National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Klondike Gold Rush National Historical Park

Natural Resource Condition Assessment

Natural Resource Report NPS/NRPC/WRD/NRR—2011/288

ON THE COVER. Taiya River Valley
Photograph by: Barry Drazkowski, August 2009

Klondike Gold Rush National Historical Park

Natural Resource Condition Assessment

Natural Resource Report NPS/NRPC/WRD/NRR—2011/288

Barry Drazkowski

Andrew Robertson

Greta Bernatz

GeoSpatial Services
Saint Mary's University of Minnesota
700 Terrace Heights, Box #7
Winona, Minnesota 55987

This report was prepared under Task Agreement J8W07080025 between the National Park Service and Saint Mary's University of Minnesota, through the Pacific Northwest Cooperative Ecosystem Studies Unit.

January 2011

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Printed copies of this report were produced in a limited quantity, and they are only available as long as the supply lasts. This report is also available from the Natural Resource Publications Management Web site (http://www.nature.nps.gov/publications/NRPM).

Please cite this publication as:

Bernatz, G. C., A. G. Robertson, and B. W. Drazkowski. 2010. Klondike Gold Rush National Historical Park: Natural resource condition assessment. Natural Resource Report NPS/NRPC/WRD/NRR—2010/288. National Park Service, Fort Collins, Colorado.

NPS 461/106400, January 2011

Contents

Contents (continued)

Page

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Tables

Page

Tables (continued)

Page

Plates

Photos

Page

Acronyms and Abbreviations

ADEC – Alaska Department of Environmental Conservation

ADF&G – Alaska Department of Fish and Game

EPA – Environmental Protection Agency

EPMT – Exotic Plant Management Team

GIS – Geographic Information Systems

GLBA – Glacier Bay National Park and Preserve

GMU – Game Management Unit

I&M – Inventory and Monitoring

KLGO – Klondike Gold Rush National Historical Park

NPS – National Park Service

NRCA – Natural Resource Condition Assessment

RSS – Resource Stewardship Strategy

SEAN – Southeast Alaska Network

SITK – Sitka National Historical Park

SMUMN GSS – Saint Mary's University of Minnesota Geospatial Services

USFS – United States Forest Service

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Acknowledgments

Thank you to Jeff Albright, program lead of the Natural Resource Condition Assessment Program, Water Resources Program Center, National Park Service, who provided programmatic insight and guidance on project development, ecological frameworks, and project implementation. The authors are grateful to the staff in the National Park Service Alaska Regional Office for their coordination, collaboration, advocacy, technical expertise, and willingness to grow and adapt through a new and largely unfamiliar process. Specifically, thank you to Sara Wesser for her support, advocacy, and attention to process. Thank you to the staff of the Southeast Alaska Network whose work greatly contributed to the scientific expertise and local ecological knowledge available for this report. Finally, thank you to the Klondike Gold Rush National Park staff, specifically Dave Schirokauer and Theresa Thibault, without whose input this project and report would not have the substance it does. To all those who reviewed and commented on this report, thank you. Your contributions increase its professional value.

Executive Summary

The discovery of gold in the Canadian Yukon in the late 1800s drew tens of thousands of stampeders to the Skagway area en route to the goldfields. Gold seekers traveled from Skagway and Dyea up the valleys and through the Chilkoot and White Passes to access the interior. The gold rush significantly impacted the demographics, culture, and environment of the region (KLGO 2009). At the time, people across North America were captured by the excitement of the event and the harsh conditions stampeders faced.

To commemorate this event, Congress created Klondike Gold Rush National Historical Park (KLGO) on June 30, 1976 (Public Law 94-323). The purpose of the park is “to preserve in public ownership for the benefit and inspiration of the people of the United States, historic structures and trails associated with the Klondike Gold Rush of 1898” (KLGO 2009). Prior to the Park designation, Congress established the Skagway Historic district and the White Pass National Historic Landmark on June 13 of 1962. Subsequent to the Park designation, Congress established The Chilkoot Trail and Dyea National Historic Landmark which contain the park’s Dyea and Chilkoot Trail units.

