Melanie Smith

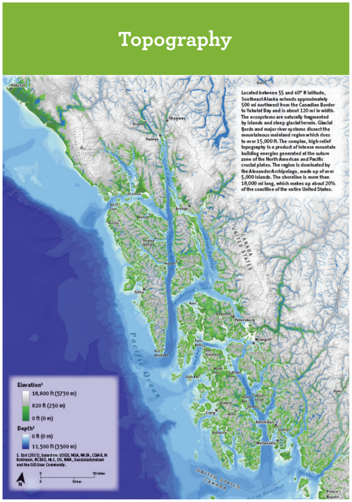
PHYSICAL SETTING

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

PHYSICAL SETTING MAPS INDEX



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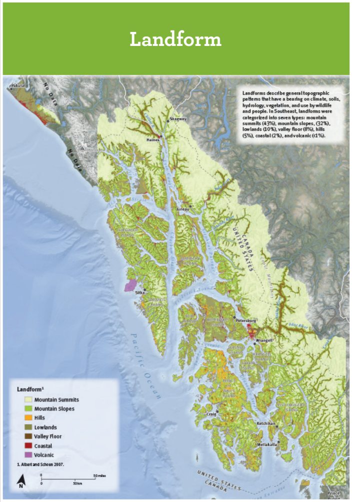

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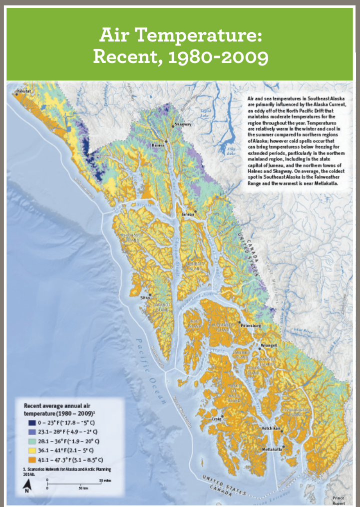

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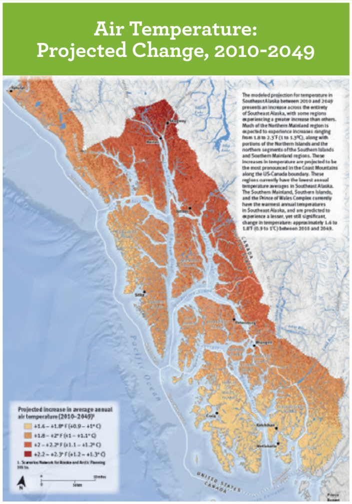

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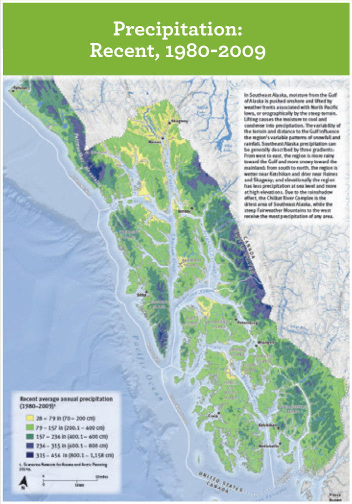

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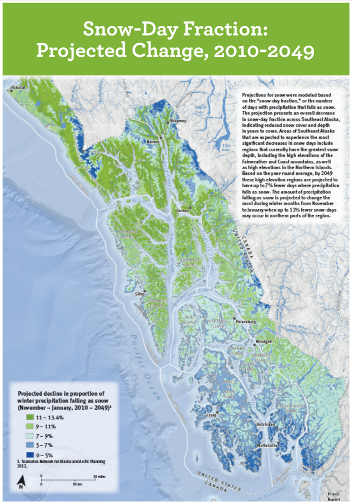

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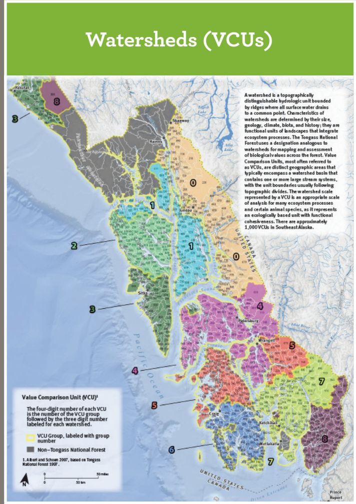

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TOPOGRAPHY

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).

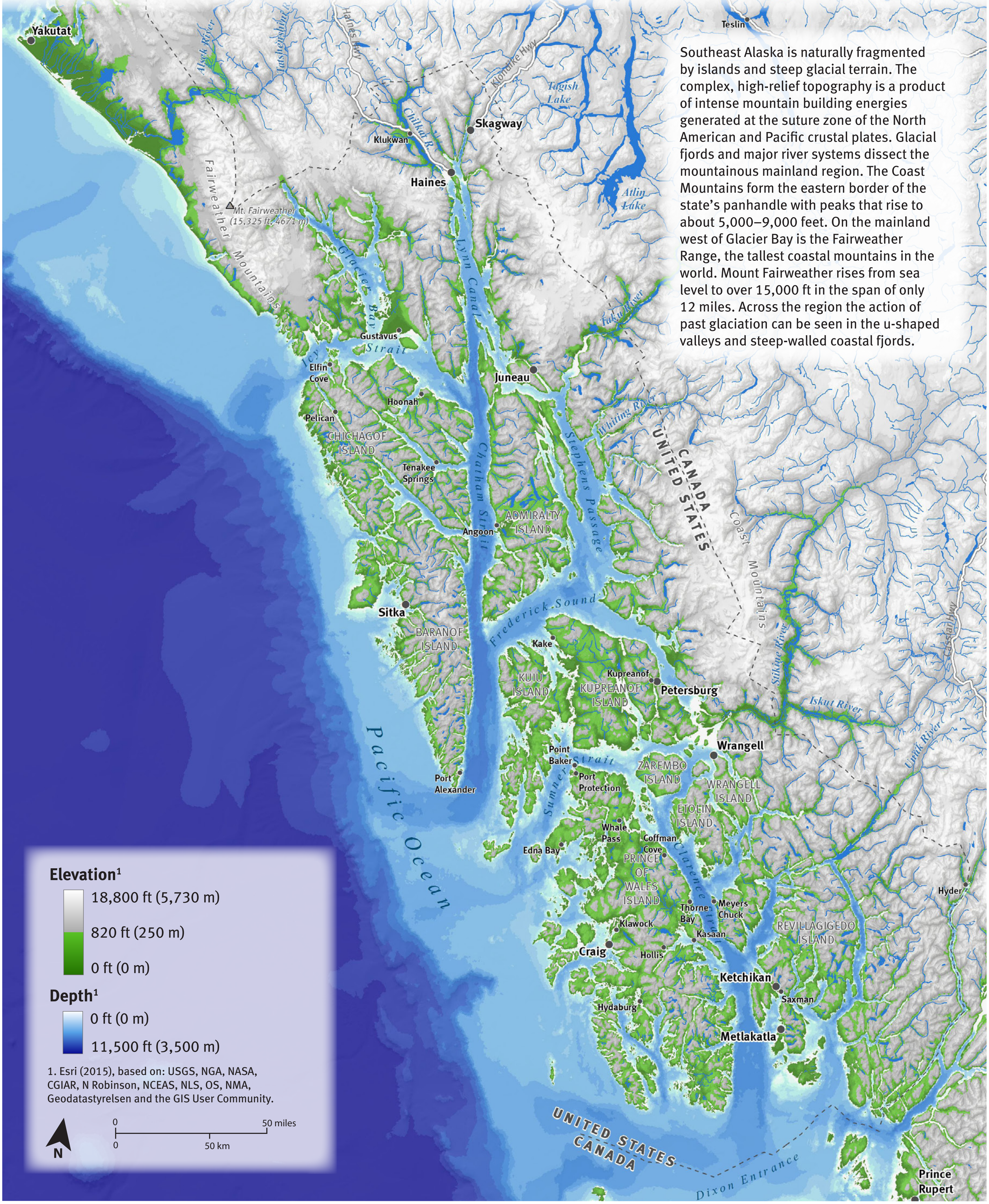
MAP DATA SOURCES

- 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).

Audubon ALASKA

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.



