the Kenai River in 1986.

Red (Sockeye) Salmon

In the Pacific Region, red salmon, also known as sockeye, were the first salmon to be commercially harvested. Because of their color, rich oil content, flavor, and superior flesh quality they remain the most sought after of all the Pacific salmon. Sockeyes are the most economically important species in Alaska. While the economic dominance does not hold true in Southeast, they are still the salmon most harvested by personal use and subsistence fishers in Southeast (Schindler et al. 2010).

In Southeast Alaska in 2012, the total sockeye harvest in commercial, personal use, and subsistence salmon fisheries was 0.9 million sockeye, which is 0.4 million lower than the long-term average of 1.3 million sockeye (Conrad and Davidson 2013, p. 4). From 2002 to 2011, driftnets took 45% of the commercial harvest of sockeye, purse seiners took 35%, setnets took 11%, and trollers took less than 1% of the commercial sockeye harvest. Hatcheries took 8% and produced 12% of the commercial common property fishery (which constitutes approximately 108,000 fish) (Conrad and Davidson 2013). The ten-year average ex-vessel value of the Southeast sockeye fishery from 2002–2011 was $9 million (Conrad and Davidson 2013).

The estimated average annual sport catch of red salmon in Southeast Alaska from 2004–2013 was 33,732 fish. The estimated catch in 2013 alone was 35,923. Anglers keep almost 60% of the sockeyes that they reel in, a retention number topped only by coho. The harvest numbers are therefore lower than the catch numbers. The estimated average annual sport harvest of red salmon in Southeast Alaska from 2004–2013 was 17,376 fish, while the estimated sport harvest of red salmon in Southeast in 2013 alone was 21,146 fish. A little over half the red salmon caught came from freshwater (Alaska Department of Fish and Game 2015b).

Silver (Coho) Salmon

In 2012, the total commercial, personal use and subsistence harvest of coho salmon (also called silver salmon) was 2.1 million fish. This was well below the recent 10-year average harvest of 2.6 million. The record harvest for silver salmon of 5.7 million occurred in 1994 (Conrad and Davidson 2013). From 2002 to 2011, trollers took 58% of coho harvest, driftnets took 12%, purse seiners took 11%, and setnets took 5% (Conrad and Davidson 2013). Hatcheries took 12% and produced 27% of the common property commercial coho take (Vercessi 2013a). The ex-vessel value of the coho fishery in Southeast was $18.1 million, just below the ten-year average of $19 million (Conrad and Davidson 2013).

Sport anglers catch more coho than any other Alaska fish. In 2013, sport anglers caught an estimated 485,581 coho, compared to 245,936 Pacific halibut, the second-most-caught recreational fish in Alaska, and compared to 324,543 pink, the second-most-caught anadromous fish species in Alaska. The harvest of cohos by recreational anglers was 70% of those caught, estimated at 339,586, with 91% harvested in saltwater (Alaska Department of Fish and Game 2015b). The state angling record for coho salmon is a 26 lb (12 kg) fish caught in 1976 in Icy Strait.

Pink (Humpy) Salmon

Pink salmon have dominated the commercial fish harvest in Southeast Alaska since the early 1900s. In the past 10 years pink salmon has comprised 74% of Southeast's total salmon harvest. In 2012, the pink harvest was below the ten-year average and came in at 21.3 million pinks, compared to the record harvest at 77.8 million pink salmon in 1999. Lower harvests in some years are generally attributed to the pink salmon's unique life cycle rather than declining populations. But a drought in 2004 likely also contributed to the wider fluctuations now seen in pink salmon numbers (Piston and Heinl 2014). The commercial pink salmon harvest in 2012 was valued at more than $101.1 million (Conrad and Davidson 2013).

Between 2002 and 2011, purse seiners harvested 92% of the commercial pink salmon. Driftnetters took 3%, while setnets, trollers, and hatcheries all harvested minimal amounts (Conrad and Davidson 2013).

As with the pink salmon commercial fishery, catch numbers for pink salmon in the recreational fishery vary widely by year. In 2005, sport anglers caught an estimated 428,382 pinks. In contrast, sport anglers caught only an estimated 178,336 pinks in 2008. This wide disparity is due in part to the pink salmon's life cycle in which pinks spawn at two years of age, with different populations returning on odd and even years. A drought in 2004 is another likely cause of the large swings between even and odd year stocks now regularly seen in pink salmon numbers. Prior to 2004 the odd-even-year regime was not as drastic, with even years being the bigger producers. The dismal harvest and the subsequent early closure of the fishery in 2006 was the smallest catch in almost two decades (Piston and Heinl 2014).

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Melanie Smith / Nick Jans

Steelhead fishing, Prince of Wales Island.

More recently, 2013 was a strong year for the recreational pink fishery. The estimated 324,543 pinks caught by sport anglers in 2013 was second only to silver salmon in anadromous fish numbers. Often considered a lower quality salmon by locals, about 70% of the pinks caught recreationally were returned to the water, leaving the estimated sport harvest at 95,783 pinks. Although anglers caught a substantial number of pinks in freshwater—an estimated 95,783—only 12,275 of those pinks were kept (Alaska Department of Fish and Game 2015b). The state angling record for pink salmon is a 13 lb (6 kg) fish caught on the Moose River on the Kenai Peninsula in 1974.

Chum (Dog) Salmon

Southeast Alaska once saw wild chum salmon harvest at over 9 million, in 1917 (Piston and Heinl 2011). Numbers plummeted during 1962–1984. Today, most chum production comes from hatcheries (Conrad and Gray 2014). With the establishment of the state hatchery program in 1971, the population of chum salmon has more than doubled since the 1980s. According to Conrad and Davidson (2013), "the recent 10-year average chum harvest is six times pre-hatchery production [excluding the early 1900s] and the 2012 fishery was nearly eight times that amount." In 2012, the total harvest of chum salmon in commercial, personal use, and subsistence was 12.4 million, the sixth highest total since statehood (Conrad and Davidson 2013).

Purse seiners took 38% of the chum salmon harvested commercially. Driftnets took 23%, trollers took 3%, and setnetters took less than 1%. Hatcheries took 35% of the commercial chum salmon harvest (an arrangement set up to pay for operations), by far the highest percentage of any of the commercial salmon fisheries.

The sport catch numbers for chum vary widely by year. Between 2003 and 2013 the catch went from an estimated high of 84,306 in 2004 to a low of 33,698 in 2010. In 2013, sport anglers caught an estimated 57,942 chum. The anglers kept, or harvested, an estimated 22,737 chum, or 39% of the catch. About 87% of the chum taken in the recreational fishery were caught in saltwater (Alaska Department of Fish and Game 2015b). The chum salmon state angling record is a 32 lb (14.5 kg) fish in 1985 at Caamano Point near Ketchikan.

Steelhead

Steelhead are not fished commercially, but are prized by sport anglers for the thrill of catching this strong oceanic version of the rainbow trout. Due to population concerns, the State places significant limits on steelhead fishing in Alaska. In 1994, state regulations went into effect to dictate that anglers could only keep steelhead that are over 36 in (91 cm) in length, thus protecting most first-time spawners and effectively excluding about 95% of all steelhead (Harding and Coyle 2011). Regulations further limit anglers to one fish per day, with a total limit of two fish per season. Steelhead are almost exclusively caught in freshwater and are overwhelmingly a catch and release species. In 2013, for instance, anglers landed an estimated 6,163 steelhead, but only kept 46 (Alaska Department of Fish and Game 2015b).

Dolly Varden

Dolly Varden, also known as Arctic char, were once wrongly accused of predating the young of other salmonids, and had a bounty on their heads from 1921–1939 (Harding and Coyle 2011). Today Dollies are prized as a sport fish and for their excellent taste, but primarily constitute a catch and release fishery. Like steelhead, Dolly Varden are not fished commercially. But historically, Dolly Varden constituted a large amount of the bycatch from commercial salmon harvest.

Dolly Varden are the most frequently caught of the trout and char species in Southeast Alaska. Just over 75% of the Dolly Varden captured are caught in freshwater (Alaska Department of Fish and Game 2015b). In 2013, for instance, sport anglers in Southeast Alaska

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kept a little under 20% of the Dolly Varden they caught, with an estimated catch of 56,778 Dolly Varden and a harvest of about 10,859 fish (Alaska Department of Fish and Game 2015b). The state Dolly Varden/Arctic char angling record is a 27 lb fish caught in 2002 on the Wulik River at Kivalina, Alaska.

CONSERVATION ISSUES

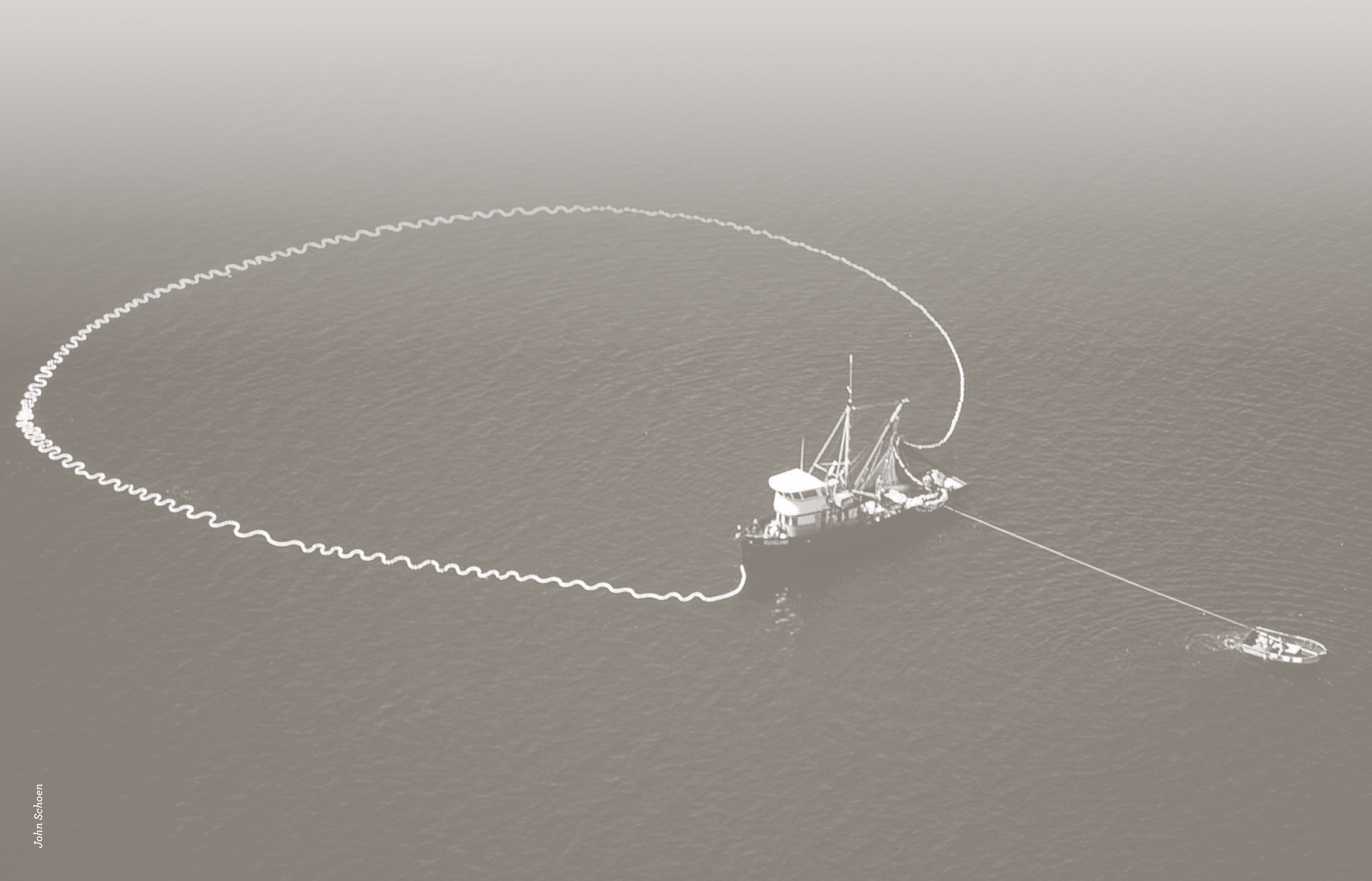
The fisheries in Southeast provide a solid foundation to the region's economy. Fisheries in turn are dependent on prudent stock management and sound habitat conservation practices, in both marine and terrestrial environments. Clearcut logging in watersheds can harm salmon runs by introducing sedimentation to streams, lowering recruitment of large woody debris, and warming water temperatures. Wild stocks also face threats from overharvest, climate change, and escaped pathogens from farm-raised organisms. By implementing sustainable and careful management of Southeast Alaska's incredible aquatic resources, fisheries managers can have a profound positive effect on the region's economic and cultural way of life, as well as on the interconnected natural ecosystem.

MAPPING METHODS

This map includes data from several different sources: the ADFG Hatchery locations and salmon harvest data were provided by ADFG's Division of Commercial Fisheries to the Alaska chapter of The Nature Conservancy, who processed the data for publication (Alaska Department of Fish and Game: Division of Commercial Fisheries and The Nature Conservancy 2011, 2013). The mariculture data represent currently permitted aquatic farm locations, and were provided by the ADFG Mariculture program (Alaska Department of Fish and Game: Commericial Fisheries Division: Mariculture Program 2013). Aquaculture sites are from the Environmental Sensitivity Index dataset (NOAA: Office of Response and Restoration 2005).

MAP DATA SOURCES

- Hatcheries: Alaska Department of Fish and Game: Division of Commercial Fisheries and The Nature Conservancy (2013)
- Mariculture sites: Alaska Department of Fish and Game: Commericial Fisheries Division: Mariculture Program (2013)
- Aquaculture: NOAA: Office of Response and Restoration (2005)
- Salmon harvest: Alaska Department of Fish and Game: Division of Commercial Fisheries and The Nature Conservancy (2011).