As a unit in the National Park System, KLGO is also responsible for the management and conservation of its natural resources. This mandate is supported by the National Park Service Organic Act of 1916, which directs the Park Service to:

> “conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations”.

As a result of this and other laws and policies, management of this park is focused on the preservation of cultural and historical resources as well as the natural setting within which they occur.

In 2003, the National Park Service (NPS) Water Resources Division received funding through the Natural Resource Challenge program to systematically assess watershed resource conditions in NPS units, establishing the Watershed Condition Assessment Program. This program, now titled the Natural Resource Condition Assessment (NRCA) Program, aims to provide documentation about the current conditions of important park resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. Findings from the NRCA, including the report and accompanying map products, will help KLGO managers to:

- develop near-term management priorities,
- engage in watershed or landscape scale partnership and education efforts,
- conduct park planning (e.g., Resource Stewardship Strategy),
- report program performance (e.g., Department of Interior’s Strategic Plan “land health” goals, Government Performance and Results Act).

Specific project expectations and outcomes for the KLGO NRCA are listed in chapter three.

For the purpose of this NRCA, key park resources were identified by NPS staff and are represented as indicators in the project framework. While this list of indicators is not all inclusive, it includes natural resources and processes that are currently of the greatest concern to park management in KLGO. The final project framework contains 20 indicators. This framework outlines the resources (indicators), measures, and the reference condition when available.

This study involved reviewing existing literature and data for each of the indicators in the framework, and, where appropriate, analyzing the data in order to provide summaries or to create new spatial or statistical representations. After gathering data regarding current condition of indicator measures, a qualitative statement was created comparing the current conditions to a reference condition when possible. The discussions in chapter four represent a comprehensive summary of available existing information regarding the current condition of these resources. They represent not only the most current published literature, but also unpublished park information and, most importantly, the perspectives of park experts.

Assessing the condition of KLGO natural resources at a park-wide or landscape level is problematic. First, to assert that KLGO is a single landscape is a significant oversimplification. Second, defining a sole condition for the whole park implies it is possible to understand the complex interrelationships between all of the components comprising this diverse park. Indeed, the park’s diverse landscape is what allows so many species to thrive and survive. Inventories of plants, breeding birds, coastal birds, and lichens reveal a rich variety of species supported by the KLGO landscape and climate, and the condition of these resources is generally considered good. Situated at the head of the Lynn Canal, the area is thought to be the greatest center of plant diversity in the state (Pojar and MacKinnon 2004). Lichen species never before documented have been discovered in the park in recent years.

The diverse landscape and the park’s location also contribute to many of the threats these natural resources face. Some habitats are restricted to small areas as the elevation and ecological gradient changes rapidly proceeding up the Taiya and Skagway valleys. The western toad, for example, relies on wetlands in the Dyea area for breeding habitat and concern exists regarding apparent declines in breeding site occupancy and success. Breeding at only a few ponds each year, the entire population can be significantly impacted by a single outburst flood from a proglacial lake, a change in the hydrological regime, or a disease outbreak such as chytrid fungus. The many available ecological niches also provide an opportunity for exotic species to establish and spread into native vegetation. While closely monitored, and managed when possible, exotic and invasive species are of concern in all park units.

The park’s proximity to Skagway enables hundreds of thousands of people to visit each year. KLGO received more visitors in 2009 than any other national park in Alaska. The majority of these visitors arrive on cruise ships, which present an air and water quality hazard. Cruise ships operate diesel and residual fuel oil (bunker fuel) generators while in port, releasing visible exhaust. Additional transportation, facilities, and services necessary to support the large summer population emit compounds such as NO_x and SO_2 into the air. Haze is not uncommon in the KLGO area, and air and water quality measurements near Skagway have detected higher levels of some contaminants compared to undisturbed sites in other parts of the region. Visitors may also unknowingly introduce exotic species to the park, and high visitation increases the number of bear-human encounters that may lead to bears becoming conditioned to anthropogenic foods.