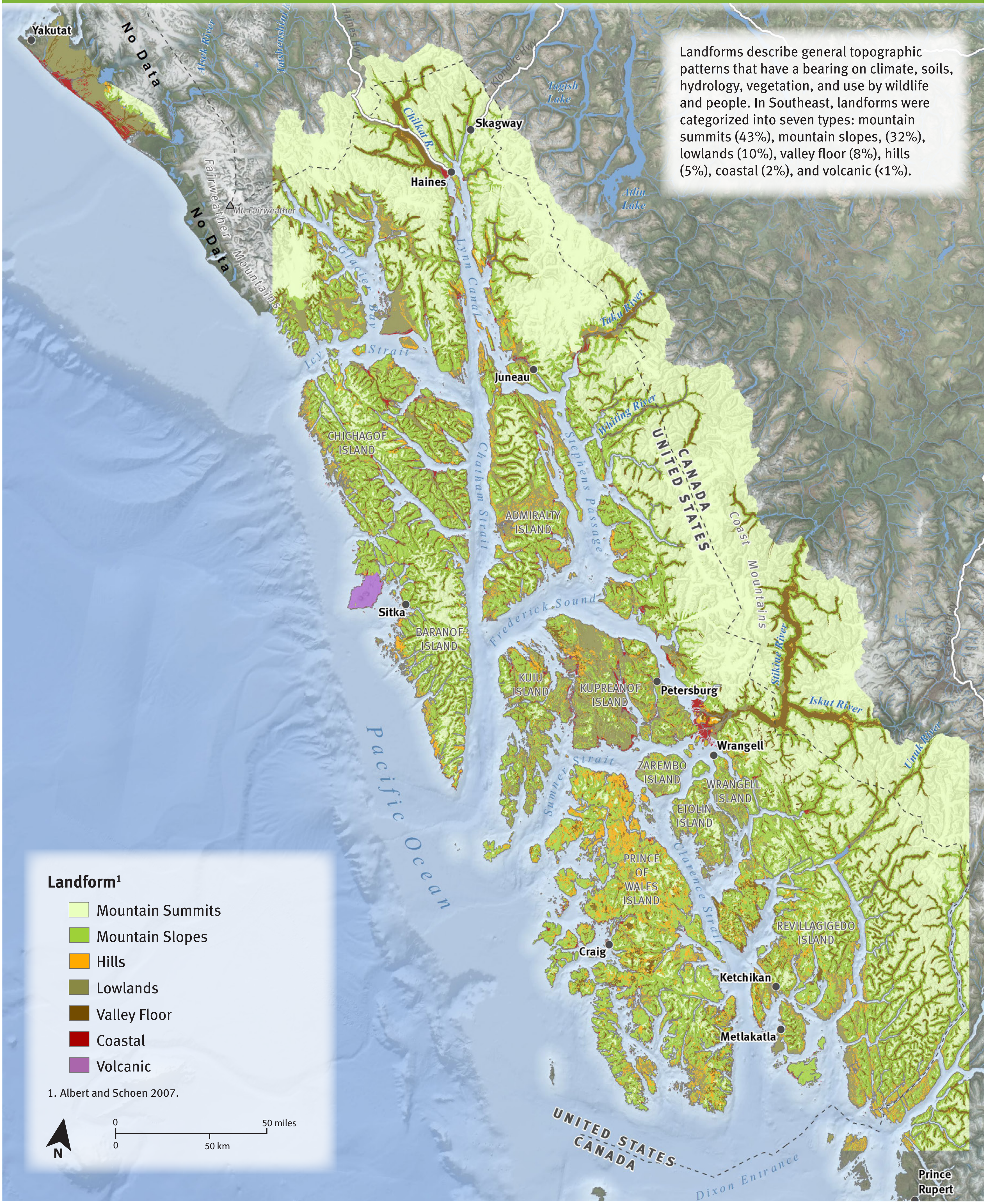
1. Esri (2015), based on: USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen and the GIS User Community.

Map 2.1: Topography

Landform

Audubon
ALASKA

The Nature Conservancy



Landforms describe general topographic patterns that have a bearing on climate, soils, hydrology, vegetation, and use by wildlife and people. 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%).

1. Albert and Schoen 2007.

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.

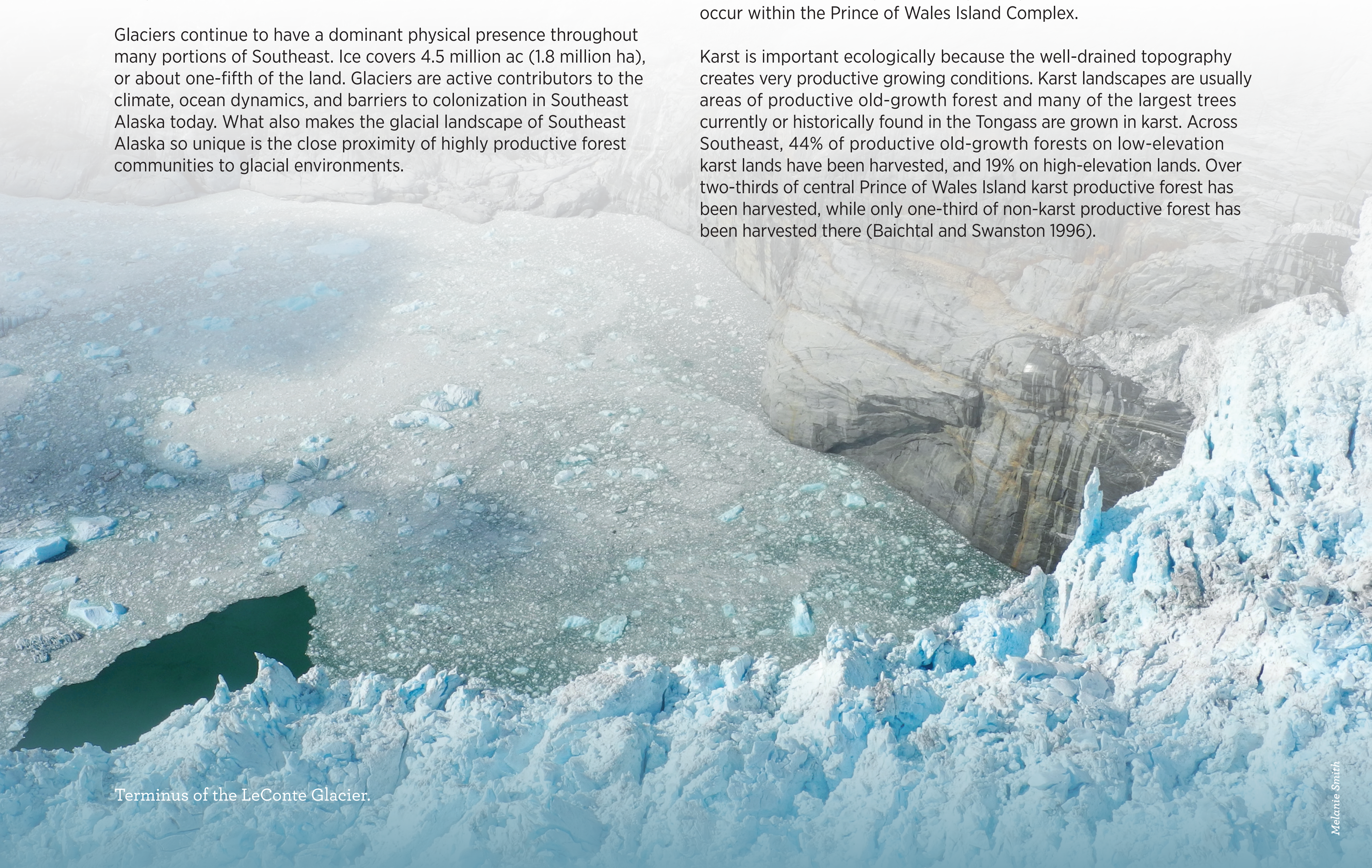
The largest expanses of glaciers and icefields in Southeast Alaska are primarily located in the Northern Mainland and Southern Mainland biogeographic province groups (see Biogeographic Provinces map and summary in next chapter for more information) at the Brady, Juneau, and Stikine icefields. Over a 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).