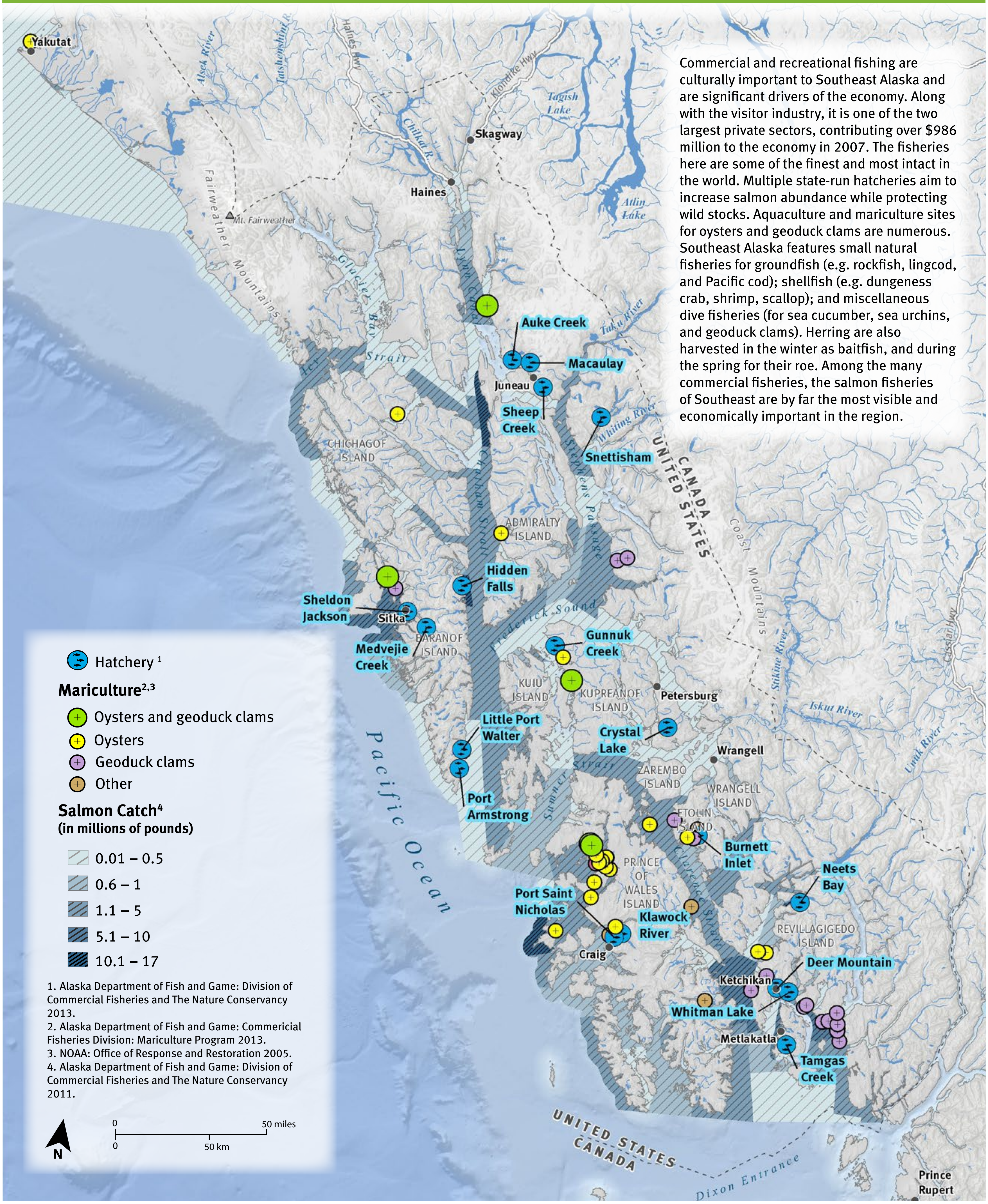


John Schoen

Audubon ALASKA

Commercial Fishing

Commercial and recreational fishing are culturally important to Southeast Alaska and are significant drivers of the economy. Along with the visitor industry, it is one of the two largest private sectors, contributing over $986 million to the economy in 2007. The fisheries here are some of the finest and most intact in the world. Multiple state-run hatcheries aim to increase salmon abundance while protecting wild stocks. Aquaculture and mariculture sites for oysters and geoduck clams are numerous. Southeast Alaska features small natural fisheries for groundfish (e.g. rockfish, lingcod, and Pacific cod); shellfish (e.g. dungeness crab, shrimp, scallop); and miscellaneous dive fisheries (for sea cucumber, sea urchins, and geoduck clams). Herring are also harvested in the winter as baitfish, and during the spring for their roe. Among the many commercial fisheries, the salmon fisheries of Southeast are by far the most visible and economically important in the region.



Map 7.6: Commercial Fisheries

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LAND USE DESIGNATIONS

John Cannon and Melanie Smith

Southeast Alaska is managed in broad land use categories that range from congressionally designated Wilderness to private development lands. As the largest landowner in the region, the Tongass National Forest's land management plan drives much of the region's land use allocation. Most broadly, the lands and waters of the Tongass are managed in three Land Use Designation (LUD) groups: Wilderness, Natural Setting, and Development. Within each of these three groups, there is a further division into several specific LUDs for a total of 17 designations on the Tongass. Additionally, there is one Minerals LUD that overlays areas within the Natural Setting group. LUDs identify the most important natural areas to be protected, set forth lands targeted for intensive uses such as logging, and also provide guidelines for the management of these areas to ensure that ecological value is maintained into the future.

The following information is referenced from the Tongass Land Management Plan (TLMP) and Plan Amendment (US Forest Service 2008d; USFS Tongass National Forest 2015), and is summarized in Table 7-7.

There are four Development LUDs, including Experimental Forest, Modified Landscape, Timber Production, and Scenic Viewshed. These designations represent more intensive uses such as forestry.

The 13 non-development LUDs (Wilderness and Natural Setting groups) aim to preserve the important biological value or wilderness characteristics that define these areas. The three designations within the Wilderness group afford some of the highest levels of protection from human impact. These designations include Wilderness, Wilderness National Monument, and Nonwilderness National Monument. There are 19 Wilderness areas identified in the Tongass National Forest.

The Natural Setting group includes ten LUDs. After Wilderness, the next most protective designation is LUD II. These places are roadless areas which make up a large part of the official Inventoried Roadless Areas (IRAs) on the Tongass. These areas emphasize wilderness values, prohibit timber cutting, and allow roads only in rare situations. There are 12 LUD II roadless areas identified within the Tongass National Forest.

Both Wilderness and LUD II roadless areas allow hunting and fishing, temporary camps and facilities for the harvest of fish and game, and traditional access, including established use of motorboats and fixed-wing airplanes. The other designations within the Wilderness group and the Natural Settings group are less protective but still aim to conserve drinking water, old growth habitat, wild and scenic wild rivers, and to specifically provide for remote recreation opportunities.

WILDERNESS LUD GROUP

Wilderness areas are managed with the goal of maintaining natural ecological processes largely free from the impact of civilization. These areas exhibit qualities described by the Wilderness Act of 1964 as being important to recreation, science, ecosystem integrity, spiritual values, opportunities for solitude, and wildlife needs. Managers thus limit motorized use in these areas to the minimum needed for the administration of Wilderness.

Most National Monument areas also fall under the Wilderness designation, and appear as **National Monument/Wilderness** in the accompanying map. National Monuments embody a combination of outstanding scientific and historical features. These designations provide specifically for the protection and study of particular resources that may include cultural resources, geology, plant and animal succession, or brown bear (*Ursus arctos*) and Bald Eagle (*Haliaeetus leucocephalus*) populations.

John Schoen

Old-growth habitat and Wild, Scenic, and Recreational rivers are some of the conservation land uses on the Tongass National Forest.

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TABLE 7-7 Tongass National Forest Land Use Designations (adapted from USFS Tongass National Forest 2015).

Land Use Designation (LUD)	Acres
Wilderness LUD Group	Total: 5,908,240
Wilderness	2,630,037
Wilderness National Monument	3,110,924
Nonwilderness National Monument	167,279
Natural Setting LUD Group	Total: 7,734,138
Land Use Designation II	875,454
Remote Recreation	2,004,323
Semi-Remote Recreation	3,007,591
Old-Growth Habitat	1,188,034
Municipal Watershed	43,975
Research Natural Area	56,057
Special Interest Area	329,454
Wild River	187,425
Scenic River	15,501
Recreational River	26,324
Development LUD Group	Total: 3,448,987
Experimental Forest	31,420
Scenic Viewshed	307,402
Modified Landscape	728,679
Timber Production	2,381,486

The **National Monument (non-wilderness)** management efforts aim to protect natural resources, and provide for public access to the Monument, while also permitting valid mining activities, but limiting mining's impact to the extent possible.

These protected areas have their origin in the passage of ANILCA in 1980, which established 5.4 million acres (2.2 million hectares) of designated Wilderness in the Tongass, including the establishment of Admiralty Island National Monument, the Kootznoowoo Wilderness, and the Misty Fiords National Monument Wilderness. Twelve other wilderness areas were also established with the passage of this Act, from the southern, storm-swept area of Prince of Wales Island, to the outer coasts of Chichagof and Yakobi islands, to Russell Fjord in Yakutat Bay. Wilderness areas were expanded (to a total of 19) with the passage of the Tongass Timber Reform Act (TTRA) in 1990. This legislation designated an additional 280,483 ac (113,508 ha) of Wilderness.

NATURAL SETTING LUD GROUP

The areas officially known as **LUD II** were first established with the passage of the TTRA in 1990, which designated 727,762 ac (294,516 ha) for this use. No timber harvest or road construction may occur in these areas, in order to retain the wilderness character. These areas are managed for low-impact recreation and tourism opportunities, with some primitive recreational facilities permitted. Personal use of harvest cabin logs and firewood is allowed, as are water and power developments that are designed to be compatible with primitive characteristics. Roads are allowed only to provide vital linkages for infrastructure. Mineral development is allowable.

There are two Recreation Area LUDs shown on the accompanying map: Remote and Semi-Remote Recreation. **Remote Recreation** provides primitive recreation opportunities in areas largely free of any signs of human impact. Trails and primitive facilities may appear, and boat, aircraft, and snowmachine access may occur. **Semi-Remote Recreation** provides opportunities for semi-primitive recreation, as well as occasional areas of concentrated recreation facilities in a natural or natural-appearing setting. Motorized recreation activities are permitted in these areas unless specified otherwise.

Old-Growth Habitat LUDs maintain ecosystem processes and support the species associated with these intact natural habitats. These areas are managed to maintain currently present old-growth characteristics, as well as to encourage younger stands to develop successionally into mature forest stands. Managers typically limit roads and facilities within this LUD. The 2016 plan revision may allow clearcutting of second-growth forest in these areas.

Tongass National Forest also serves to maintain safe drinking water for the cities located within its boundaries. The designation of **Municipal Watersheds**, which have been established for nine cities and boroughs, illustrates this vital ecosystem service. Managers generally maintain these areas in a natural condition to ensure the consistent supply of high quality water.

The system of **Research Natural Areas** allows for the research and study of unmanipulated natural areas. This network of study areas represents the predominant vegetation types, wildlife habitats, and aquatic communities present in the Tongass National Forest. Researchers can use the system as a scientific control site to compare against specific management actions undertaken in other areas. Managers maintain these areas in as natural a state as possible, with the only facilities or roads permitted being those necessary for conducting research.

A system of **Special Interest Areas** provides for the protection, study, and enjoyment of certain areas with unique cultural, geological, botanical, zoological, recreational, scenic, or other special features. Managers may permit facilities if they provide for compatible public uses and are not visually disruptive, but otherwise these areas are maintained in a natural state.

Wild and Scenic Rivers are designated to maintain, enhance, and protect the free-flowing, unmodified condition of the river as well as provide opportunity for recreation and tourism. **Recreational Rivers** are designated to maintain, improve, and protect the essentially free-flowing condition through a modified setting that allows timber, roads, and other developments.

DEVELOPMENT LUD GROUP

Experimental Forest areas provide opportunities for the study of forest management activities. These areas allow timber harvest for research and demonstration purposes, as well as the roads necessary to carry out this experimental harvest.

The main objective of **Scenic Viewsheds** is to maintain the visual quality of these areas as seen from roads, trails, water travel routes, and recreation sites. The harvest from Scenic Viewsheds also supplies timber to meet market demand. All identified suitable timber in these areas is harvestable, subject to any other applicable regulations, with a priority placed on maintaining scenic integrity.

Areas identified as **Modified Landscape** also seek to provide a sustained yield of timber, while placing less emphasis than Scenic Viewsheds on minimizing the visibility of timber activity. Guidelines encourage avoiding clearcutting when other methods meet land management objectives. Recreation opportunities that are compatible with roaded areas are available in these areas.

Timber Production areas are managed to provide sustained long-term timber yields. Managers place little emphasis on maintaining the visual quality of these areas. However, this LUD encourages the reduction of clearcutting when other methods may be available for meeting land management objectives. Recreation opportunities associated with roaded areas are available in these areas.

In all, the LUDs prescribed for the Tongass National Forest provide zoning for how the forest should be managed, and what uses should be permitted. This vision seeks to protect the Forest's important natural features, while continuing to make timber resources available for harvest.

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LANDS OUTSIDE OF THE NATIONAL FOREST

Other nationally significant protected lands that are in the region, but not a part of the Tongass National Forest, include Glacier Bay National Park and Klondike Gold Rush National Historical Park, managed by the National Park Service.

The Haines State Forest is managed by the State of Alaska for a sustained yield of resources that include timber, recreation and tourism, minerals, and fish and wildlife habitat.

Much of the rest of Southeast Alaska is privately owned by Native Corporations, municipalities, or individuals. Those lands are largely developed areas within communities, or lands used for timber or transportation.

CONSERVATION ISSUES

The Tongass National Forest is the major land owner in Southeast Alaska. Accordingly, the TLMP largely determines the ecologic and economic setting of the region. The land uses of the forest provide an array of values such as solitude and aesthetic beauty, clean water, wildlife habitat, and job opportunities. The use of these lands fuels the region's fishing, tourism, and timber industries. Conservation of much of the landscape is important for maintaining healthy ecosystems and, in turn, economic opportunities, into the future.

Adequate protection of the Forest requires conservation of lands at multiple scales, including large-scale or watershed-scale reserves as well as designations such as buffers of important natural features. In addition to the protection afforded by Wilderness and Natural Setting LUDs, there are other conservation measures specified in the TLMP that help to protect important natural resources within the matrix of lands not otherwise protected. These include beach fringe and riparian buffers, and old-growth reserves.

Beach fringe buffers cover all marine coastline and estuaries, specifying that a 1,000-foot-wide buffer of beach fringe forest will be left in its natural state. These protections help to ensure that the ecological integrity of these biologically important and sensitive habitat areas is maintained. Riparian buffer regulations vary depending on the classification of the stream type, but generally do not permit any logging operations within 100 feet of a stream. These protected buffers help to ensure that salmon, an important food resource for wildlife and humans alike, is not adversely affected by logging.