Anthropogenic influence in the White Pass Unit is different because the unit is traversed by a railway that runs several trains per day during the five month long summer season. However, this unit is more difficult to access by foot than the Skagway or Chilkoot Trail Units due to the lack of trails and the steep, often brushy terrain. The challenges faced by visitors wanting to access the the White Pass Unit are also faced by researchers. This is reflected in the limited quantity of data and reports pertaining to this region of the park. The lack of recent data regarding water quality, air quality, hydrology, and wetlands in is a significant data gap and limits the conclusions that can be made regarding the condition of the entire park.

Climate is an additional factor which contributes to the diversity of the park and also presents a potential stressor to many ecosystem components. The drier climate in KLGO, when compared to much of southeast Alaska, allows some species to survive in the park that are not found elsewhere in the region. Changes in climate, however, can alter habitats that already have a limited distribution. Ice cover in the park's watershed has declined over the last fifty years, and climate models predict continued warming in the coming decades (Feierabend and Schirokauer 2008, Scenarios Network for Alaska Planning 2009). This has important implications for several resources. Glacial melt influences the quantity and timing of stream discharge and also impacts water quality, which in turn affects the abundance, distribution and hydrology of wetlands. Plant and animal species dependent upon these resources, including western toads and fish, face possible habitat disruption. Receding glaciers have also left proglacial lakes in their wake, threatening natural and cultural resources with the potential for outburst flood events. Warming temperatures may also alter the composition of plant communities and allow for exotic species to invade from warmer regions.

It is important to note that the project framework does not include all possible indicators and measures for each ecosystem component, only those deemed to be of highest importance. The condition and trend of the selected indicators may not fully represent the condition and trends of the larger ecosystem components of which they are a part or of the entire park. It is also important to consider that condition assessments were made with varying amounts of available data and with varying degrees of confidence. The individual indicator assessments in chapter four provide detail regarding the available data and how condition was determined for each indicator.

Literature Cited

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

Klondike Gold Rush National Historical Park. 2009. Klondike Gold Rush National Historical Park - Foundation statement. Klondike Gold Rush National Historical Park, Alaska/Washington.

Pojar, J., and A. MacKinnon. 2004. Plants of the Pacific Northwest coast: Washington, Oregon, British Columbia & Alaska. Rev. ed. Lone Pine Publishing, Canada.

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/downloads/climate-change-summary-reports). Accessed 7 July 2010.

Chapter 1 NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter “parks”. For these condition analyses they also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The resources and indicators emphasized in the project work depend on a park’s resource setting, status of resource stewardship planning and science in identifying high-priority indicators for that park, and availability of data and expertise to assess current conditions for the things identified on a list of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, not replace, traditional issue and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope[1]
- employ hierarchical indicator frameworks[2]
- identify or develop logical reference conditions/values to compare current condition data against[3,4]
- emphasize spatial evaluation of conditions and GIS (map) products[5]
- summarize key findings by park areas[6]
- follow national NRCA guidelines and standards for study design and reporting products

NRCAs Strive to Provide…

Credible condition reporting for a subset of important park natural resources and indicators

Useful condition summaries by broader resource categories or topics, and by park areas

[1] However, the breadth of natural resources and number/type of indicators evaluated will vary by park

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent “roll up” and reporting of data for measures ⇨ conditions for indicators ⇨ condition reporting by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions

[4] Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management “triggers”)

[5] As possible and appropriate, NRCAs describe condition gradients or differences across the park for important natural resources and study indicators through a set of GIS coverages and map products

[6] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on a area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested

Although current condition reporting relative to logical forms of reference conditions and values is the primary objective, NRCAs also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences are also addressed. This can include past activities or conditions that provide a helpful context for understanding current park resource conditions. It also includes present-day condition influences (threats and stressors) that are best interpreted at park, watershed, or landscape scales, though NRCAs do not judge or report on condition status per se for land areas and natural resources beyond the park's boundaries. Intensive cause and effect analyses of threats and stressors or development of detailed treatment options is outside the project scope.

Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: 1) to assist selection of study indicators; 2) to recommend study data sets, methods, and reference conditions and values to use; and 3) to help provide a multi-disciplinary review of draft study findings and products.

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and Monitoring Program. For example, NRCAs can provide current condition estimates and help establish reference conditions or baseline values for some of a park's "vital signs" monitoring indicators. They can also bring in relevant non-NPS data to help evaluate current conditions for those same vital signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

> ***Important NRCA Success Factors …***
>
> *Obtaining good input from park and other NPS subjective matter experts at critical points in the project timeline*
>
> *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ➪ indicators ➪ broader resource topics and park areas)*
>
> *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts.

NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[7] and help parks report to government accountability measures[8].

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in our present data and knowledge bases across these varied study components.

NRCAs can yield new insights about current park resource conditions but in many cases their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Over the next several years, the NPS plans to fund a NRCA project for each of the ~270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA Program information is posted at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm.

NRCA Reporting Products…

Provide a credible snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations
(near-term operational planning and management)

Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values
(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public
("resource condition status" reporting)

---

[7] NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy(RSS) but study scope can be tailored to also work well as a post-RSS project

[8] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget

Chapter 2 Introduction and Resource Setting

2.1 Introduction

2.1.1 Enabling Legislation

The discovery of gold in the Canadian Yukon in the late 1800s drew tens of thousands of stampeders to the Skagway area en route to the goldfields. Gold seekers left Skagway and Dyea carrying a one year supply of goods and materials weighing over one ton. They travelled up the valleys and through the Chilkoot and White Passes to access the interior gold fields. The gold rush significantly impacted the demographics, culture, and environment of the region (KLGO 2009). At the time, people across North America were captured by the excitement of the event and the harsh conditions stampeders faced.

Photo 1. Gold seekers climbing the Golden Stairs on the Chilkoot Trail in 1898 (KLGO archives).

To commemorate this event, Congress created Klondike Gold Rush National Historical Park on 30 June 1976 through the authorization of the United States Congress (Public Law 94-323). The