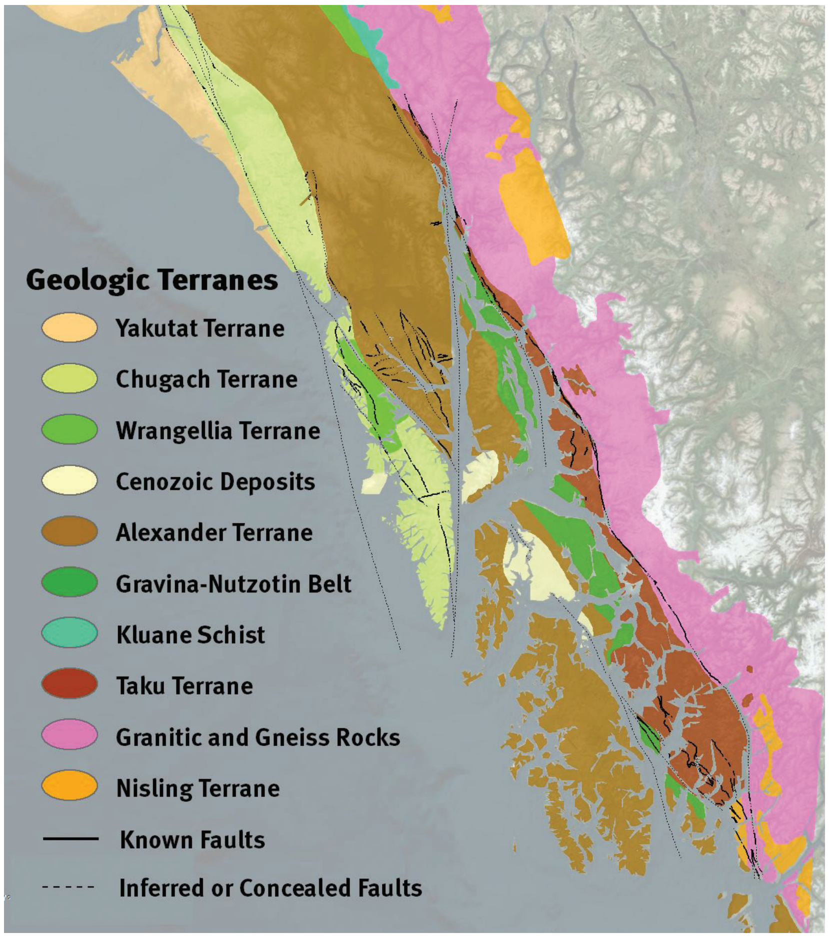
MAPPING METHODS

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

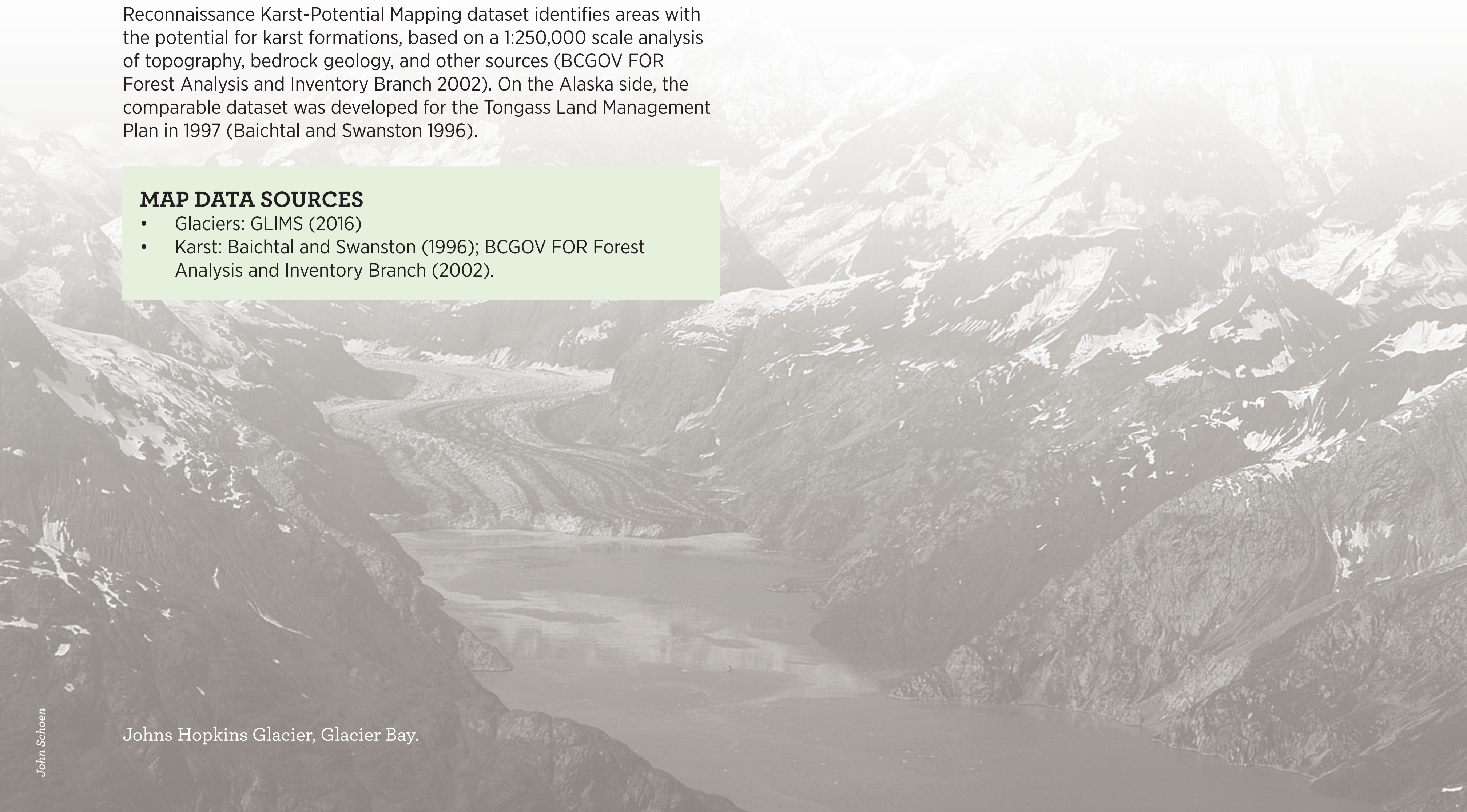
The karst data came from two different sources: in British Columbia, the Reconnaissance Karst-Potential Mapping dataset identifies areas with the potential for karst formations, based on a 1:250,000 scale analysis of topography, bedrock geology, and other sources (BCGOV FOR Forest Analysis and Inventory 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.

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.

☐ Glaciers[1]
▨ Karst[2,3]

1. GLIMS 2016.
2. Baichtal and Swanston 1996.
3. BCGOV FOR Forest Analysis and Inventory Branch 2002.

Map 2.3: Geologic Setting: Glaciers & Karst

MAPS ON PAGES 16, 17

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.

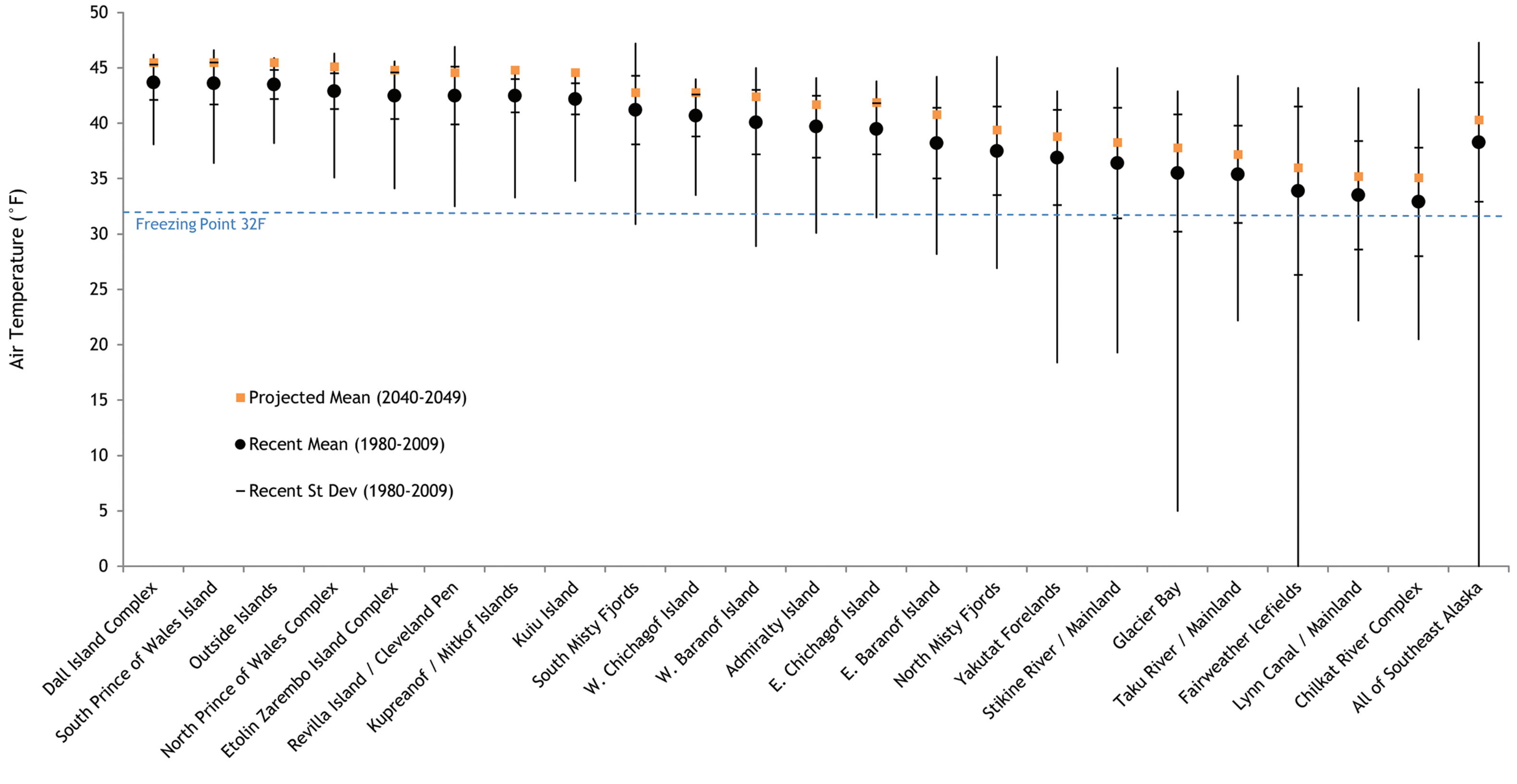
Much of the Northern Mainland region is expected to experience increases ranging from 1.8 to 2.3°F (an increase of 1 to 1.3°C), along with portions of the Northern Islands and the northern segments of the Southern Inside Islands and Southern Mainland regions. These increases in temperature are projected 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 communities (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.