Old-growth reserves were identified to ensure sufficient quality, quantity, and spatial arrangement of mature forest habitat to support ecosystem processes and the species dependent upon mature forest stands. A system of reserves was envisioned to achieve this goal that is comprised of small, medium, and large old-growth reserves (OGRs). Medium and large reserves serve to protect some of the best and largest core habitat areas remaining, while the small reserves serve to maintain a functioning distribution of high-quality habitat that conserves landscape connectivity.

Together, these protected areas form a network to help ensure the continued health of this ecosystem. Currently, the future status of this network is uncertain—the current plan amendment proposes to enter beach fringe and riparian buffers and OGRs for clearcutting of second-growth. Because these areas can be vital habitat for fish, mammals, and birds, conservationists are concerned that the new plan may degrade the integrity of these places through clearcut logging, in lieu of letting the buffers and reserves continue to mature.

Audubon and partners such as The Nature Conservancy (TNC), Trout Unlimited (TU), and the Southeast Alaska Conservation Council (SEACC) have worked diligently for decades to identify and propose improvements to the Tongass conservation lands network. SEACC and others have proposed additional Wilderness areas as well as Wild and Scenic Rivers that should be given further consideration. The Audubon-TNC Conservation Area Design and TU-Audubon T77 watershed proposals aim to permanently protect watersheds essential to the functioning of the whole forest ecosystem, in combination with the finer-scale beach fringe, riparian, and OGR protections in TLMP. Those plans are described in the next sections.

MAPPING METHODS

Land Use Designations were developed by the Forest Service using Tongass-wide forest maps, with an accuracy of 3500 feet. These are then updated as needed for specific projects, to resolve gaps or conflicts between LUDs and existing harvest units, roads, or other boundaries. The Forest Service has resolved these inconsistencies as needed, by following physical features, endeavoring to maintain the natural setting, and using best professional judgment (US Forest Service 2008d).

MAP DATA SOURCES

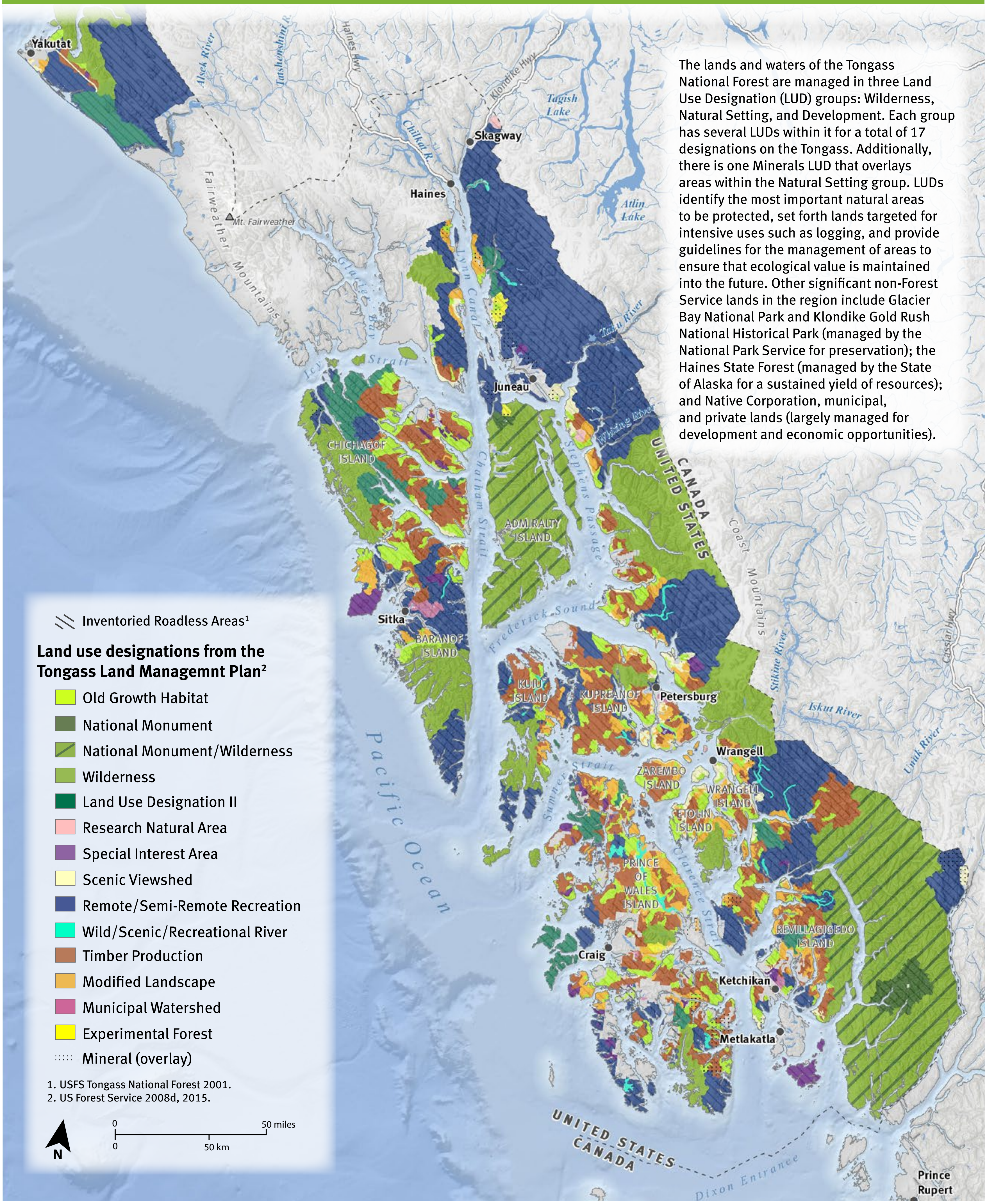
- Land Use Designations: US Forest Service (2008d); US Forest Service (2015)
- Legislatively protected areas: US Forest Service (2008d)
- Inventoried Roadless Areas USFS Tongass National Forest (2001).

John Schoen

Audubon ALASKA

Land Use Designations

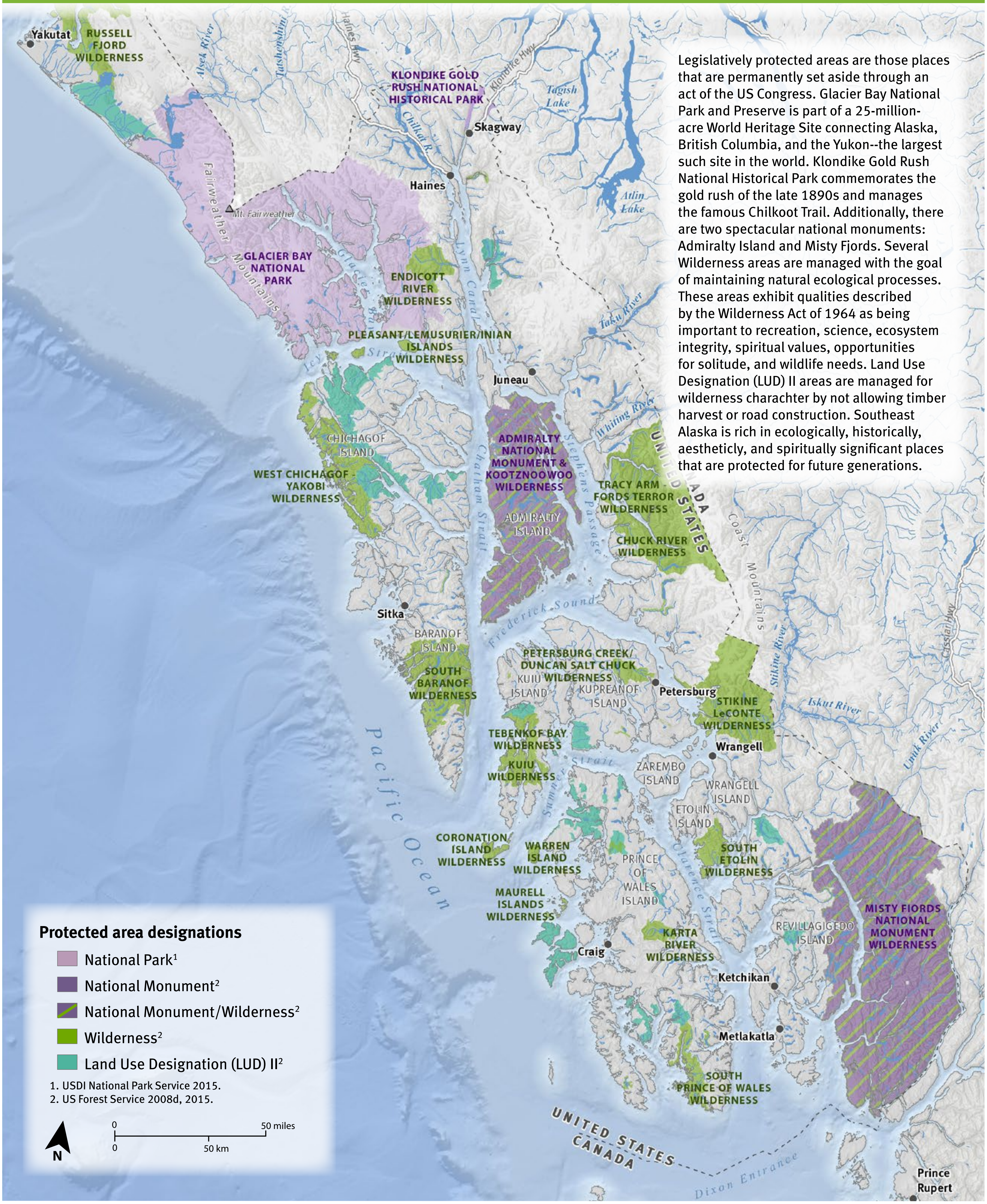
The lands and waters of the Tongass National Forest are managed in three Land Use Designation (LUD) groups: Wilderness, Natural Setting, and Development. Each group has several LUDs within it for a total of 17 designations on the Tongass. Additionally, there is one Minerals LUD that overlays areas within the Natural Setting group. LUDs identify the most important natural areas to be protected, set forth lands targeted for intensive uses such as logging, and provide guidelines for the management of areas to ensure that ecological value is maintained into the future. Other significant non-Forest Service lands in the region include Glacier Bay National Park and Klondike Gold Rush National Historical Park (managed by the National Park Service for preservation); the Haines State Forest (managed by the State of Alaska for a sustained yield of resources); and Native Corporation, municipal, and private lands (largely managed for development and economic opportunities).



Map 7.7: Land Use Designations

Legislatively Protected Areas

Legislatively protected areas are those places that are permanently set aside through an act of the US Congress. Glacier Bay National Park and Preserve is part of a 25-million-acre World Heritage Site connecting Alaska, British Columbia, and the Yukon--the largest such site in the world. Klondike Gold Rush National Historical Park commemorates the gold rush of the late 1890s and manages the famous Chilkoot Trail. Additionally, there are two spectacular national monuments: Admiralty Island and Misty Fjords. Several Wilderness areas are managed with the goal of maintaining natural ecological processes. These areas exhibit qualities described by the Wilderness Act of 1964 as being important to recreation, science, ecosystem integrity, spiritual values, opportunities for solitude, and wildlife needs. Land Use Designation (LUD) II areas are managed for wilderness charachter by not allowing timber harvest or road construction. Southeast Alaska is rich in ecologically, historically, aestheticly, and spiritually significant places that are protected for future generations.



Map 7.8: Legislatively Protected Areas

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A CONSERVATION AREA DESIGN FOR SOUTHEAST ALASKA

David Albert and John Schoen, Revised by Melanie Smith

In Southeast Alaska today, resource managers, scientists, and conservationists have an unprecedented opportunity for protecting the ecological integrity and unique natural qualities of this coastal rainforest, while also sustaining local economies and maintaining the quality of life valued by the people who live and work in the region. The opportunities for conserving intact landscapes have largely disappeared throughout much of the world.

To maintain ecological integrity in Southeast, scientists and resource managers must refine the regional conservation strategy through a collaborative process that uses the best available science. Audubon Alaska and The Nature Conservancy (TNC) provided such as strategy in the *Conservation Assessment and Resource Synthesis for the Coastal Forests and Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest* (Schoen and Dovichin 2007). The overarching goal of the conservation assessment was to conserve the biological diversity and ecosystem function of the temperate rainforest of Southeast Alaska.

The Conservation Area Design is the focus of the 2007 Audubon-TNC Conservation Assessment. That report explains the foundation of this work in great detail. Data, methods, results, and discussion of that work are very briefly summarized here. For more information on the ideas behind watershed-scale conservation, the process, and results of this work, read Chapters 2 and 10 of that report.

PROCESS

To achieve that goal, Audubon and TNC first reviewed existing resource information for Southeast and the Tongass and developed a spatial database that integrated data across administrative boundaries from Yakutat to Ketchikan. That was followed by developing a process for ranking individual ecological values by watershed within 22 biogeographic provinces distributed across the region. Finally, combined ecological values were modeled using the Marxan tool to provide a conservation blueprint for the region.

In this collaborative project, a scientific advisory committee of agency and university scientists was established for guidance. Public documents reviewed included scientific literature, resource inventories, agency reports, and planning documents (such as the US Forest Service 1997 Tongass Forest Land and Resource Management Plan and environmental impact statement). In addition, knowledgeable field experts were identified and interviewed. The mapping component of this project was spearheaded by TNC in cooperation with Audubon by using data layers from state and federal resource agencies.

ECOLOGICAL FOUNDATION

An effective conservation strategy requires a measure of geographic distribution and representation of the natural range of variability within which populations and ecosystems occur (Poiani et al. 2000). A well-balanced geographic distribution is particularly important in Southeast Alaska where ecosystems are naturally fragmented by islands and steep glacial terrain, and isolated from the continent of North America by mountains and icefields along the coastal mountain range (Cook and MacDonald 2001; MacDonald and Cook 1996). This assessment used a regional geographic stratification based on Southeast biogeographic provinces to ensure that conservation areas are sufficiently distributed among the islands and mainland. This assessment focuses on conservation of whole watersheds, and restoration of developed watersheds. Importantly, these areas are supplemented by the finer-scale reserves set forth in the TLMP for a multi-scaled conservation approach that would preserve the forest over the long-term, for species functioning from small to large scales.