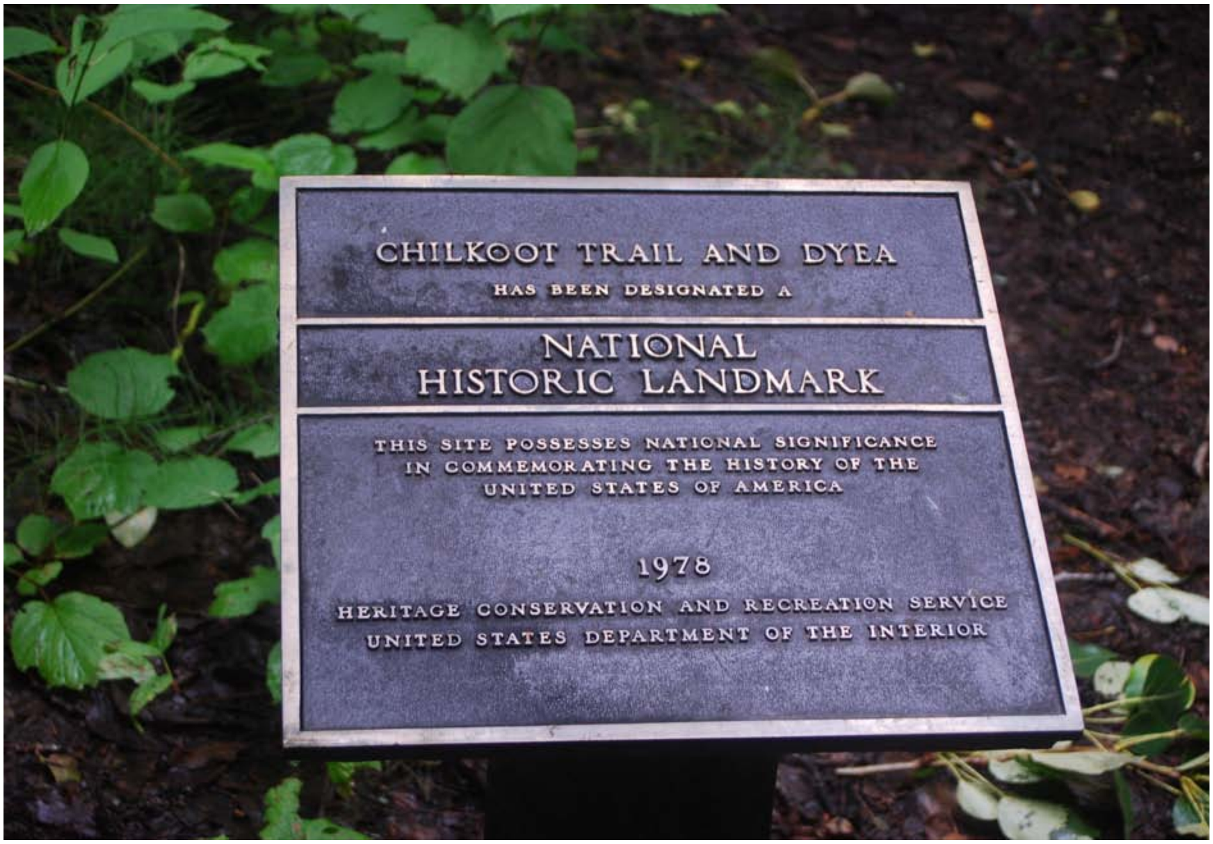


Photo 2. Plaque commemorating the designation of Chilkoot Trail and Dyea as a national historic landmark.

purpose of the park is “to preserve in public ownership for the benefit and inspiration of the people of the United States, historic structures and trails associated with the Klondike Gold Rush of 1898” (KLGO 2009). Prior to the Park designation, Congress established the Skagway Historic district and the White Pass National Historic Landmark on June 13 of 1962. Subsequent to the Park designation, Congress established The Chilkoot Trail and Dyea National Historic Landmark, which contains the park’s Dyea and Chilkoot Trail units.

Photo 3. Historic structure at Dyea.

The park is comprised of four units. One unit is located in Seattle, Washington to recognize the importance of the city as a gateway and supply source for gold seekers on their way to Alaska. This unit is managed by the Pacific West National Park Service Region and is not addressed in this assessment. The remaining three units of Klondike Gold Rush National Historical Park (KLGO) are in Alaska: the Skagway Unit, the Chilkoot Trail Unit, and the White Pass Unit. The National Park Service Alaska Region manages these units. Each unit contains different pieces of history, including buildings, trails, and artifacts left behind by the massive influx of people that came to find fame and fortune (KLGO 2000).The cultural resources that this park has been established to preserve represent the material evidence of past human activities and they are finite and non-renewable.

As a unit in the National Park System, KLGO is also responsible for the management and conservation of its natural resources. This mandate is supported by the National Park Service Organic Act of 1916, which directs the Park Service to:

> “conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations”.

As a result of this and other laws and policies, management of this park is focused on the preservation of cultural and historical resources as well as the natural setting within which they occur.

The authorizing language described above is used in the Natural Resource Condition Assessment as the fundamental direction for setting natural resource reference conditions and defining specific areas of natural resource management interest. The NRCA, however, does not address the condition of historic and cultural features associated with the Klondike Gold Rush.

On the centennial of the 1898 Gold Rush, KLGO and Chilkoot Trail National Historic Site in Canada were named an international park, forming the Klondike Gold Rush International Historical Park (U.S. President 1998). This designation was made to provide enjoyment to the public, honor the history of the Klondike Gold Rush, and preserve the natural and cultural resources within the park (KLGO 2000).