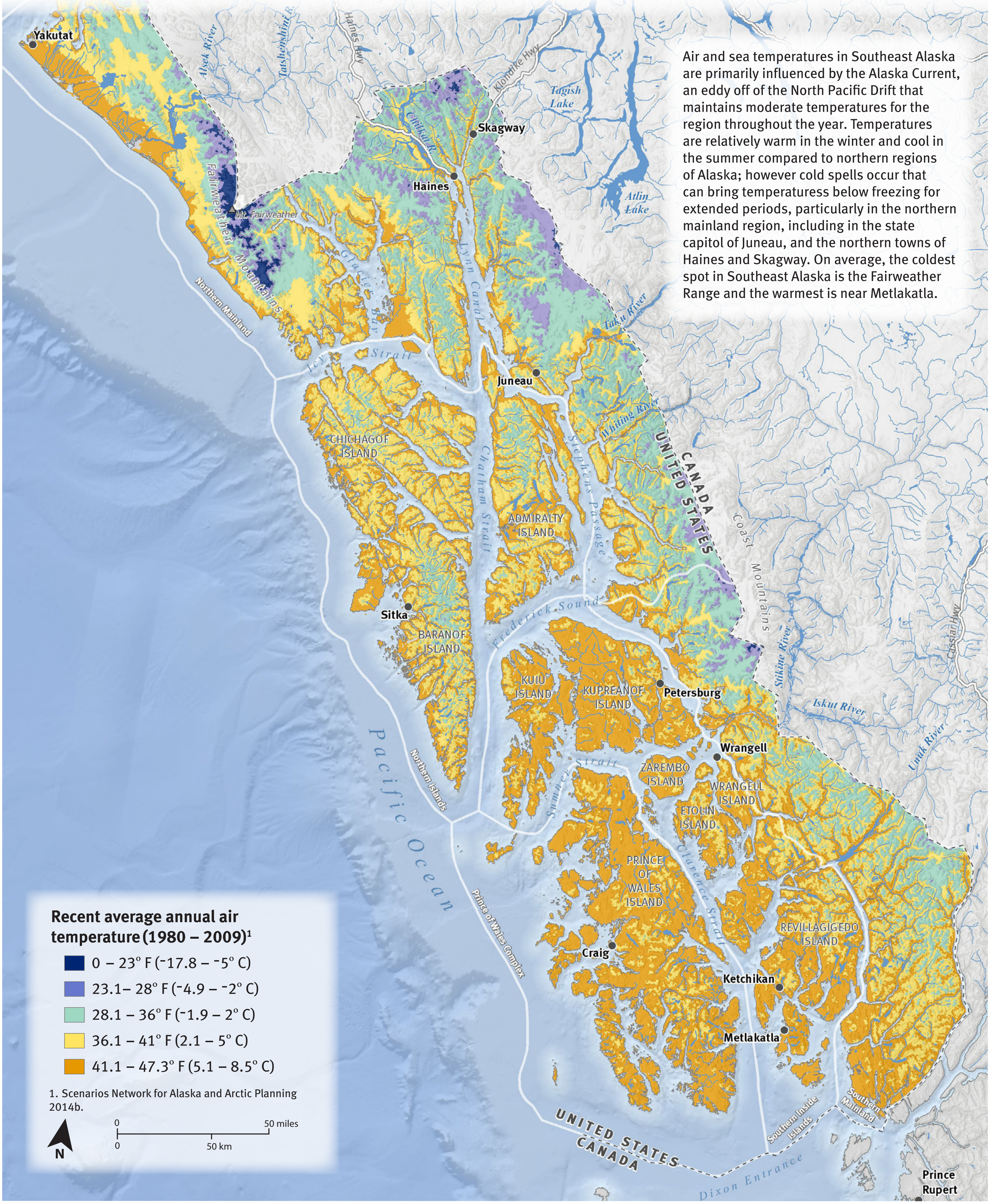
Projected Data

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



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.

Recent average annual air temperature (1980 – 2009)[1]

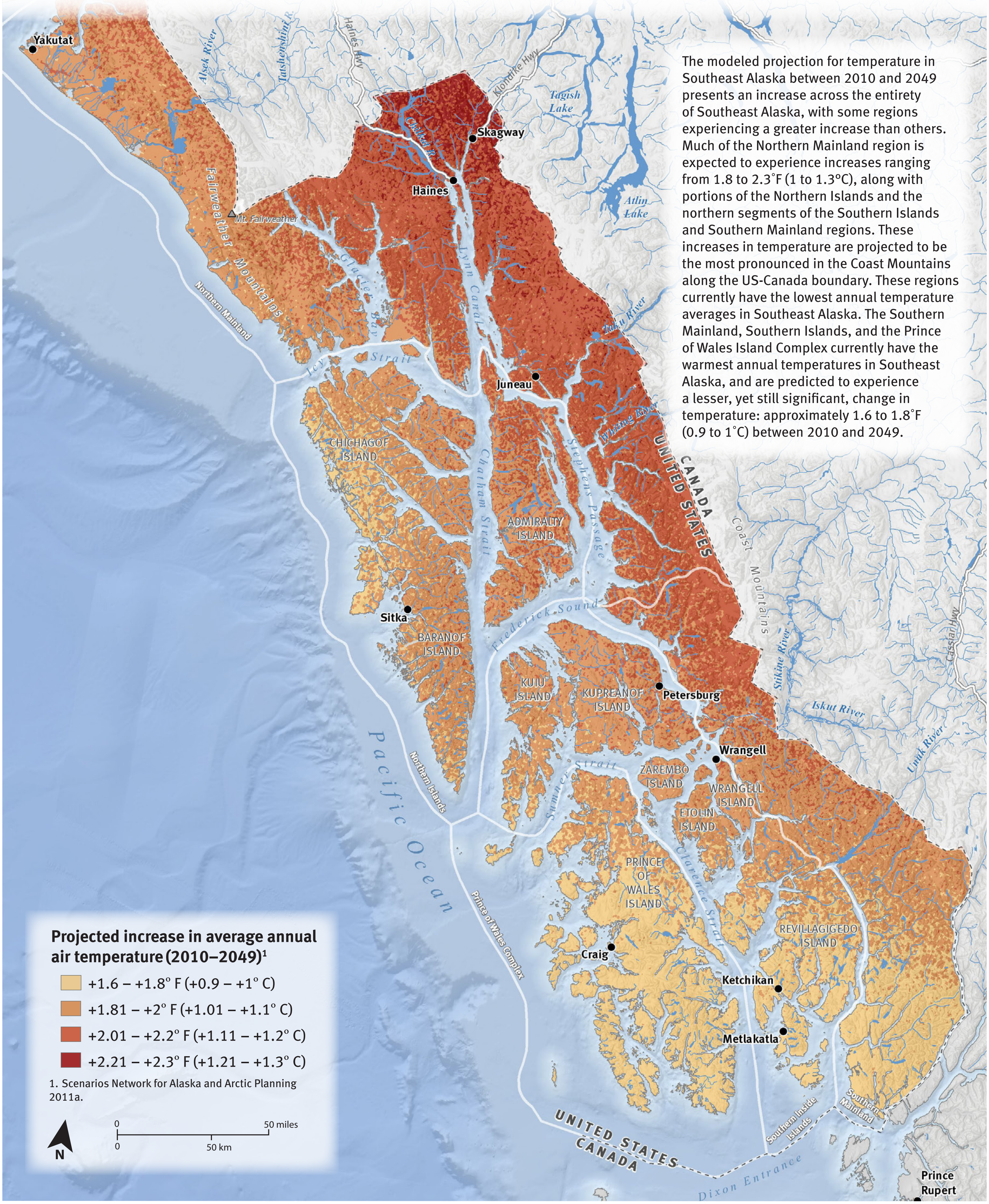
- 🟦 0 – 23° F (⁻17.8 – ⁻5° C)
- 🟪 23.1– 28° F (⁻4.9 – ⁻2° C)
- 🟩 28.1 – 36° F (⁻1.9 – 2° C)
- 🟨 36.1 – 41° F (2.1 – 5° C)
- 🟧 41.1 – 47.3° F (5.1 – 8.5° C)

[1] Scenarios Network for Alaska and Arctic Planning 2014b.

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 1.3ºC), 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.

1. Scenarios Network for Alaska and Arctic Planning 2011a.

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

MAPS ON PAGES 20, 21

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).

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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.