The assessment focused on conservation at the watershed scale to preserve ecological processes in holistic, functional landscape units. According to Lertzman and MacKinnon (2013), "The most compelling argument for watersheds as reserves is that, more than any other delineations of equivalent size (or investment), they represent areas of landscape with strong internal connections among ecosystem processes and weaker external connections. Thus, watershed-based reserves have a greater likelihood of maintaining the ecological integrity of the area over the long-term without significant human subsidies."

A central element of the Tongass National Forest's TLMP conservation strategy is a system of small and medium-sized old-growth reserves that are intended to serve as linkages between larger conservation areas. Site-specific protection standards apply within development LUDs and other lands, including buffers on riparian forests and beach and estuary fringe forests. These measures are critical to maintain ecological function within developed landscapes.

The Ecological Society of America has developed a set of principles for managing national forests in the US (Aber et al. 2000). Principles that are relevant to land management and conservation in Southeast and the Tongass include:

- Conservation of forest biodiversity requires reducing forest fragmentation by clearcuts and roads, avoiding harvest in vulnerable areas such as old-growth stands and riparian zones, and restoring natural structural complexity to cutover sites
- Planning at the landscape level is needed to address ecological concerns such as biodiversity, water flows, and forest fragmentation
- Despite natural disturbance and successional change, forest reserves are much more likely to sustain the full biological diversity of forests than lands managed primarily for timber production
- Protection of water quality and yield and prevention of flooding and landslides require greater attention to the impacts of logging roads and recognition of the value of undisturbed buffer zones along streams and rivers
- Traditional beliefs that timber harvesting can duplicate and fully substitute for the ecological effects of natural disturbance are incorrect, although newer techniques such as retaining trees and large woody debris on harvest sites can more closely mimic natural processes
- There is no scientific basis for asserting that silvicultural practices can create forests that are ecologically equivalent to natural old-growth forests, although our understanding of forest ecology can help restore managed forests to more natural conditions.

While the ultimate benchmark for successful conservation is to maintain the diversity, natural distribution, and functional roles of species and ecological systems (Noss et al. 1997; Poiani et al. 2000), it was not practical to assess every species or habitat association. Instead, a representative set of focal targets were selected for this conservation assessment:

- Brown and black bear (*Ursus arctos* and *U. americanus*) habitat
- Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) winter habitat
- Marbled Murrelet (*Brachyramphus marmoratus*) old-growth nesting habitat
- Anadromous fish habitat (for five species of Pacific salmon (*Oncorhynchus spp.*) and steelhead (*O. mykiss*)
- Estuaries
- Riparian and upland large-tree old-growth forest.

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RESULTS

This conservation assessment analyzed the distribution, abundance, and management of biologically important communities as a foundation to maintain the biological diversity of the region, conserve a wide range of species, and maintain ecosystem integrity.

The "Conservation Priority" watersheds identified are those with highest concentrations of ecological values, which represent a globally rare opportunity for conservation of coastal rainforest ecosystems and associated species. These watersheds contain approximately 34% of existing habitat values for all focal species and ecological systems combined.

An important set of watersheds with high concentrations of ecological values but which have also sustained substantial roading and logging activity represent areas appropriate for a balanced prescription with emphasis on second-growth timber production and restoration of habitat values for fish and wildlife. These areas are described as zones of "Restoration Priority" to emphasize the necessity to maintain critical ecosystem functions throughout the forest matrix and in the context of overall forest management objectives. Core areas of biological value within the Restoration Priority areas represent the highest concentration of intact ecological values and, in this context, represent important opportunities for conservation of remaining old-growth characteristics within the matrix and for enhancing connectivity among watersheds. Restoration Priority watersheds represent approximately 15% of existing habitat values for the combined focal species and ecological systems studied.

"Lower Value" watersheds are typical of extensive areas of bedrock and glacier-dominated landscapes along the mainland coast and southern and eastern Baranof Island. These areas contain lower ecological values, and represent approximately 10% of existing habitat for combined focal species and ecological systems.

CONSERVATION ISSUES

The ecological integrity (i.e., long-term productivity and resilience of fish, wildlife, and their habitats) of Southeast's rainforest ecosystem will depend, in large part, on balancing industrial development with sound conservation measures, including an expanded watershed-scale reserve system for this region.

An expanded system of intact watershed reserves would complement the current TLMP conservation strategy and minimize risks to ecosystem integrity, including sensitive populations of fish and wildlife and rare habitat types. As an example, floodplain and karst forest communities represent small but important components of the forest ecosystems of Southeast. This study estimated that a significant portion of the rare, large-tree floodplain and karst old growth forests (>50% in some provinces) have been harvested in Southeast during the last century.

Audubon Alaska recommends the following conservation measures throughout Southeast and the Tongass:

- Maintain and expand the existing conservation reserve network to include additional intact watersheds (Conservation Priority Watersheds) throughout Southeast and the Tongass
- Each of Southeast's 22 biogeographic provinces should include a representative set of intact watershed reserves of high ecological value
- Apply best management practices (e.g., TLMP conservation strategy including, old-growth reserves, habitat buffers, standards and guidelines, and State Forest Practices Act guidelines) to resource development projects conducted in matrix lands throughout Southeast. Particular emphasis should be placed on maintaining riparian buffers and productive salmon spawning and rearing habitat throughout Southeast including outside of the Tongass
- Consider establishing additional critical habitat areas surrounding state lands and waters that include high-value and/or sensitive fish and wildlife habitats and where multiple land or water jurisdictions overlap, consider developing co-management agreements to safeguard fish and wildlife habitat values.

MAPPING METHODS

This conservation assessment synthesized geographic information for a wide range of resource values integrated across public and private lands. Primary input data included biogeographic provinces, vegetation and land cover, landform and soils, shoreline, watersheds, elevation, streams and lakes, spawning and rearing salmonid distribution, and wetlands. Where possible, attributes and merged data from the Tongass National Forest were cross-referenced with other data sources into seamless layers for all of Southeast. For this purpose, Landsat imagery (current in 1999–2002) was acquired to fill gaps related to forest condition on private lands and to map estuaries in areas for which the National Wetlands Inventory was not yet complete.

This data was used to assess total habitat value within each watershed (also termed Value Comparison Unit [VCU]), by biogeographic province, and then rank the VCUs from most to least habitat for each focal target assessed (bears, deer, estuaries, etc.). The resulting "watershed matrix" spreadsheets consisted of a quantitative ecological ranking (within each biogeographic province) for each individual focal target within VCUs across Southeast.

Next, all focal targets were assessed together to identify optimal areas for conservation of multiple species. That analysis was conducted by using the Marxan spatial optimization tool (Possingham et al. 2000) for developing and evaluating reserve networks based on explicit conservation goals. Marxan was used at a range of spatial scales, including (1) entire watershed units (VCUs), (2) core areas within biogeographic provinces, and (3) core areas within VCUs. The watershed context provided the primary, landscape-scale characterization, while "core areas" represented the highest concentrations of intact ecological values at the sub-watershed scale.

Although this "spatial optimization" tool relies on an iterative simulated annealing, scenario-based algorithm, in short the Marxan analysis simply identifies the most concentrated distribution of habitat values across the landscape. 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. Many conservation efforts have been based on manual mapping, simple overlay, and expert opinion to identify priority areas. The optimization tool described allows conservation planners to base evaluation of alternatives on explicit and quantitative criteria for a more objective prioritization process.

Because habitat for the six fish species was highly spatially correlated, we used all salmon species habitat combined as a single target in the final model. Other focal targets included old-growth forest (big-tree riparian and upland stands), estuaries, brown and black bear summer habitat, Sitka black-tailed deer winter habitat, and Marbled Murrelet nesting habitat. Marxan was utilized to optimize a conservation area design for the combination of these values.

The combined ranking of ecological values at the watershed- and sub-watershed scales provided an analytical framework for conservation and management prescriptions across a range of ecological conditions. This information will allow managers and conservationists to focus conservation efforts on the most important core areas of ecological value.

MAP DATA SOURCES

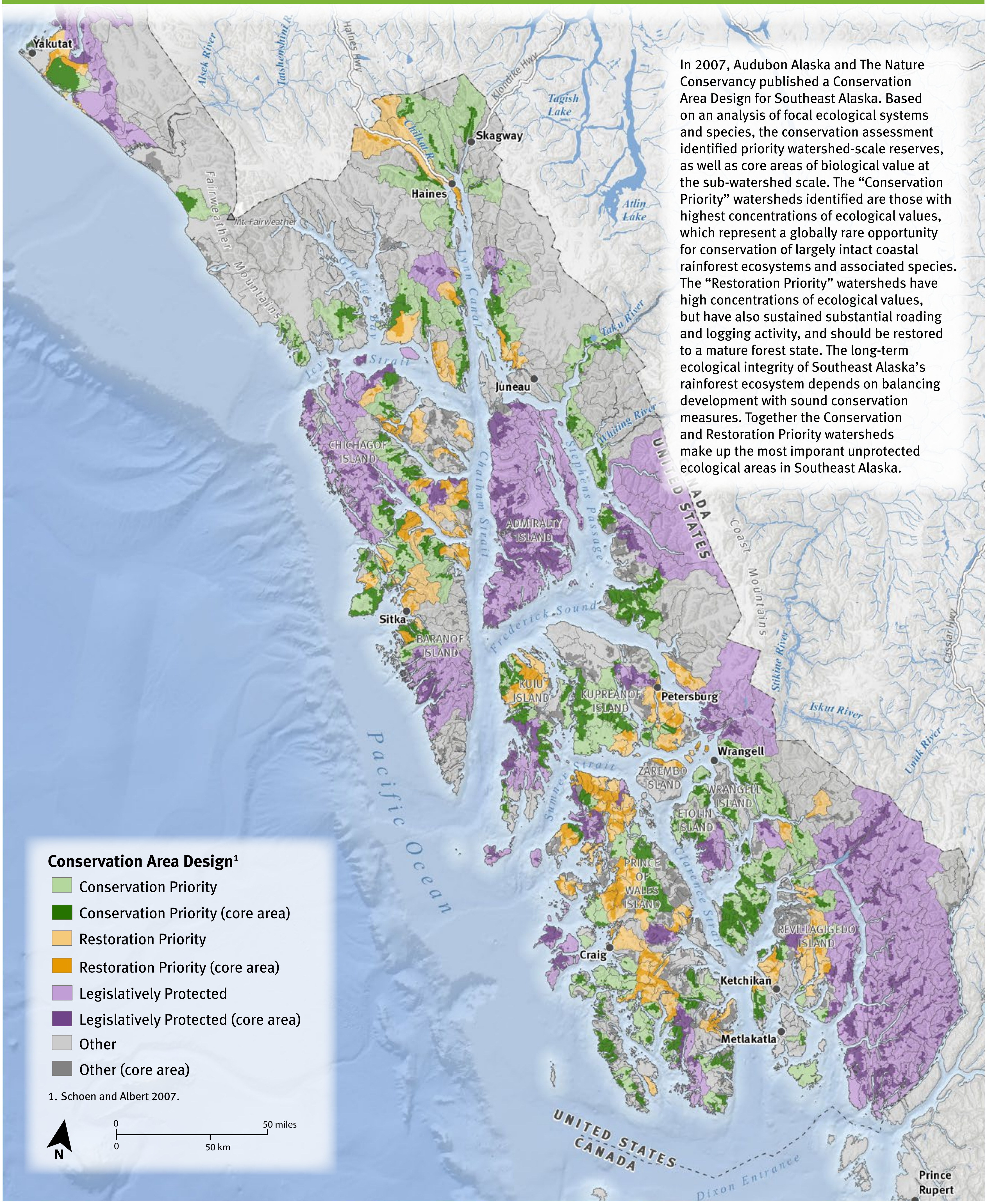
- Conservation area design: Albert and Schoen (2007).

Audubon ALASKA

The Nature Conservancy

A Conservation Area Design for Southeast Alaska

In 2007, Audubon Alaska and The Nature Conservancy published a Conservation Area Design for Southeast Alaska. Based on an analysis of focal ecological systems and species, the conservation assessment identified priority watershed-scale reserves, as well as core areas of biological value at the sub-watershed scale. The "Conservation Priority" watersheds identified are those with highest concentrations of ecological values, which represent a globally rare opportunity for conservation of largely intact coastal rainforest ecosystems and associated species. The "Restoration Priority" watersheds have high concentrations of ecological values, but have also sustained substantial roading and logging activity, and should be restored to a mature forest state. The long-term ecological integrity of Southeast Alaska's rainforest ecosystem depends on balancing development with sound conservation measures. Together the Conservation and Restoration Priority watersheds make up the most imporant unprotected ecological areas in Southeast Alaska.



Map 7.9: A Conservation Area Design for Southeast Alaska

MAP ON PAGE 216

TONGASS 77 WATERSHEDS

Melanie Smith

The Tongass 77 (T77), also known as the "Salmon Forest" Proposal, designates key watersheds in Southeast Alaska for permanent protection to safeguard the most important salmonid habitat across the region that is currently open to development status. The proposal is based on a scientific assessment of Southeast Alaska's Coastal Forests and Mountains Ecoregion (Schoen and Dovichin 2007). The assessment resulted in a habitat ranking system for six salmonid species as well as other values. Top watersheds were identified in each of the 14 biogeographic provinces in Southeast Alaska that are not in legislatively protected status, based on combined values for the six anadromous fish species, plus related habitat quality indicators such as old-growth forest, bear and deer habitat, and estuaries.

Salmon were selected as a focal species for forest management because spawning and rearing salmon are widely distributed in streams and rivers throughout Southeast Alaska and because these fish play a fundamental role in the ecology of coastal, freshwater, and terrestrial systems. Salmon are keystone species because they transfer marine-derived nutrients into the terrestrial and freshwater ecosystems, and many terrestrial and freshwater species and ecological processes are inextricably connected to salmon (Willson and Halupka 1995).

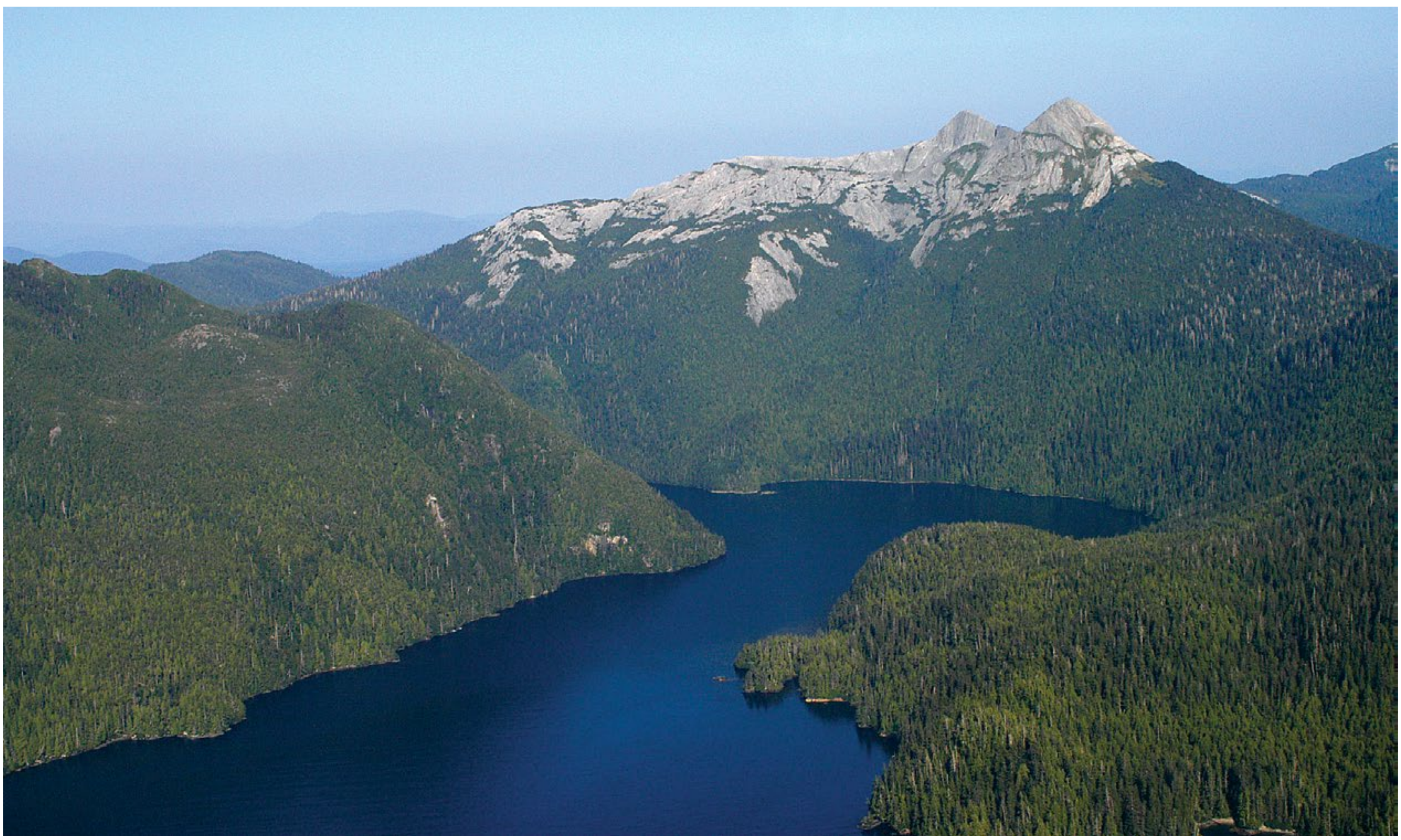
The project assessed top watersheds for each biogeographic province in order to account for the unique island biogeography of different areas of the Tongass. The Tongass 77 are therefore a dispersed network of sites identified at the whole watershed scale, employing both a "single large" and "several small" reserve design at the province or ecoregion scale, respectively. This land management strategy is analogous to preserving an ecological investment portfolio (Schindler et al. 2010). The proposal will permanently protect top watersheds in Southeast Alaska.

The Tongass 77 proposal includes all of the top-ranking (i.e. #1) watersheds within all 14 of the biogeographic provinces in Southeast Alaska not under permanent protection, based on values for all six fish species and related habitat conservation targets. Also included in the Tongass 77 are the #1 ranking watersheds for the six individual fish species assessed, as well as the highest ranking watersheds for all salmonids combined. Salmonid species included:

- King (Chinook) salmon (*Oncorhynchus tshawytscha*)
- Red (sockeye) salmon (*O. nerka*)
- Silver (coho) salmon (*O. kisutch*)
- Pink (humpy) salmon (*O. gorbuscha*)
- Chum (dog) salmon (*O. keta*)
- Steelhead trout (*O. mykiss*)

In addition to including valuable fish habitat, the proposal is supplemented with watersheds that capture other biological values in order to ensure the region will sustain a viable ecosystem. The Tongass 77 captures the #1 ranking watershed in each province for the following ecosystem components, which are highly correlated with healthy salmon habitat:

- Estuaries (highly important anadromous fish habitat)
- Riparian large-tree old growth (nutrient exchange, large woody debris, cold water refuge, erosion stability)
- Black and brown bear (*Ursus americanus* and *U. arctos*) summer habitat (correlated with salmon concentration areas)
- Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) wintering habitat (indicative of healthy upland forest at the watershed scale)
- Marbled Murrelet (*Brachyramphus marmoratus*) nesting habitat (an ecological link between old-growth forest and the marine ecosystem).



John Schoen

Waterfall Bay (Dall Island) is one of the Tongass 77 watersheds.

MAP ON PAGE 216

The proposal included all identified top-ranked watersheds in Southeast Alaska, except those: already protected, in non-federal ownership, actively managed for other values (such as urban recreation, experimental forest, or active timber sale), or lacking public support (for example, the strong landowner opposition to protecting the Taku, which is the top salmon watershed in all of Southeast Alaska). In addition to the #1 watersheds, the proposal included several carefully chosen individual watersheds deemed important through additional review by scientists and fishermen. Additional watersheds met one or more of the following criteria:

- Based on all salmonid values combined, fell within the top 10% of watersheds in Southeast Alaska (without the biogeographic province filter)
- Based on all (salmonid and other) habitat correlates combined, fell within the top 10% of watersheds in Southeast Alaska (without the biogeographic province filter)
- Fell within the top five watersheds for a biogeographic province
- Identified as a Tier 1 watershed based on ecological optimization modeling as described by Albert and Schoen (2007). Tier 1 watersheds fall within the top 25% of each biogeographic province, using an evaluation of the smallest footprint to achieve the highest value for the combination of all salmonid and other habitat correlates combined
- ADFG data indicated exceptional salmon production and/or diversity.

The Tongass 77 proposal was based on several years of rigorous data collection, scientific analysis, and modeling, combined with local knowledge of the highest productivity areas. The proposal therefore captures the most important places in Southeast Alaska's Tongass National Forest for ensuring the long-term existence and health of the Southeast Alaska ecosystem and salmon fishery.

CONSERVATION ISSUES

The Tongass 77 Watersheds make up the most ecologically important but unprotected 1.89 million ac (764,855 ha) of the 17 million ac (6,879,656 ha) Tongass National Forest. Conservation of whole watersheds maintains ecological processes and local habitat diversity (Lertzman and MacKinnon 2013). Including key watersheds across provinces ensures well-distributed, high-quality habitat that will sustain population viability and ecosystem integrity across Southeast Alaska. The Tongass 77 includes both intact and developed watersheds, in order to capture those watersheds most important to ensuring long-term viability of the region as a salmon forest.

Four of the T77 watersheds have changed status since the proposal was developed. In 2015, the National Defense Reauthorization Act included a provision for the transfer of lands to Sealaska Corporation. To the dismay of conservation groups, that land transfer included Nutkwa Inlet, one of the T77 watersheds proposed for LUD II designation. At the same time, however, three other watersheds were placed into LUD II status as part of the Sealaska deal. Those were Lovelace Creek, Lake Kushneahin, and Sarkar Lakes.

Currently Southeast Alaska has a $1 billion fishing industry that supports 7,000 jobs, and a $1 billion tourism and recreation industry which supports another 10,000 jobs. The same watersheds that support ecological values also contribute to Southeast Alaska's economic vitality. Trout Unlimited and Audubon Alaska recommend permanent protection for the remaining Tongass 77 watersheds to continue these opportunities for future generations.

MAPPING METHODS

The Tongass 77 watersheds are based on the collection of spatial data generated by Audubon Alaska and TNC for the Conservation Assessment and Resource Synthesis for the Coastal Forests and Mountains Ecoregion (Schoen and Dovichin 2007), as well as scientific research and local knowledge from fishermen collected by Trout Unlimited.

More specific information about mapping methods for each focal resource appears in the summaries for Estuaries, Productive Old Growth, Anadromous Fish Species Richness, King Salmon, Red Salmon, Silver Salmon, Pink Salmon, Chum Salmon, Marbled Murrelet, Sitka Black-tailed Deer, Black and Brown Bears, and Conservation Area Design.

MAP DATA SOURCES

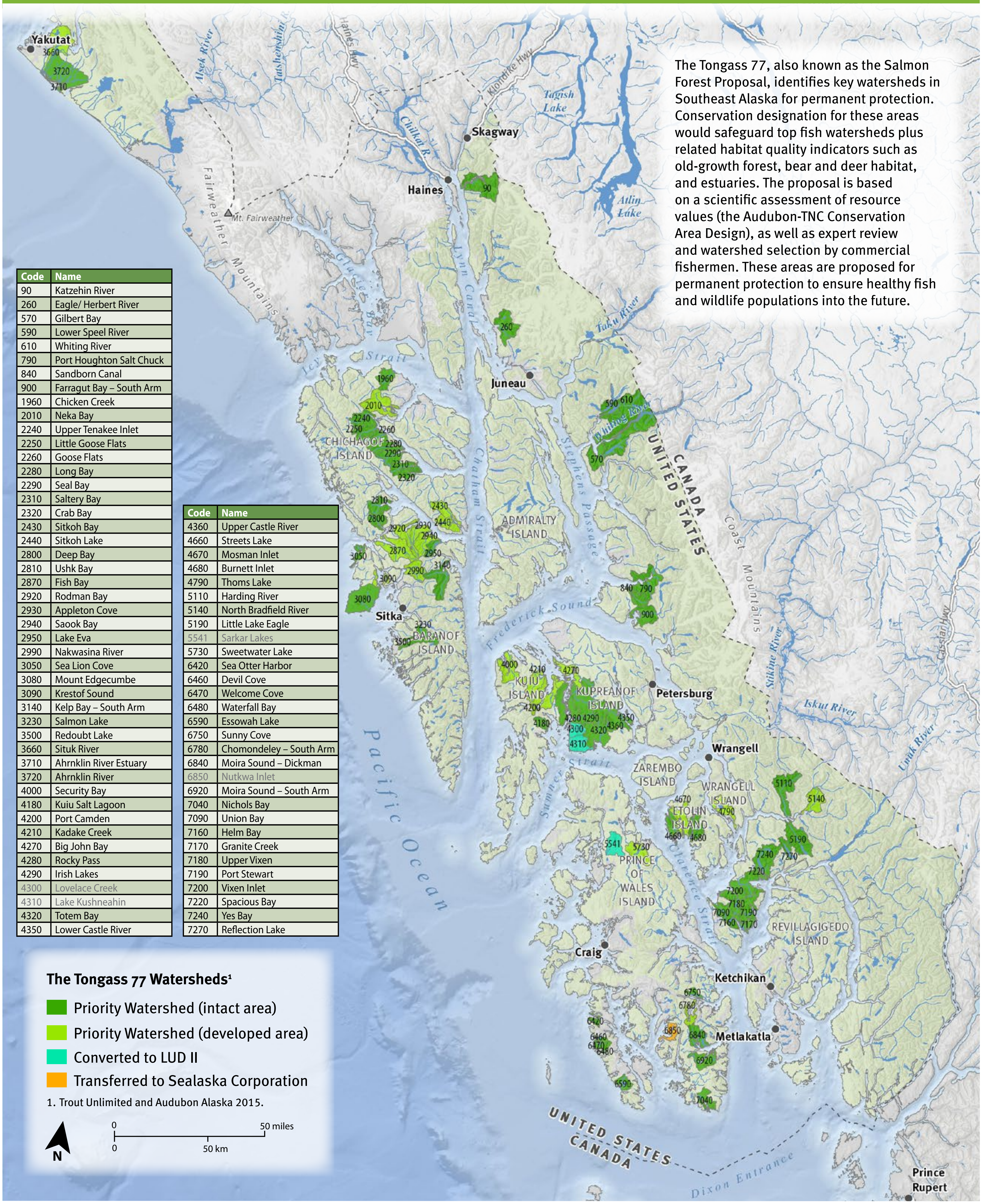
- Tongass 77 watersheds: Trout Unlimited and Audubon Alaska (2015).

John Schoen

Tongass 77 Watersheds

Audubon ALASKA

TROUT UNLIMITED



The Tongass 77, also known as the Salmon Forest Proposal, identifies key watersheds in Southeast Alaska for permanent protection. Conservation designation for these areas would safeguard top fish watersheds plus related habitat quality indicators such as old-growth forest, bear and deer habitat, and estuaries. The proposal is based on a scientific assessment of resource values (the Audubon-TNC Conservation Area Design), as well as expert review and watershed selection by commercial fishermen. These areas are proposed for permanent protection to ensure healthy fish and wildlife populations into the future.