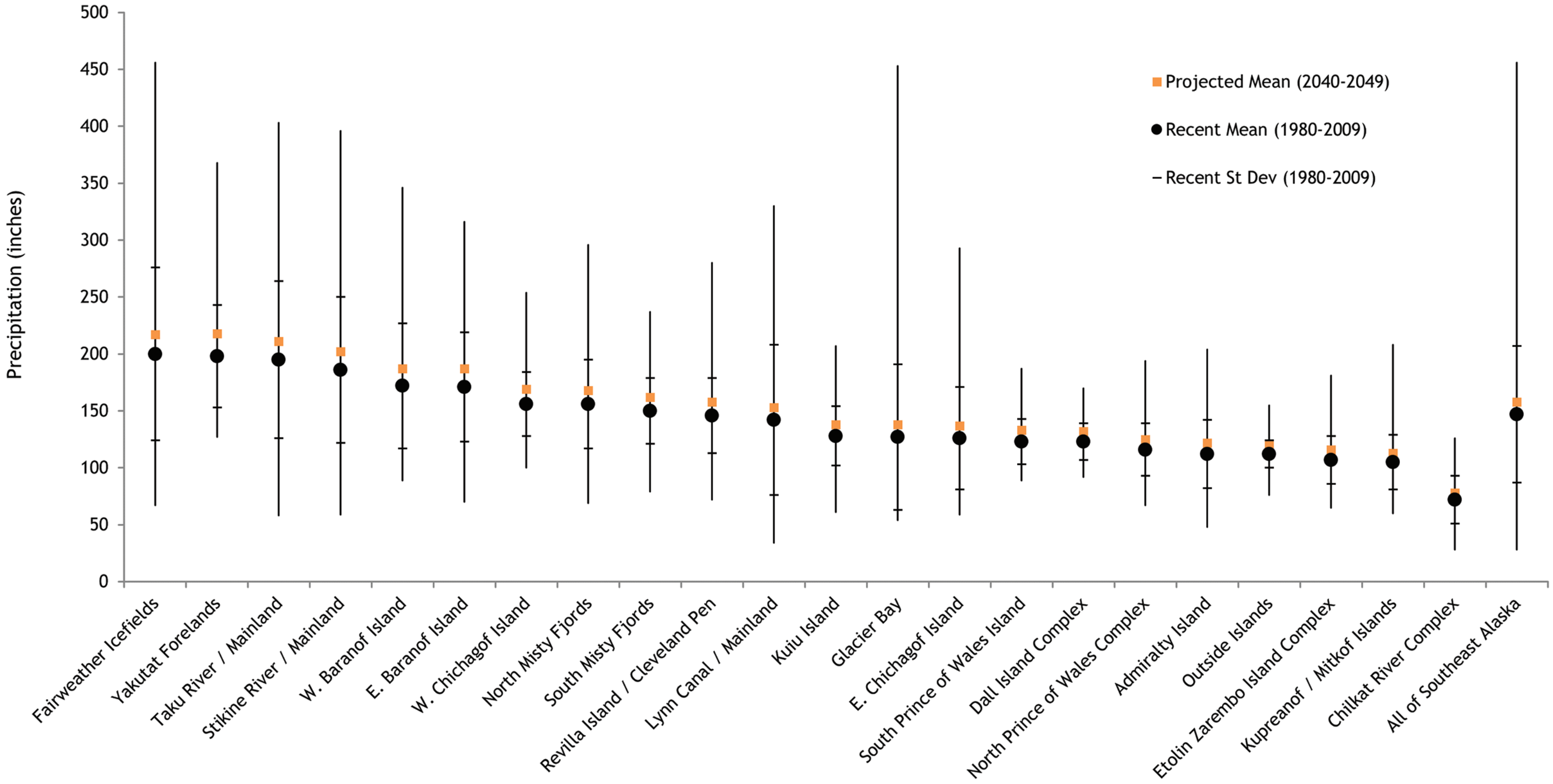
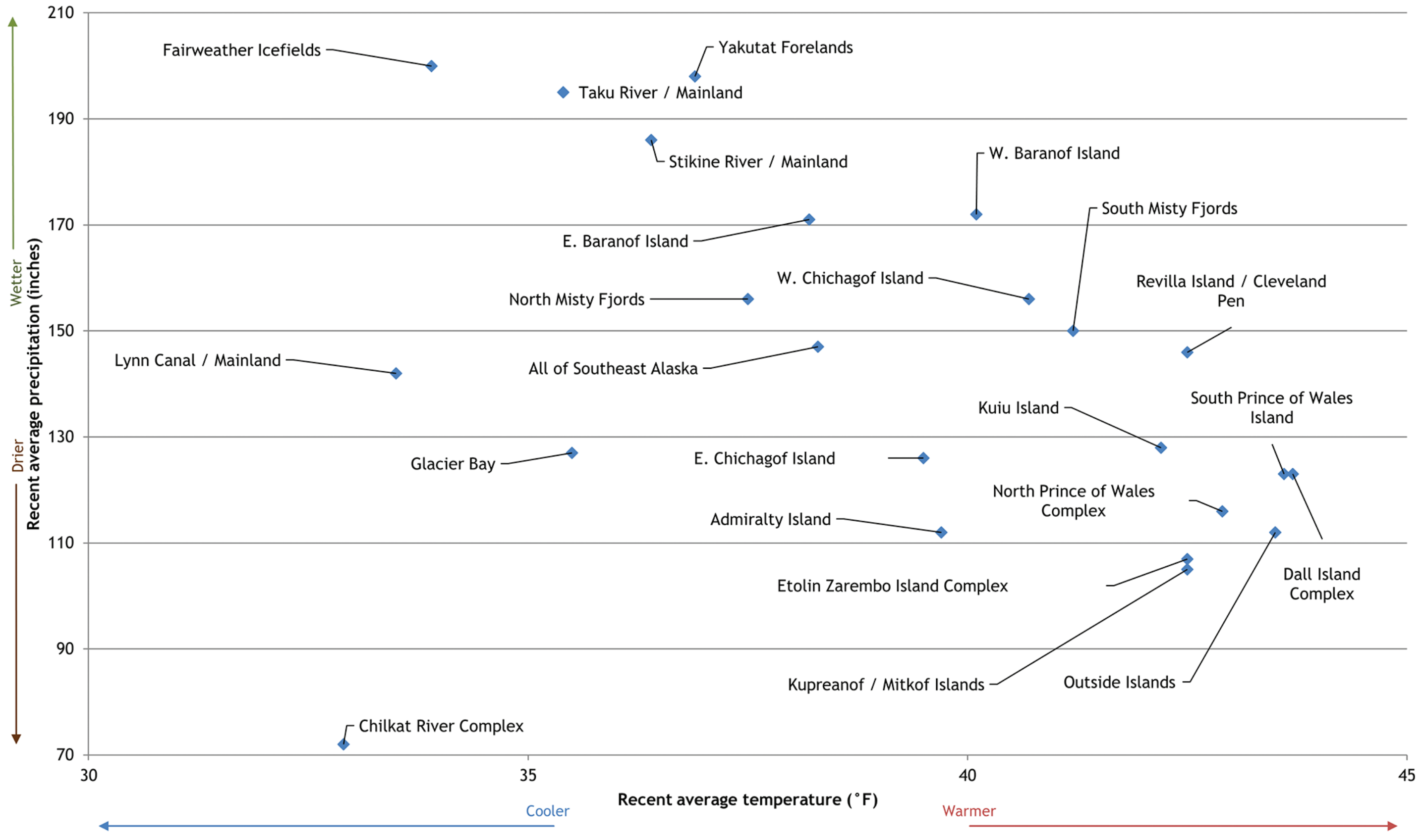
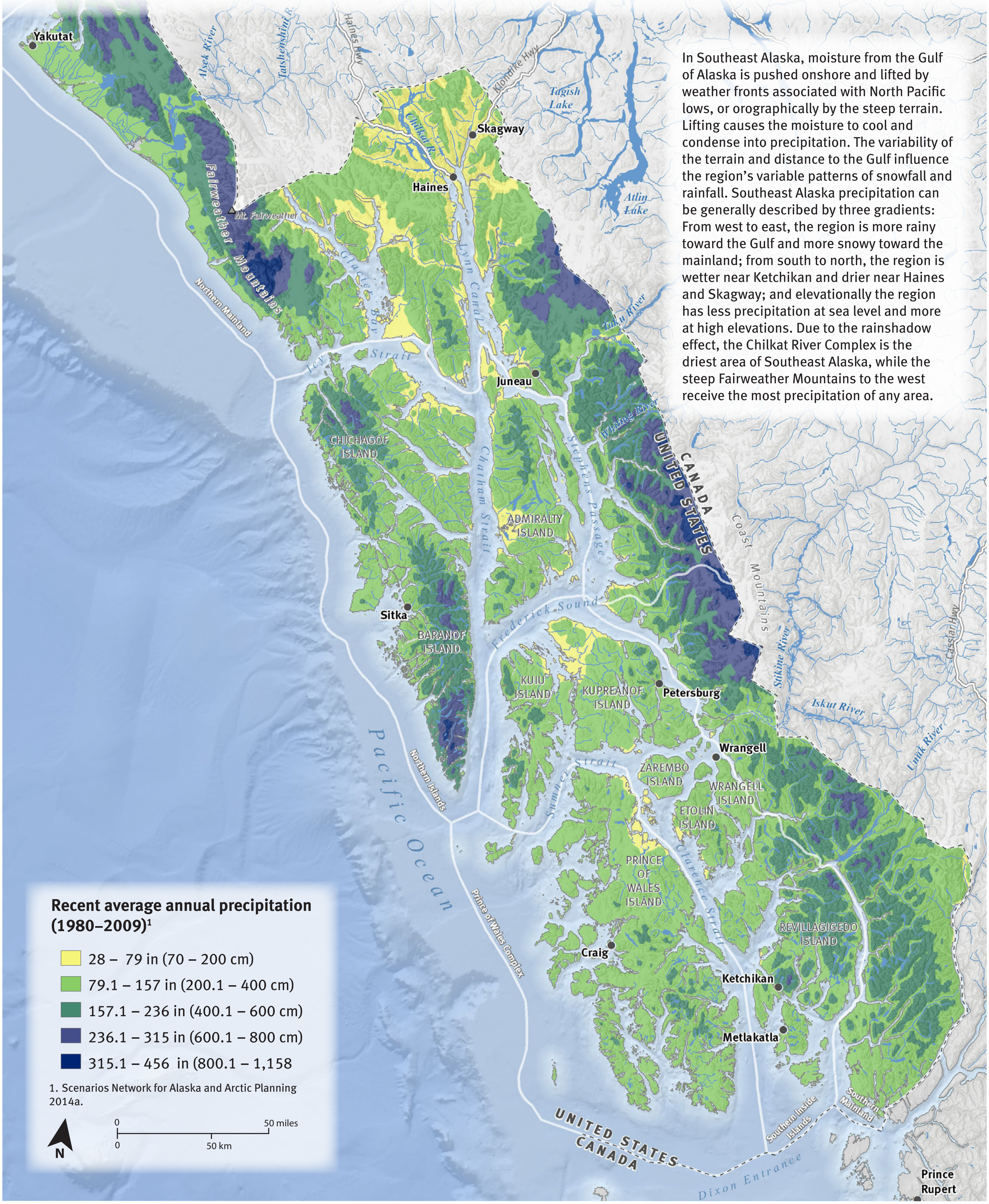


FIGURE 2-3 Linear regression comparing recent mean annual temperatures to recent mean annual precipitation, by biogeographic province.



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.

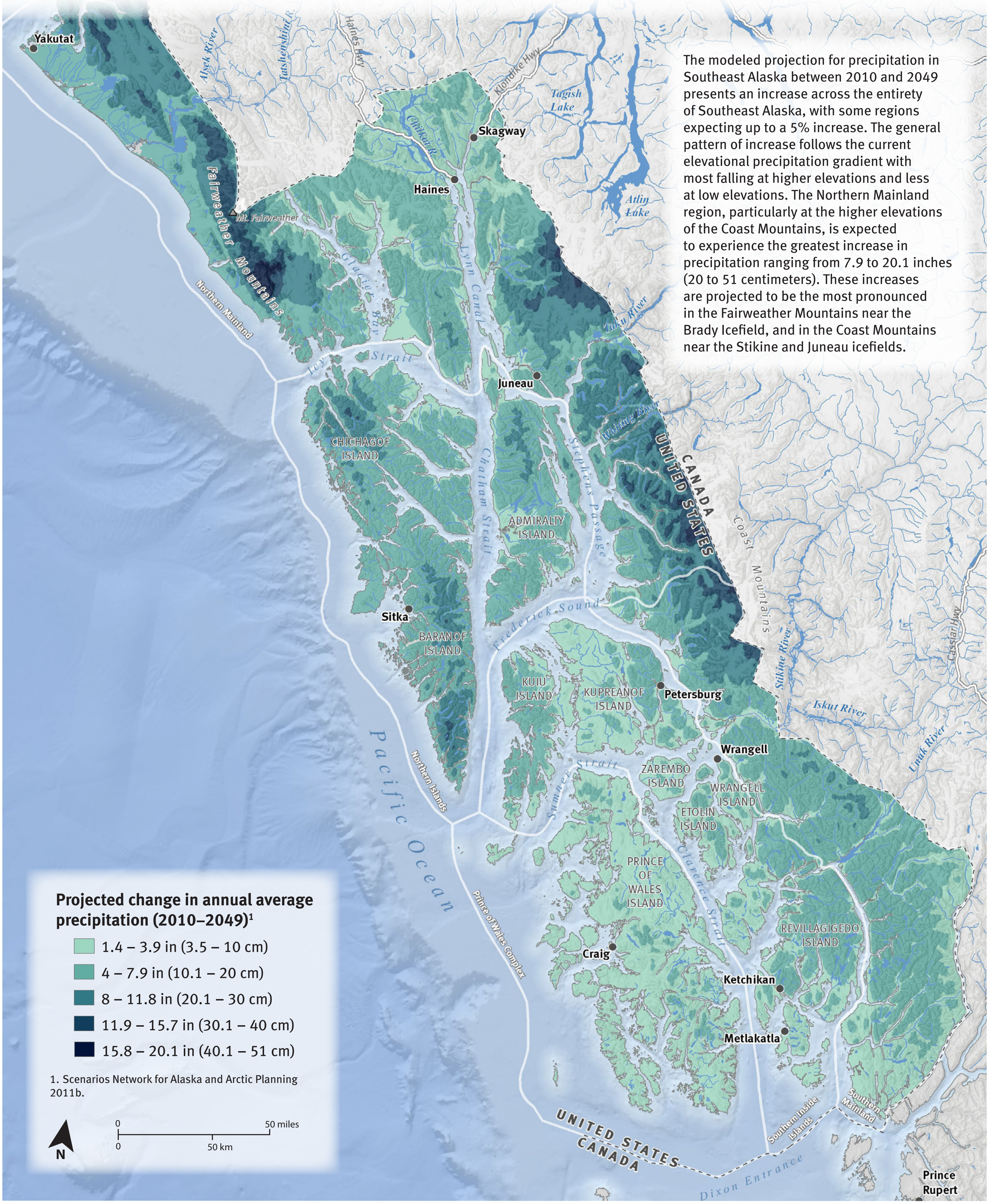
[1] Scenarios Network for Alaska and Arctic Planning 2014a.

Map 2.6: Precipitation: Recent, 1980–2009

Audubon ALASKA

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.



1. Scenarios Network for Alaska and Arctic Planning 2011b.

Map 2.7: Precipitation: Projected Change, 2010–2049

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.

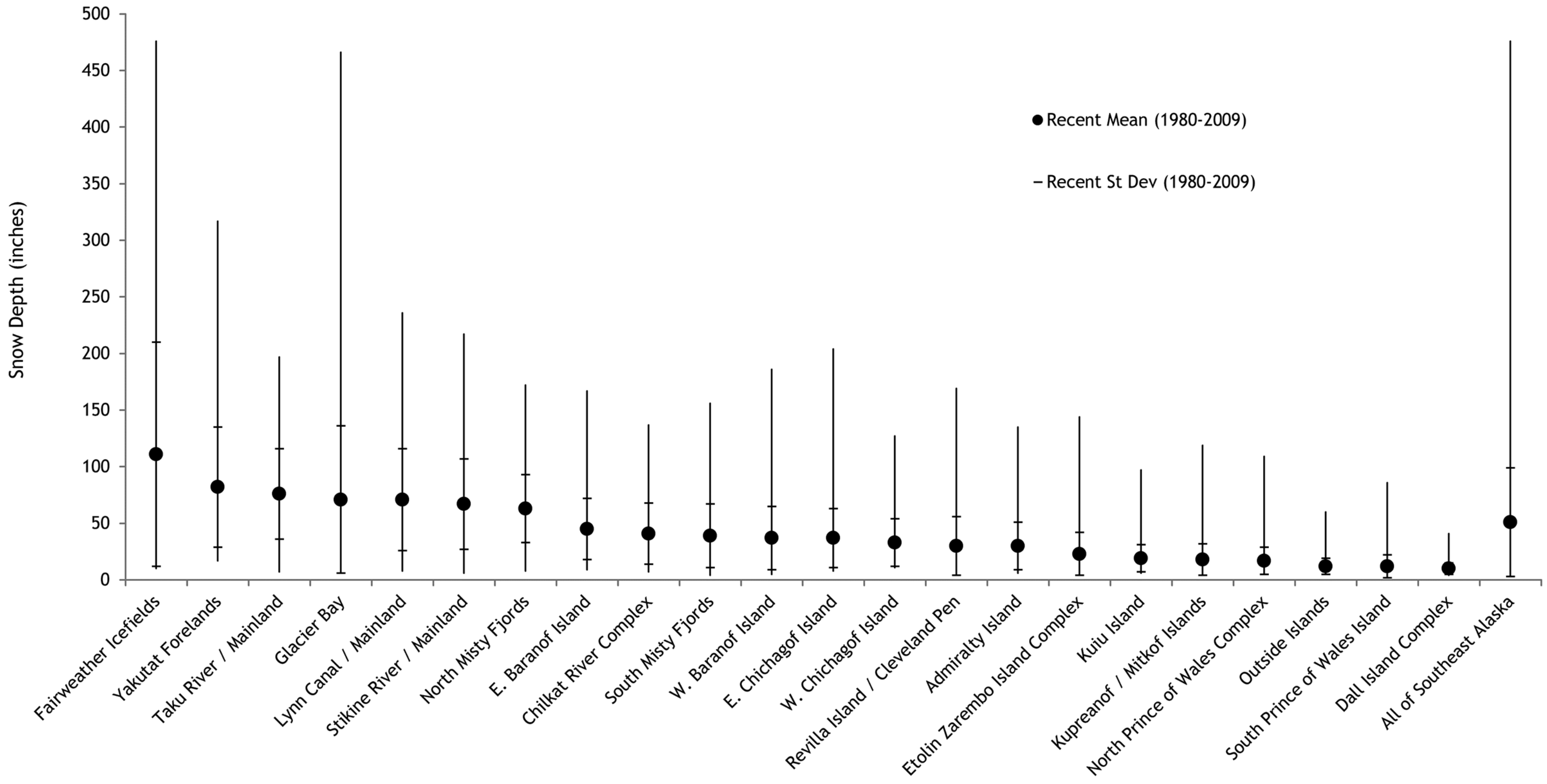


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TABLE 2-2 Projected change in monthly snow-day fraction, by elevation class, between the decades of 2010–2019 and 2040–2049 for Southeast Alaska.

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.

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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.