Code	Name
90	Katzehin River
260	Eagle/ Herbert River
570	Gilbert Bay
590	Lower Speel River
610	Whiting River
790	Port Houghton Salt Chuck
840	Sandborn Canal
900	Farragut Bay – South Arm
1960	Chicken Creek
2010	Neka Bay
2240	Upper Tenakee Inlet
2250	Little Goose Flats
2260	Goose Flats
2280	Long Bay
2290	Seal Bay
2310	Saltery Bay
2320	Crab Bay
2430	Sitkoh Bay
2440	Sitkoh Lake
2800	Deep Bay
2810	Ushk Bay
2870	Fish Bay
2920	Rodman Bay
2930	Appleton Cove
2940	Saook Bay
2950	Lake Eva
2990	Nakwasina River
3050	Sea Lion Cove
3080	Mount Edgecumbe
3090	Krestof Sound
3140	Kelp Bay – South Arm
3230	Salmon Lake
3500	Redoubt Lake
3660	Situk River
3710	Ahrnklin River Estuary
3720	Ahrnklin River
4000	Security Bay
4180	Kuiu Salt Lagoon
4200	Port Camden
4210	Kadake Creek
4270	Big John Bay
4280	Rocky Pass
4290	Irish Lakes
4300	Lovelace Creek
4310	Lake Kushneahin
4320	Totem Bay
4350	Lower Castle River

Code	Name
4360	Upper Castle River
4660	Streets Lake
4670	Mosman Inlet
4680	Burnett Inlet
4790	Thoms Lake
5110	Harding River
5140	North Bradfield River
5190	Little Lake Eagle
5541	Sarkar Lakes
5730	Sweetwater Lake
6420	Sea Otter Harbor
6460	Devil Cove
6470	Welcome Cove
6480	Waterfall Bay
6590	Essowah Lake
6750	Sunny Cove
6780	Chomondeley – South Arm
6840	Moira Sound – Dickman
6850	Nutkwa Inlet
6920	Moira Sound – South Arm
7040	Nichols Bay
7090	Union Bay
7160	Helm Bay
7170	Granite Creek
7180	Upper Vixen
7190	Port Stewart
7200	Vixen Inlet
7220	Spacious Bay
7240	Yes Bay
7270	Reflection Lake

The Tongass 77 Watersheds[1]

- Priority Watershed (intact area)
- Priority Watershed (developed area)
- Converted to LUD II
- Transferred to Sealaska Corporation

1. Trout Unlimited and Audubon Alaska 2015.

0 50 miles
0 50 km
N

Map 7.10: Tongass 77 Watersheds

REFERENCES

Aber, J., N. Christensen, I. Fernandez, J. Franklin, L. Hidinger, M. Hunter, J. McMahon, D. Mladenhoff, J. Pastor, D. Perry, R. Slangen, and H. van Miergroet. 2000. Applying ecological principles to management of US national forests. *Issues in Ecology* 6:1-20.

ACE Conservation GIS Center. 2015. Transboundary Mines. Alaska Center for the Environment, Anchorage, AK.

Alaback, P., G. Nowacki, and S. Saunders. 2013. Natural disturbance patterns in the temperate rainforests of Southeast Alaska and adjacent British Columbia, In *North Pacific Temperate Rainforests: Ecology and Conservation*. J. W. Schoen and G. H. Orians eds., pp. 73–88. University of Washington Press, Seattle, WA.

Alaback, P. B. 1980. Biomass and production of understory vegetation in seral Sitka spruce-western hemlock forests of Southeast Alaska. Ph.D. thesis, Oregon State University.

______. 1984. Plant Succession Following Logging in the Sitka Spruce-Western Hemlock Forests of Southeast Alaska: Implications for Management. US Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR.

Alaback, P. B. and J. C. Tappeiner. 1984. Response of Understory Vegetation to Thinning in the Sitka Spruce-Western Hemlock Forests of Southeastern Alaska. Forest Science Laboratory. US Forest Service, Juneau, AK.

Alaska Center for Energy and Power. 2015a. Alaska Energy Wiki: Hydroelectric Power Generation. Accessed online Dec 21 2015 at http://energy-alaska.wikidot.com/hydro.

______. 2015b. Alaska Energy Wiki: Southeast Alaska (Hydro). Accessed online Dec 21 2015 at http://energy-alaska.wikidot.com/southeast-alaska-hydro.

Alaska Department of Fish and Game. 2000. Subsistence in Alaska: A Year 2000 Update. Alaska Department of Fish and Game, Juneau, AK.

______. 2014. Subsistence in Alaska: A Year 2012 Update. Alaska Department of Fish and Game, Anchorage, AK.

______. 2015a. Alaska Commercial Salmon Harvests and Exvessel Values Database. Anchorage, AK. Accessed online at http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisherySalmon.exvesselquery.

______. 2015b. Alaska Sport Fishing Survey: Regional Summary Estimates. Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, AK. Accessed online Mar 11 2015 at http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

______. 2015c. Community Subsistence Information System: Harvest Information. ADFG, Juneau, AK. Accessed online at http://www.adfg.alaska.gov/sb/CSIS/.

______. 2015d. Definition of Data Collection Terms Pertinent to the eLandings System. Accessed online March 23 2015 at https://elandings.alaska.gov/documentation/ar01s09.html.

______. 2015e. Memorandum: GMU 2 Wolf Population Estimate Update, Fall 2014. State of Alaska, Ketchikan, AK.

______. 2016. Fisheries Statistics: Participation & Earnings. ADFG Commercial Fisheries Entry Commission, Juneau, AK. Accessed online at https://www.cfec.state.ak.us/fishery_statistics/earnings.htm.

Alaska Department of Fish and Game: Division of Commercial Fisheries and The Nature Conservancy. 2011. Salmon Harvest Areas. ADFG/TNC, Juneau, AK.

______. 2013a. Alaska Fish Hatcheries. ADFG/TNC, Juneau, AK.

______. 2013b. Southeast Alaska Mariculture Sites. ADFG/TNC, Juneau, AK.

Alaska Department of Natural Resources. 1987. Promised Land: A History of Alaska's Selection of its Congressional Land Grants. Alaska Department of Natural Resources, Division of Land & Water Management, Anchorage, AK.

______. 2000. Fact Sheet: Land Ownership in Alaska. Accessed online at http://dnr.alaska.gov/mlw/factsht/land_fs/land_own.pdf

______. 2015a. Alaska State Land Offering: Auction #477. Anchorage, AK.

______. 2015b. Frequently Asked Questions About Land Sales. Accessed online 2016 at http://dnr.alaska.gov/mlw/landsale/sale_faq.cfm

Alaska Department of Natural Resources Division of Forestry. 2015. Alaska's State Forests - Haines State Forest. Accessed online April 2016 at http://forestry.alaska.gov/stateforests#haines.

______. 2016. Southern Southeast Area Operational Forest Inventory For State Forest and General Use Lands. Anchorage, AK.

Alaska Department of Natural Resources: Information Resource Management. 2006. State Mining Claims and Leases. ASGDC, Anchorage, AK. Accessed online at http://dnr.alaska.gov/mdfiles/trans_alaska_pipeline.html.

______. 2015. General Land Status - October 2015 - All Attributes - Clipped to 1:63,360 Coastline. Accessed online at http://dnr.alaska.gov/mdfiles/gls_ac.html.

Alaska Department of Transportation and Public Facilities. 2014. Juneau Access Improvements Project Draft Supplemental Environmental Impact Statement. Juneau, AK.

Alaska Department of Transportation and Public Facilities Southcoast Region. 2016. Juneau Access Improvements. Accessed online Jun 17 2016 at http://dot.alaska.gov/sereg/projects/juneau_access/index.shtml.

Alaska Electric Light and Power Company. 2015. AEL&P's History. Accessed online Dec 21 2015 at http://www.aelp.com/history/history.htm.

Alaska Industrial Development and Export Authority. 2009. Existing Hydro Power Sites and Energy Tie Lines. The Nature Conservancy, Juneau, AK.

______. 2016. Snettisham Hydroelectric Facility Project Fact Sheet. Alaska Industrial Development and Export Authority, Anchorage, AK.

Alaska Marine Highway System. 2014. Annual Traffic Volume Report 2014: Alaska Marine Highway System. Anchorage, AK.

______. 2015. Alaska Marine Highway System. Alaska Department of Transportation and Public Facilities, Accessed online Sep 9 2015 at http://www.dot.state.ak.us/amhs/index.shtml.

Alaska Statute. 1978. Subsistence Use and Allocation 16.05.258.

Alaska.org. 2016. Alaska Marine Highway System. Alaska Channel, Accessed online Sep 9 2015 at http://www.alaska.org/transportation/ferry.

AlaskaCruises.com. 2015. Alaska Cruise Lines & Alaska Cruise Line Operators. Accessed online Nov 4 2015 at http://www.alaskacruises.com/cruise-lines/cruise-lines.html.

Albert, D. M. and J. W. Schoen. 2007. A conservation assessment for the coastal forests and mountains ecoregion of southeastern Alaska and the Tongass National Forest, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

______. 2013. Use of historical logging patterns to identify disproportionately logged ecosystems within temperate rainforests of southeastern Alaska. *Conservation Biology* 27:774–784.

ANILCA. 1980. ANILCA, Public Law 96-487.

Annette Island School District. 2005. The Metlakatla Indian Community. Annette Island School District, Annette Island, AK.

Archibald, G. 2015. Mining in Southeast Alaska and British Columbia (personal communication).

Armstrong, R., R. Carstensen, M. Willson, and M. Osborn. 2009. The Mendenhall wetlands: A globally recognized important bird area. Samhwa Printing Company, Juneau, AK.

Arrowstar Resources Ltd. 2015. Developing Resources and Mineral Assets. Vancouver, BC. Accessed online at http://www.arrowstarresources.com/s/Home.asp.

Audubon Alaska. 2015a. Alaska Marine Highway Route. Anchorage, AK.

______. 2015b. Audubon Comments on the Haines Highway MP 3.5 to MP 25.3 Draft Revised Environmental Assessment in relation to the Chilkat Bald Eagle Preserve. Audubon Alaska, Anchorage, AK.

______. 2015c. Cruise Ship Ports. Audubon Alaska, Anchorage, AK.

______. 2015d. Prince of Wales Wolves: The Long-term Impacts of Logging and Roads Push a Tongass Wolf Population Toward Extinction. Audubon Alaska, Anchorage, AK.

______. 2016. Chilkat Bald Eagle Preserve. Accessed online May 9 2016 at http://ak.audubon.org/conservation/chilkat-bald-eagle-preserve.

Audubon Alaska, The Nature Conservancy, United States Forest Service, Province of British Columbia, GeoBase, United States Geological Survey, Glacier Bay National Park, and D. Leversee. 2012. Transboundary Land Classification. Audubon Alaska, Anchorage, AK.

BC Hydro. 2014. New transmission line ready to power Northwest B.C. Vancouver, BC. Accessed online at https://www.bchydro.com/news/press_centre/news_releases/2014/new-transmission-line-ready-to-power-northwest-bc.html.

Beier, C. 2011. Factors influencing adaptive capacity in the reorganization of forest management in Alaska. *Ecology and Society* 16:40-59.

Beier, C. M., A. L. Lovecraft, and F. S. I. Chapin. 2009. Growth and collapse of a resource system: An adaptive cycle of change in public lands governance and forest management in Alaska. *Ecology and Society* 14(2):5.

Beier, C. M., T. M. Patterson, and F. S. I. Chapin. 2008. Ecosystem services and emergent vulnerability in managed ecosystems: A geospatial decision-support tool. *Ecosystems* 11(6):923-938.

Black & Veatch. 2012. Southeast Alaska Integrated Resource Plan. Alaska Energy Authority, Juneau, AK.

Bradner, T. 2015. Greens Creek, Kensington Mines expanding production. *Alaska Journal of Commerce*.

Brehmer, E. 2015. Long-awaited Sealaska land transfer completed. *Alaska Journal of Commerce*.

Bureau of Land Management. 2015. Alaska Land Transfer Program. Accessed online Nov 5 2015 at http://www.blm.gov/ak/st/en/prog/ak_land_transfer.html.

Canarc Resource Corp. 2015. New Polaris Project. Vancouver, BC. Accessed online at http://canarc.net/projects/new_polaris/.

Carstensen, R. and R. H. Armstrong. 2004. Birds and Plane Safety at Juneau Airport. Report for Juneau Audubon Society, Juneau, AK.

Case, D. S. and D. A. Voluck. 2012. *Alaska Natives and American Laws*. 3rd edition. University of Alaska Press, Anchorage, AK.

Coeur Mining Inc. 2015. Coeur Mining: Mines and Projects, Kensington, Alaska. Accessed online Aug 6 2015 at http://www.coeur.com/mines-projects/mines/kensington-alaska#.VcQU-vmrFQK.

Conrad, S. and W. Davidson. 2013. Overview of The 2012 Southeast Alaska and Yakutat Commercial, Personal Use, and Subsistence Salmon Fisheries. Management Report No. 13-03. Alaska Dept of Fish and Game, Divisions of Sport Fish and Commercial Fisheries, Anchorage, AK.

Conrad, S. and D. Gray. 2014. Overview of the 2013 Southeast Alaska and Yakutat Commercial, Personal Use, and Subsistence Salmon Fisheries. No. 14-28. Alaska Department of Fish and Game, Division of Sport and Commercial Fisheries, Anchorage, AK.

Constantine Metal Resources Ltd. 2016. Palmer VMS - AK. Vancouver, BC. Accessed online April 6 2016 at http://constantinemetals.com/projects/palmer/.

Cook, J. and S. MacDonald. 2001. Should endemism be a focus of conservation efforts along the North Pacific Coast of North America? *Biological Conservation* 97:207-213.

Cook, J. A., N. G. Dawson, and S. O. MacDonald. 2006. Conservation of highly fragmented systems: The north temperate Alexander Archipelago. *Biological Conservation* 133:1-15.

Crone, L. K. and J. R. Mehrkens. 2013. Indigenous and Commercial Uses of the Natural Resources in the North Pacific Rainforest with a Focus on Southeast Alaska and Haidi Gwaii, In *North Pacific Temperate Rainforests: Ecology and Conservation*. J. W. Schoen and G. H. Orians eds., pp. 73–88. University of Washington Press, Seattle, WA.

Demer, L. 2014. State working on new permitting system for cruise ship waste. Alaska Dispatch News, Anchorage, AK.

Environmental Protection Agency. 1997. A-J Gold Mine Project Abandoned. Accessed online 11 March 2016 at http://yosemite.epa.gov/opa/admpress.nsf/a21708abb48b5a9785257359003f0231/91402049d71310d9852570c-b005a4e96!OpenDocument

ESRI/Bing Maps. 2015. Bing Maps Hybrid Imagery Base Map. ESRI, Redlands, CA.

FAA. 1995. Alaska Airports and Runways. Alaska Department of Natural Resources, Land Records Information Section, Accessed online at http://mapper.landrecords.info/SpatialUtility/SUC?cmd=md&layerid=43.

Fall, J. A., C. L. Brown, D. Caylor, S. Georgette, T. Krauthoefer, and A. W. Paige. 2003. Alaska Subsistence Fisheries 2002 Annual Report. 315. Alaska Dept of Fish and Game, Juneau, AK.

Fall, J. A., M. Kerlin, B. Easley, and R. J. Walker. 2004. Subsistence Harvests of Pacific Halibut in Alaska, 2003. Alaska Department of Fish and Game, Juneau, AK.

Fall, J. A., D. S. Koster, and M. Turek. 2007. Subsistence Harvests of Pacific Halibut in Alaska, 2006. Alaska Dept of Fish and Game, Juneau, AK.

Federal Highway Administration. 2006. AASHTO: Interstate 50th Anniversary: Linking the Power of the Past to the Promise of the Future. Accessed online at https://web.archive.org/web/20081010060935/http:/www.interstate50th.org/docs/InterstateHighwayFactSheet.pdf.

Fienup-Riordan, A. 1984. The Spirit of ANCSA: Native expectations and the Alaska Native Claims Settlement Act. Papers Prepared for Overview Round Table Discussions, February 27 - March 16, 1984, Anchorage, AK.

Flanders, L. S. and J. Cariello. 2000. Tongass Road Condition Survey Report. Alaska Department of Fish and Game, Juneau, AK.

Flanders, L. S., J. Sherburne, T. Paul, M. Kirchoff, S. Elliot, K. Brownlees, B. Schroeder, and M. Turek. 1998. Tongass Fish and Wildlife Resource Assessment 1998. Alaska Dept of Fish and Game, Juneau, AK.

Gabriele, C. M., C. W. Clark, A. S. Frankel, and B. Kipple. 2011. Glacier Bay's underwater sound environment: The effects of cruise ship noise on humpback whale habitat. *Alaska Park Science* 9:12-17.

Galginaitus, M. 2004. Subsistence Resource Report for the Couverden Forest Service Project. Applied Sociocultural Research, Anchorage, AK.

Galore Creek Mining Corporation. 2015. Project Overview. Vancouver, BC. Accessed online at http://gcmc.ca/section.asp?pageid=20213.

GeoBC. 2004. Digital Road Atlas. Accessed online at http://geobc.gov.bc.ca/base-mapping/atlas/dra/.

Golden, K. 2009. Coeur Alaska wins Supreme Court case: Production expected to start in 2010. Juneau Empire, Juneau, AK.

Government of British Columbia. 2014. Mount Polley Mine Tailings Dam Breach, Likely, August 4, 2014. Accessed online 2015 at http://www.env.gov.bc.ca/epd/mount-polley/.

Griffiths, M. 2014. Tulsequah Chief Mine loses big investor. Juneau Empire, Juneau, AK.

Ground Truth Trekking. 2015. Alaska Metals Mining. Accessed online July 25 2015 at http://www.groundtruthtrekking.org/Issues/MetalsMining.html.

Harding, R. D. and C. L. Coyle. 2011. Southeast Alaska Steelhead, Trout, and Dolly Varden Management. Alaska Department of Fish and Game, Juneau, AK.

Heard, W., R. Burkett, F. Thrower, and S. McGee. 1995. A review of chinook salmon resources in Southeast Alaska and development of an enhancement program designed for minimal hatchery-wild stock interaction. *American Fisheries Society* 15:21-37.

Hecla Mining Company. 2015. Home page. Accessed online July 25 2015 at http://www.hecla-mining.com/.

Hennon, P. E., D. V. D'Amore, P. G. Schaberg, D. T. Wittwer, and C. S. Shanley. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow cedar in the North Pacific coastal rainforest. *BioScience* 62:147-158.

Hull, T. and L. Leask. 2000. Dividing Alaska, 1867-2000: Changing land ownership and management. *Institute of Social and Economic Research* XXXII:1-12.

Huntington, H. P. 1992. *Wildlife Management and Subsistence Hunting in Alaska*. University of Washington Press, Seattle, WA.

Hutchison, O. K. and V. J. LaBau. 1975. The forest ecosystem of Southeast Alaska: Timber inventory, harvesting, marketing, and trends. USDA Forest Service Pacific Northwest Forest and Range Experiment Station, Portland, OR.

Jones, E. and B. Chadwick. 2011. Managing Alaska's King Salmon. Alaska Department of Fish and Game, Juneau, AK. Accessed online 2015 at http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=511.

Juneau Empire staff. 2009. A brief history of mining, logging in the Juneau area. Juneau Empire, Juneau, AK.

Kaufman, A. 1958. Southeast Alaska's mineral industry. Juneau, Alaska.

Kirchhoff, M. D. and J. W. Schoen. 1987. Forest cover and snow: Implications for deer habitat in Southeast Alaska. *The Journal of Wildlife Management* 51:28-33.

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

Kruse, J. A., R. Frazier, and L. Fahlman. 1988. Tongass Resource Use Cooperative Survey (TRUCS) Technical Report Number One: Research Design and Field Phase. Institute of Social and Economic Research, University of Alaska Anchorage, Anchorage, AK.

Lasley, S. 2012. Mining News: Junior taps high-grade gold in SE Alaska. *North of 60 Mining News* 17.

Lavoie, J. 2015. 'It's the New Wild West': Alaskans Leery As B.C. Pushes For 10 Mines in Transboundary Salmon Watersheds. DeSmog Canada.

Lazenby, H. 2015. Tulsequah Chief mine determined 'substantially started' – BC Ministry of Environment. Creamer Media, Accessed online August 12 at http://www.miningweekly.com/article/tulsequah-chief-mine-determined-substantially-started-2015-01-15.

Leopold, A. and R. Barrett. 1972. Implications for Wildlife of the 1968 Juneau Unit Timber Sale. School of Forestry and Conservation, University of California Berkeley, Berkeley, CA.

Lertzman, K. and A. MacKinnon. 2013. Why watersheds: Evaluating the protection of undeveloped watersheds as a conservation strategy in northwestern North America, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 189-226. University of Washington Press, Seattle, WA.

Lindenmayer, D. B., J. F. Franklin, and J. Fischer. 2006. General management principles and a checklist of strategies to guide forest biodiversity conservation. *Biological Conservation* 131:433-445.

Low Impact Hydropower Institute. 2015. Overview. Accessed online December 21 2015 at http://lowimpacthydro.org/about-us/overview/.

MacDonald, G. F. 2001. The Haida: Children of the Eagle and Raven. Accessed online March 29, 2006 at http://www.civilization.ca/aborig/haida/haindexe.html#menu.

MacDonald, S. O. and J. A. Cook. 1996. The land mammal fauna of Southeast Alaska. *Canadian Field-Naturalist* 110:571-598.

Martin, M. C. 2015. Mount Polley to re-open after last year's disaster. Juneau Empire, Juneau, AK.

Mater, C. 2014. A New Way to Look at Establishing a Second Growth Wood Products Economy in SE Alaska. Mater Engineering, Corvallis, OR.

McDowell Group. 2015a. Economic Impact of Alaska's Visitor Industry, 2013–2014 Update. Alaska Department of Commerce, Community, and Economic Development, Juneau, AK.

______. 2015b. The Economic Value of Alaska's Seafood Industry. Alaska Seafood Marketing Institute, Juneau, AK.

Miller, M. 2012. First resource estimate made by potential Herbert Glacier mine developers. KTOO Public Radio.

Miller v. United States. 1947. Ninth Circuit Court, 159 F.2d 997.

Moritz, K. 2015. State moves forward on road plan. Juneau Empire, Juneau, AK.

Naves, L. C., M. F. Turek, and W. E. Simeone. 2010. Subsistence-personal Use Salmon Harvest, Southeast-Yakutat Management Region, 1996-2006. Alaska Department of Fish and Game, Anchorage, AK.

Newton, R. G. and M. L. Moss. 1984. The Subsistence Lifeway of the Tlingit People: Excerpts of Local Interviews. Administrative Document 131. US Forest Service, Alaska Region, Juneau, AK.

Nie, M. 2006. Governing the Tongass: National forest conflict and political decision making. *Environmental Law* 36(2):385–481.

NOAA: Office of Response and Restoration. 2005. Environmental Sensitivity Index, version 3.0. Seattle, WA. Accessed online at http://response.restoration.noaa.gov/maps-and-spatial-data/download-esi-maps-and-gis-data.html#Alaska.

Noss, R. F., M. O'Connell, and D. D. Murphy. 1997. *The Science of Conservation Planning: Habitat Conservation Under the Endangered Species Act*. Island Press, Washington, DC.

Nuka Research and Planning Group LLC. 2012. Southeast Alaska Vessel Traffic Study. Seldovia, AK.

Organized Village of Kake et al. v. USDA. 2015. 9th Circ. No. 11-35517 (July 29, 2015).

Orsi, J. A. and H. W. Jaenicke. 1996. *Oncorhynchus tshawytscha*. *Fishery Bulletin* 94:482-497.

Ott, R. A. and G. P. Juday. 2002. Canopy gap characteristics and their implications for management in the temperate rainforests of Southeast Alaska. *Forest Ecology and Management* 159:271-291.

Person, D. K. and T. J. Brinkman. 2013. Succession debt and roads: Short- and long-term effects of timber harvest on a large-mammal predator-prey community in Southeast Alaska, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 143-167. University of Washington Press, Seattle, WA.

Person, D. K., M. D. Kirchhoff, V. Van Ballenberghe, G. C. Iverson, and E. Grossman. 1996. The Alexander Archipelago Wolf: A Conservation Assessment. General Tech. Report PNW-GTR-384. US Forest Service, Juneau, AK.

Person, D. K. and B. D. Logan. 2012. A Spatial Analysis of Wolf Harvest and Harvest Risk on Prince of Wales and Associated Islands, Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Person, D. K. and A. L. Russell. 2008. Correlates of Mortality in an Exploited Wolf Population. *Journal of Wildlife Management* 72:1540-1549.

Piston, A. W. and S. C. Heinl. 2011. Chum Salmon Stock Status and Escapement Goals in Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

______. 2014. Pink Salmon Stock Status and Escapement Goals in Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Poiani, K. A., B. D. Richter, M. G. Anderson, and H. E. Richter. 2000. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. *BioScience* 50:133-146.

Possingham, H., I. Ball, and S. Andelman. 2000. Mathematical methods for identifying representative reserve networks, In *Quantitative Methods for Conservation Biology.* M. B. Scott Ferson ed., pp. 291-305. Springer-Verlag, New York, NY.

Powell, R. A., R. Lande, D. R. McCullough, W. Z. Lidicker, Jr., A. J. Hansen, R. L. Jarvis, Paquet, J. T. Ratti, C. C. Smith, R. D. Taber, and C. R. Benkman. 1997. Joint statement of members of the peer review committee concerning the inadequacy of conservation measures for vertebrate species in the Tongass National Forest Land Management Plan of Record.

Rakestraw, L. 1981. A history of the United States Forest Service in Alaska. USDA Forest Service, Alaska Region, Juneau, AK.

Renewable Energy Alaska Project. 2016. Alaska's Renewable Energy Projects: Hydro. Accessed online December 22 2015 at http://alaskarenewableenergy.org/why-renewable-energy-is-important/alaskas-renewable-energy-projects/.

Roppel, P. 1991. *Fortunes from the Earth: A History of the Base and Industrial Minerals of Southeast Alaska*. Sunflower University Press, Manhattan, KS.

Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. *Nature* 465:609-613.

Schoen, J. W. and E. Dovichin eds. 2007. *The Coastal Forests and Mountains Ecoregion of Southeastern Alaska and the Tongass National Forest: A Conservation Assessment and Resource Synthesis*. Audubon Alaska and The Nature Conservancy, Anchorage, AK.

Schoen, J. W. and M. D. Kirchhoff. 1990. Seasonal habitat use by Sitka black-tailed deer on Admiralty Island, Alaska. *The Journal of Wildlife Management* 54:371-378.

Schoenfeld, E. 2015. Six Cruise Ships Release Treated Sewage into Harbors. Alaska Public Radio Network.

Seabridge Gold. 2015. Featured Projects: KSM. Toronto, ON. Accessed online at http://seabridgegold.net/projects.php.

Shanley, C. S., S. Pyare, and W. P. Smith. 2013. Response of an ecological indicator to landscape composition and structure: Implications for functional units of temperate rainforest ecosystems. *Ecological Indicators* 24:68-74.

Sisk, J. 2007a. An introduction to the industrial history of southeastern Alaska: A geographic perspective, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. The Nature Conservancy and Audubon Alaska, Juneau, AK.

______. 2007b. The southeastern Alaska mining industry: Historical overview and current status, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. The Nature Conservancy and Audubon Alaska, Juneau, AK.

______. 2007c. The southeastern Alaska timber industry: Historical overview and current status, In *A Conservation Assessment and Resource Synthesis for the Coastal Forests & Mountains Ecoregion in Southeastern Alaska and the Tongass National Forest*. J. W. Schoen and E. Dovichin eds. The Nature Conservancy and Audubon Alaska, Juneau, AK.

Smith, W. P. 2013. Spatially explicit analysis of contributions of a regional conservation strategy toward sustaining northern goshawk habitat. *Wildlife Society Bulletin* 37:649-658.

Smith, W. P. and D. K. Person. 2007. Estimated persistence of northern flying squirrel populations in temperate rain forest fragments of Southeast Alaska. *Biological Conservation* 137:626-636.

Southeast Alaska GIS Library. 2011. Non-federal Forest Roads. Southeast Alaska GIS Library, Juneau, AK.

______. 2012. Transportation Atlas. Southeast Alaska GIS Library, Juneau, AK.

Southeast Conference. 2014. Southeast Alaska by the Numbers 2014. Southeast Conference, Juneau, AK.

State-Maps.org. 2015. Southeast Alaska Airports. Accessed online at http://www.alaska-map.org/airports-southeast.htm.

Stone, D. and B. Stone. 1980. *Hard Rock Gold: The Story of the Great Mines that Were the Heartbeat of Juneau*. City and Borough of Juneau, Juneau Centennial Committee, Juneau, AK.

Straugh, T. P. 2004. 2003 Deer Hunter Survey Summary Statistics. Alaska Dept of Fish and Game, Juneau, AK.

Susitna-Watana Hydro. 2015. Hydropower in Alaska: Current hydroelectric projects in Alaska. Accessed online December 21 2015 at http://www.susitna-watanahydro.org/2012/09/swh-introduces-new-website/.

TCW Economics. 2010. Economic Constributions and Impacts of Salmonid Resources in Southeast Alaska.

Tee-Hit Ton Band of Indians v. United States. 1955. US Supreme Court, 348 US 272.

The Nature Conservancy and Marine Exchange of Alaska. 2011. Annual Vessel Traffic Index (2009). The Nature Conservancy, Juneau, AK.

The Nature Conservancy: Alaska Field Office. 2011. Mapping Human Activities and Designing an Index of Cumulative Use within Estuarine and Nearshore Marine Ecosystems in Southeast Alaska. Juneau, AK.

The Wildlife Society. 2007. Final TWS Position Statement: Conservation and Management of Old-growth Forest On the Pacific Coast of North America. The Wildlife Society, Bethesda, MD.

Tlingit and Haida Indians of Alaska v. United States. 1959. US Court of Claims, 177 F. Supp. 452.