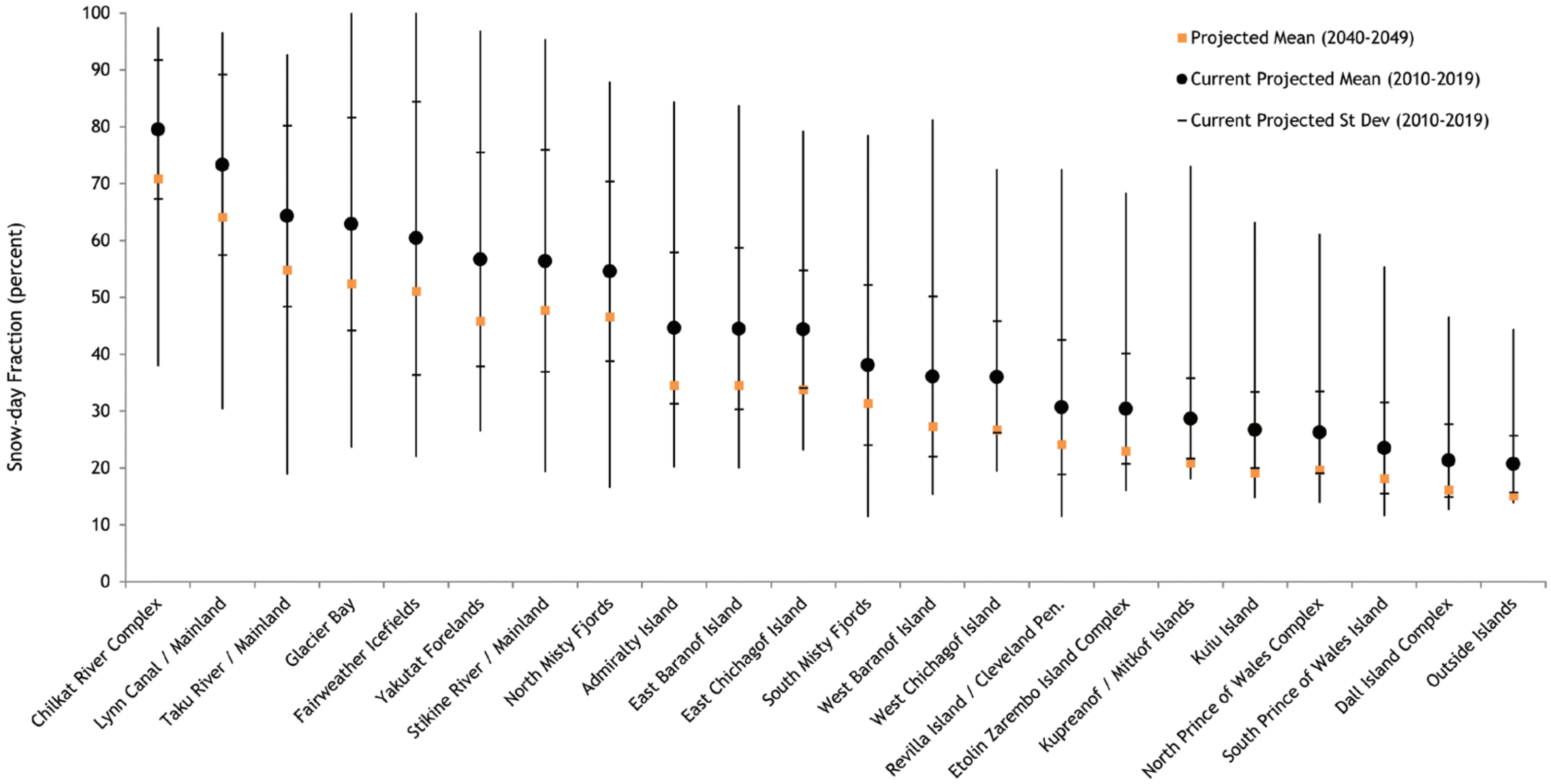
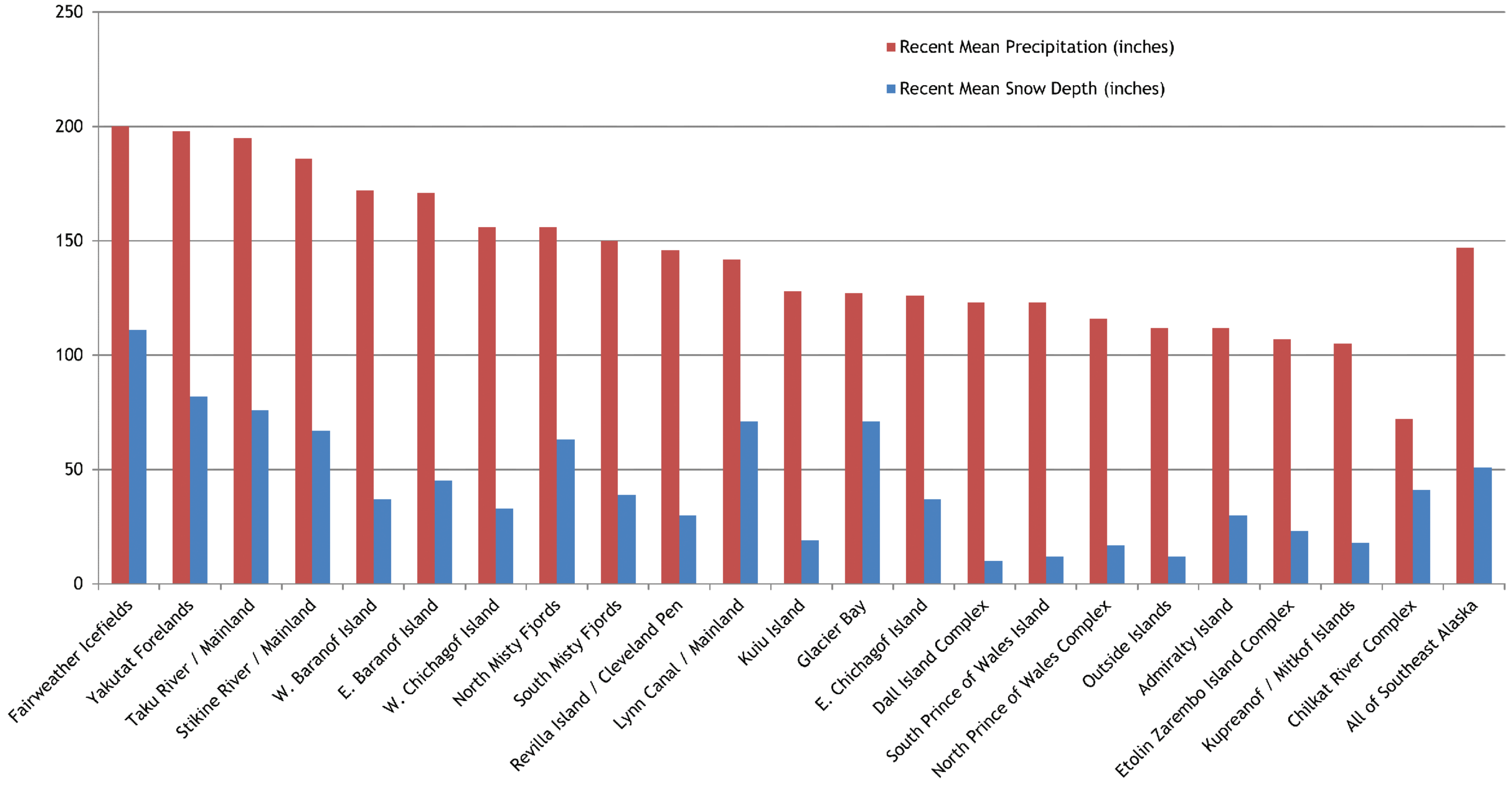
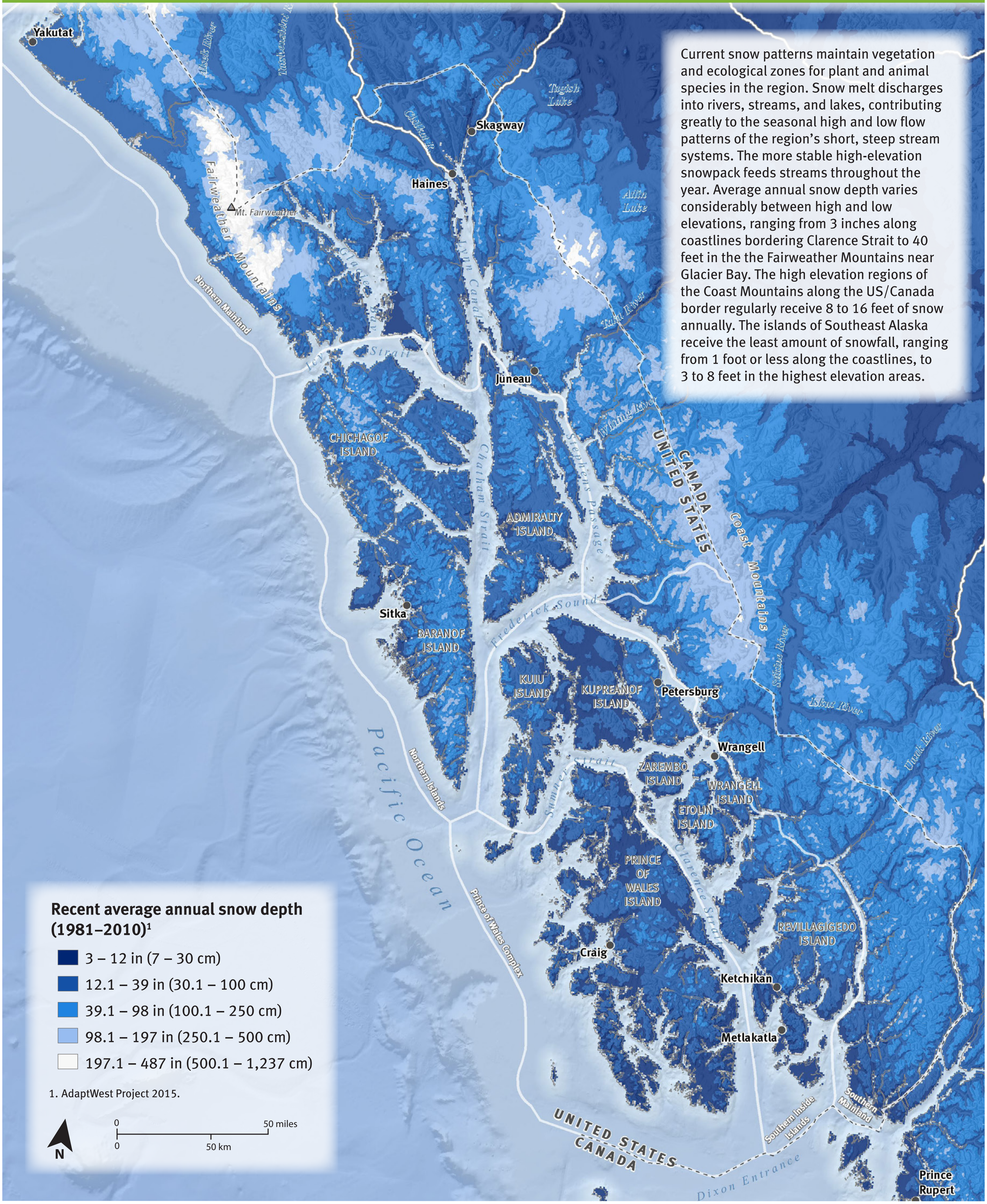


FIGURE 2-6 Mean annual precipitation and snow depth, by biogeographic province, for the recent 1980-2009 time period.



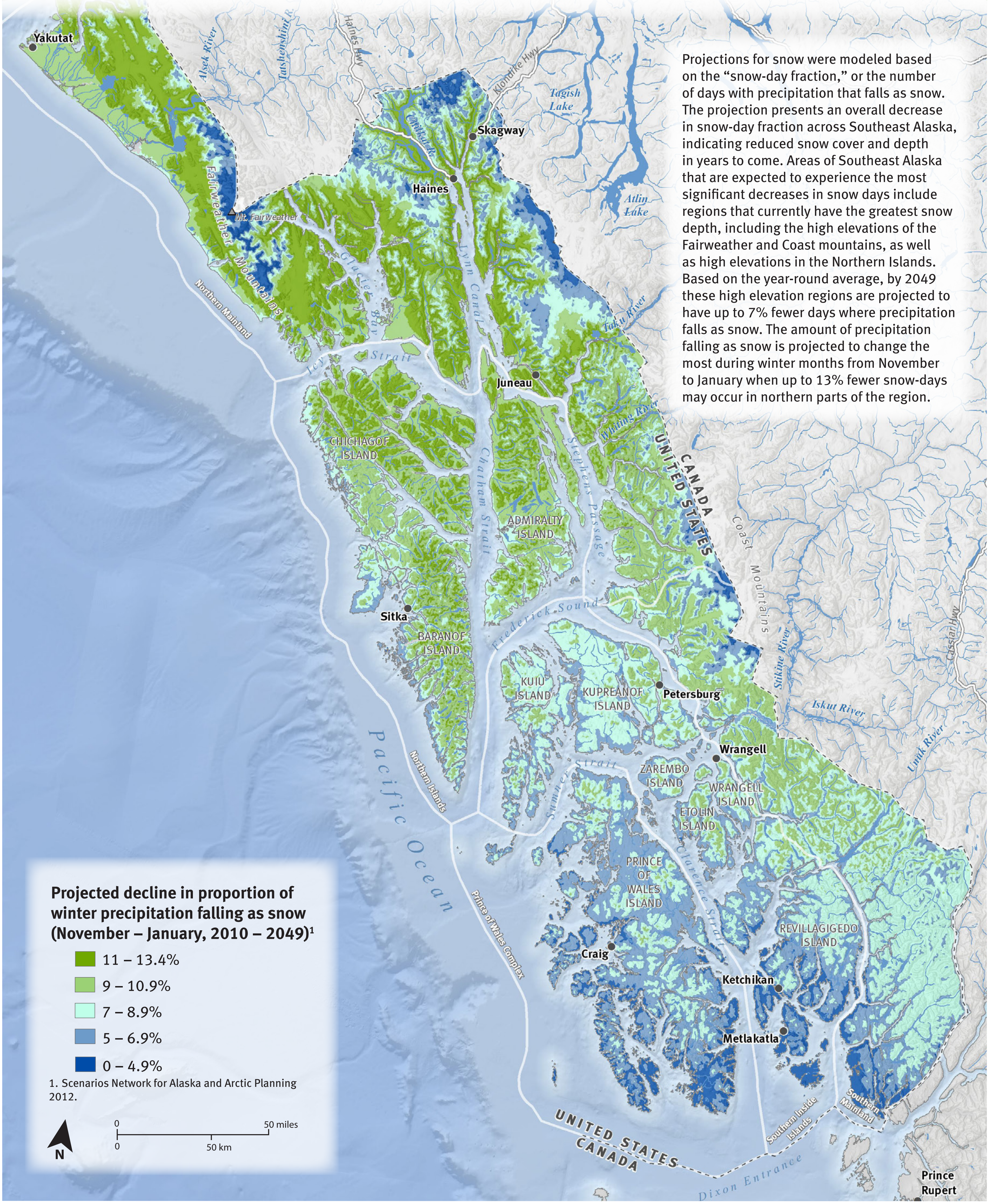
Snow Depth: Recent, 1981–2010



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



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 watersheds 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.

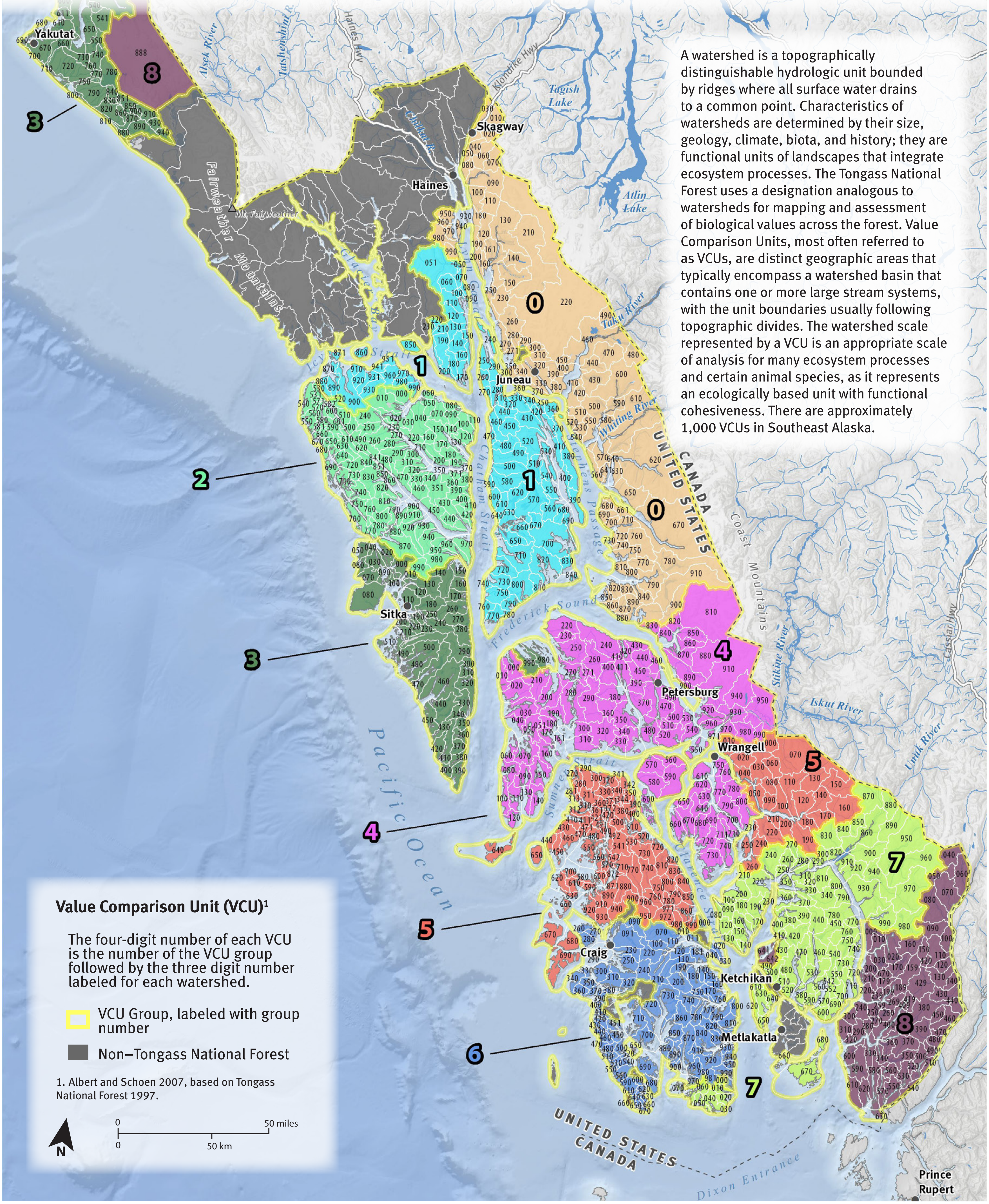
MAP DATA SOURCES

- 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.

Value Comparison Unit (VCU)[1]

The four-digit number of each VCU is the number of the VCU group followed by the three digit number labeled for each watershed.

- ☐ VCU Group, labeled with group number
- ■ Non–Tongass National Forest

[1] Albert and Schoen 2007, based on Tongass National Forest 1997.

Map 2.10: Watersheds & Value Comparison Units (VCUs)

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