Trout Unlimited and Audubon Alaska. 2015. The Tongass 77 Watersheds. Audubon Alaska, Juneau, AK.

Turek, M. F. 2009. Customary and Traditional Use Worksheet: Salmon and Eulachon in Section 15A, Southeast Alaska. Alaska Department of Fish and Game, Juneau, AK.

Turek, M. F., N. C. Ratner, and W. Simeone. 2008. Customary and Traditional Use Worksheet, Wolves, Game Management Units 1, 3, 4, and 5, Southeast Alaska. Alaska Dept of Fish and Game, Juneau, AK.

Ucore. 2016. Bokan Mountain, Alaska. Accessed online at http://ucore.com/projects/bokan-mountain-alaska/project-overview.

US Army Corps of Engineers. 1999. AK Hydro Dams in Southeast Alaska. Southeast Alaska GIS Library, Juneau, AK. Accessed online at http://seakgis.alaska.edu:8080/geoportal/rest/document?id=%7bFD493981-7289-4AB1-906B-4AE1D43458C9%7d.

US Department of the Interior. 1999. Mineral Resources of the Chichagof and Baranof Islands Area, Southeast Alaska. Technical Report 19. Bureau of Land Management, Juneau, AK.

US Fish and Wildlife Service. 2016. 12-Month Finding on a Petition to List the Alexander Archipelago Wolf as an Endangered or Threatened Species; codified at 50 C.F.R. Part 17. *Federal Register* 81.

US Forest Service. 1997a. Tongass Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 1997b. Tongass Land Management Plan Revision, Final Environmental Impact Statement. US Forest Service, Juneau, AK.

______. 2001. Special Areas; Roadless Area Conservation ("roadless rule"); 36 C.F.R. 294.10-294.14. 66 Federal Register 3244-3273.

______. 2003. Special Areas; Roadless Conservation; Applicability to the Tongass National Forest, Alaska; 36 C.F.R. 294.14. 68 Federal Register 75,136.

______. 2004. Kensington Gold Project, Final Supplemental Environmental Impact Statement Record of Decision. USDA Forest Service, Tongass National Forest.

______. 2008a. Suitable Timber GIS Layer. Tongass National Forest, Juneau, AK.

______. 2008b. Tongass Land and Resource Management Plan, Final Environmental Impact Statement, Plan Amendment, Record of Decision. US Forest Service, Washington, DC.

______. 2008c. Tongass Land and Resource Management Plan, Final Environmental Impact Statement, Plan Amendment, Volume I. 1:R10-MB-603c. US Forest Service, Juneau, AK.

______. 2008d. Tongass National Forest Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 2014. Northern Sea Otter (*Enhydra lutris kenyoni*): Southeast Alaska Stock. US Forest Service, Alaska Region, Juneau, AK. Accessed online August 20, 2015 at http://www.fws.gov/alaska/fisheries/.

______. 2015. Proposed Tongass Land and Resource Management Plan. US Forest Service, Juneau, AK.

______. 2016a. Parcels Withdrawn from Settlement, Sale, Mineral Location, and/or Entry (S_USA.Withdrawal). FSGeodata Clearinghouse. Accessed online at http://data.fs.usda.gov/geodata/edw/datasets.php.

______. 2016b. Surface Ownership Parcels, Detailed (S_USA.SurfaceOwnership). FSGeodata Clearinghouse. Accessed online at http://data.fs.usda.gov/geodata/edw/datasets.php.

______. 2016c. Timber Harvests (S_USA.Activity_TimberHarvest). FSGeodata Clearinghouse. Accessed online at http://data.fs.usda.gov/geodata/edw/datasets.php.

US Forest Service Tongass National Forest. 2002. Log Transfer Facilities. Alaska EPSCoR, Juneau, AK. Accessed online at http://southeast.epscor.alaska.edu/catalogs/9532-log-transfer-facilities.

US Geological Survey. 1996. Environmental studies of mineral deposits in Alaska. Bulletin 2156. US Government Printing Office.

US Geological Survey Mineral Resources Program: Western Region - Alaska Section. 2008. Alaska Resource Data File (ARDF). Accessed online at http://mrdata.usgs.gov/ardf/.

USDI National Park Service. 2015. Administrative Boundaries of National Park System Units 12/31/2015 - National Geospatial Data Asset (NGDA) NPS National Parks Dataset (nps_boundary.zip). Accessed online at https://irma.nps.gov/Portal.

USFS Tongass National Forest. 2001. Tongass National Forest, Roadless Rule 2001, 2013. Southeast Alaska GIS Library, Juneau, Alaska. Accessed online at http://seakgis03.alaska.edu/geoportal/rest/document?id=%7BA1E36B0E-A589-484C-B38E-9A9B8975DC6D%7D.

Vercessi, L. 2013a. Alaska Salmon Fisheries Enhancement Program 2012 Annual Report; Fishery Management Report 13-05. Alaska Department of Fish and Game, Anchorage, AK.

Vercessi, L. 2013b. Alaska Salmon Hatcheries: Contributing to Fisheries and Sustainability. Accessed online at http://www.adfg.alaska.gov/static/fishing/PDFs/hatcheries/2013_ak_hatcheries.pdf.

Voluck, D. A. 1999. First peoples of the Tongass: Law and traditional subsistence way of life, In *The Book of the Tongass*. C. Servid and D. Snow eds., pp. 89-118. Milkweed Editions, Minneapolis, MN.

Wallmo, O. C. and J. W. Schoen. 1980. Response of deer to secondary forest succession in Southeast Alaska. *Forest Science* 26:448-462.

Wikipedia. 2016a. Juneau Access Project. Wikipedia, Accessed online June 17 2016 at https://en.wikipedia.org/wiki/Juneau,_Alaska#Juneau_Access_Project.

______. 2016b. Lynn Canal Highway. Wikipedia, Accessed online June 17 2016 at https://en.wikipedia.org/wiki/Lynn_Canal_Highway.

Wild Border Watersheds. 2015. Projects. Accessed online December 1 2015 at http://wildborderwatersheds.org/projects.

Willson, M. F. and K. C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. *Conservation Biology* 9:489-497.

Wolfe, R. J. 2004. Local Traditions and Subsistence: A Synopsis from Twenty-five Years of Research by the State of Alaska. Alaska Department of Fish and Game, Juneau, AK.

Wolfe, R. J., J. Bryant, L. Hutchinson-Scarbrough, M. Kookesh, and L. Sill. 2013. The Subsistence Harvest of Harbor Seals and Sea Lions in Southeast Alaska in 2012. Alaska Department of Fish and Game, Anchorage, AK.

Wolfe, R. J. and R. J. Walker. 1987. Subsistence economies in Alaska: Productivity, geography, and development impacts. *Arctic Anthropology* 24:56-81.

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CONSERVATION SUMMARY

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Southeast Alaska, including the 17-million-acre Tongass National Forest, is a region of great complexity in its physical, ecological, and human dimensions. Often, management agencies do not have the dedicated staff or funding to pull together a resource like the *Ecological Atlas of Southeast Alaska*, or the jurisdiction to engage in planning outside their administrative boundaries. Yet, looking at landscapes holistically is vital to understanding the larger context of decisions and to assessing cumulative effects. Through publication of this comprehensive Ecological Atlas, we aim to examine ecological patterns, share interdisciplinary knowledge, inform sustainable management, and inspire an appreciation for this spectacular place.

The *Ecological Atlas of Southeast Alaska* brings together a cross-section of topics such as forest management, commercial fishing, special status wildlife, climate change, and endemism, and interprets that information spatially. As we pieced together information from a wide variety of sources into a single framework, patterns and relationships appeared, presenting opportunities for better-informed decisions. Several themes emerged from this collection of data and ecological knowledge.

KEY CONSERVATION THEMES GATHERED FROM THE ECOLOGICAL ATLAS

1. The physical geography of the Alexander Archipelago and Coast Mountains has determined the dispersal and distribution of the region's biological components. Southeast Alaska's naturally fragmented, heterogeneous landscape requires nuanced management; its diversity is fundamental to its ecological integrity. As such, the 22 distinct biogeographic provinces of the region require special management to recognize, maintain, and/or restore populations of native flora and fauna.

2. Climate change is expected to alter the dynamics of the region through an increase in temperature of about 2°F (1.1°C) in the next 35 years, which may increase precipitation, reduce snow pack, fluctuate hydrology, shift vegetation communities, and lower fish productivity.

3. Productive old-growth forest supports a myriad of species, many of which are of conservation concern due to logging effects on habitat and populations. Karst and riparian large-tree, old-growth forests are the most rare and threatened aspects of the Tongass ecosystem.

4. Estuaries are a key ecosystem component that unites the marine and terrestrial environments and supports a variety of wildlife including shorebirds, Pacific salmon, and bears.

5. Anadromous fish are an essential part of the ecology of Southeast Alaska. Salmon are keystone species that exchange nutrients among freshwater, salt water, and terrestrial areas. Management of the Tongass must recognize and support this vital relationship to maintain long-term sustainability.

6. The diversity of habitat types in Southeast Alaska supports a great richness of bird species. Including casual and accidental occurrences, 70% of Alaska's bird species can be found in Southeast. The greatest concentrations of birds occur in estuaries and nearshore marine areas; the greatest richness of species is found in the ecotone where forest meets water.

7. In Southeast Alaska's archipelago of islands and mountains, about 20% of the known mammal taxa are endemic. Management of mammal populations should incorporate values that maintain genetically distinct species and geographically well-distributed populations.

8. The primary infrastructure impact in the region is from 9,000 mi (14,000 km) of roads. The majority of roads were developed for logging; this dense road network has detrimental effects on fish and mammal populations.

9. Cruise ships, by far, are the mode of transportation that brings the largest number of people to Southeast Alaska each year: around one million passengers annually. This sector provides the largest number of resource-based jobs.[1] Primary environmental issues are air pollution, waste and discharge, and marine mammal disturbance through noise and vessel strikes.

10. While logging falls far below other sectors as far as contributions to regional employment, old-growth clearcut logging poses the largest environmental concerns for the region. Impacts include habitat loss, fragmentation, roads, and second-growth "succession debt". Logging significantly affects the biological base necessary for the operation of other, far more lucrative industries (e.g. fishing).

11. Small-scale mines represent acute but localized risk; transboundary mines can have impacts that reach across international borders to present environmental risk on a broader scale. A number of proposed mines in British Columbia may pose threats to Southeast Alaska's most productive rivers and estuaries.

12. Fishing-related industry is the largest resource-based earnings sector in Southeast Alaska (second only to government employment when compared to all earning sectors)[1]. Because salmon are vital to the functioning of both the Southeast Alaska ecosystem and economy, it is critical for the region to manage fishing-related industry sustainably.

13. The rich rainforest landscape is the primary reason why communities and industries have thrived on the Tongass for so long. With the exception of mining, the resource-based industries of commercial fishing, cruise ship tourism, and timber depend on intact, healthy forest. This is also true for subsistence hunting, sport fishing, bird watching, and many other human use aspects of Southeast Alaska.

[1] Southeast Conference. 2014. Southeast Alaska by the Numbers 2014. Southeast Conference, Juneau, AK.

Over the past four decades, Audubon Alaska has promoted the sustainability of bird, mammal, and fish populations for present and future generations. In the *Ecological Atlas of Southeast Alaska*, we continue our practice of gathering and applying science to generate conservation recommendations.

As a result of our long history of working in Southeast Alaska, the compilation of best available science in this Ecological Atlas, and the key themes described above, Audubon Alaska offers the following observations and recommendations for managing the forests of Southeast Alaska, with an emphasis on the Tongass National Forest:.

RECOMMENDATIONS FOR SUSTAINABLE MANAGEMENT OF SOUTHEAST ALASKA FORESTS

1. Ending commercial scale, old-growth clearcut logging is the single most effective decision for ecological and economic sustainability in Southeast Alaska. The Tongass is the only national forest in the US where the Forest Service still practices old-growth clearcutting. Audubon concurs with the scientific consensus that old-growth clearcutting should end immediately[2].

2. Fishing and tourism industries already far surpass the timber industry in economic importance for the region. If managed sustainably, these economic sectors stand to set a powerful example to the nation and world on how to harness a region's natural capital for the benefit of long-term, local economic prosperity. Ultimately, Southeast Alaska's future must involve proper management of the multitude of human uses, in conjunction with anticipating changes such as climate shifts and second-growth succession that will compound today's concerns.

3. Roads offer legitimate access to hunting, recreation, and fishing resources, but high road densities degrade habitat and increase harmful impacts such as poaching. As the region moves away from large-scale, old-growth clearcut logging, the US Forest Service should seize opportunities to reduce road density for wildlife while retaining reasonable access.

4. A watershed approach to forest management is a smart, holistic ecosystem approach to managing forest resources including salmon, large carnivores, and forest diversity (including large-tree old growth)[3]. "Conservation Priority" and "Restoration Priority" watersheds across the Tongass should receive special attention within land management plans. The "T77 watersheds", identified for their conservation and salmon values, should receive permanent and comprehensive protection.

5. Finally, Audubon strongly recommends continued and complete protections for old-growth reserves, beach fringe buffers, and riparian management areas. These critical habitats were set aside in the 1997 and 2008 Tongass Land Management Plan Conservation Strategy specifically to maintain the abundance and diversity of fish and wildlife species dependent on old-growth forest habitats[4]. These areas include valuable old-growth habitat as well as second-growth forest that was intended to return, as closely as possible, to old-growth characteristics.

The list of key themes and recommendations provided here is only a start to what we have to learn from this Ecological Atlas. We will continue to use the information embodied in this publication to better understand and plan for management of Southeast Alaska and the Tongass. We hope that others will use this information as a jumping-off point for further research and inquiry that promote the sustainability of Southeast Alaska's rich and productive landscape.

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[2] See http://ak.audubon.org/sites/g/files/amh551/f/national_old_growth_policy_6-25-14.pdf and http://ak.audubon.org/sites/g/files/amh551/f/tongasssocietyletter1-20-2015.pdf.

[3] Lertzman, K. and A. MacKinnon. 2013. Why watersheds: evaluating the protection of undeveloped watersheds as a conservation strategy in northwestern North America, In *North Pacific Temperate Rainforests: Ecology and Conservation*. G. H. Orians and J. W. Schoen eds., pp. 189–226. University of Washington Press, Seattle, WA.

[4] http://ak.audubon.org/sites/g/files/amh551/f/scientists_review_of_tac_recommendations.pdf.

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