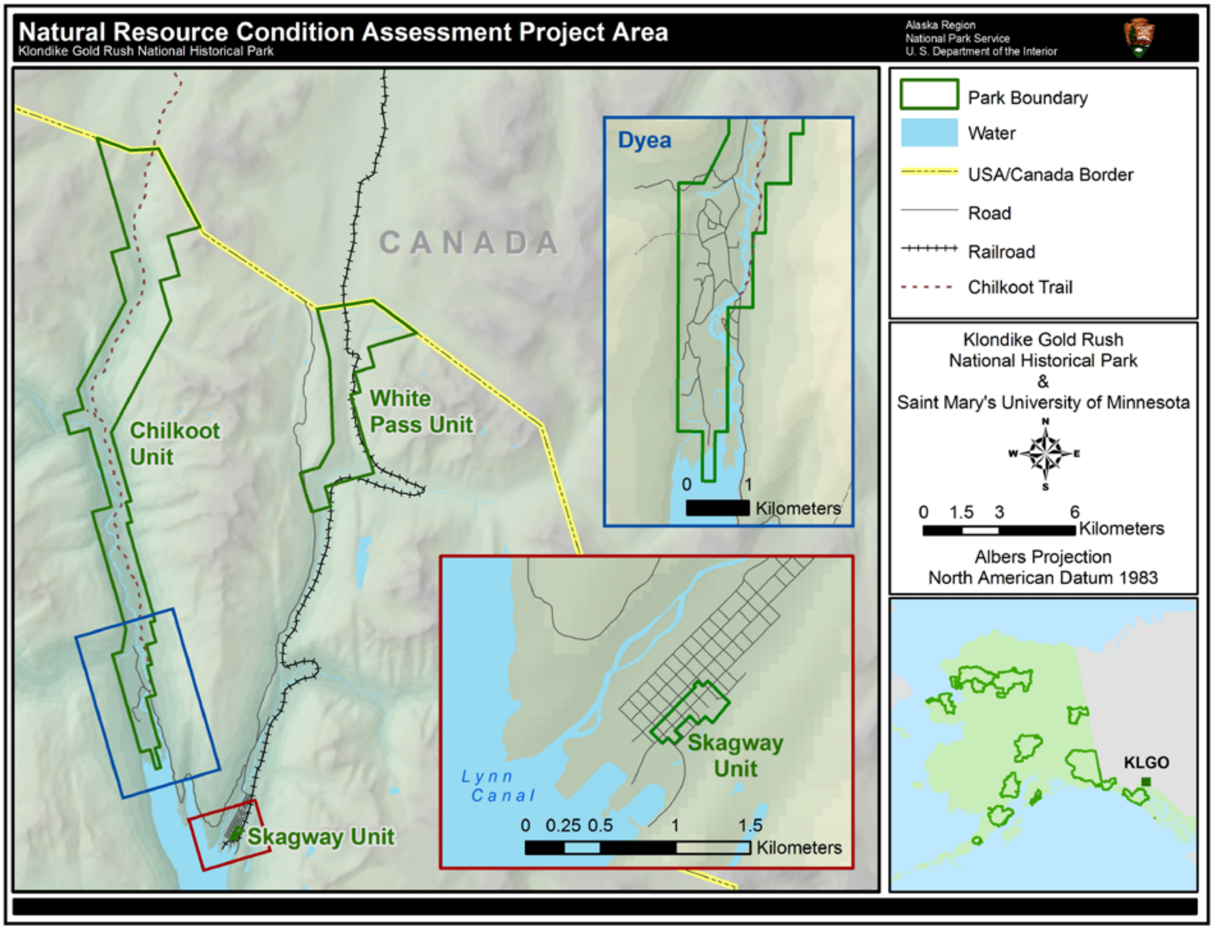


Figure 1. NRCA project area (NPS 2009).

2.1.2 Geographic Setting

Klondike Gold Rush National Historical Park is located in southeast Alaska at the northern terminus of Lynn Canal. The park consists of three units totaling approximately 13,000 acres (Figure 1). The Skagway unit covers about 12 square city blocks in the city of Skagway, Alaska. The Chilkoot Trail Unit covers about 9,700 acres, including the Chilkoot Trail corridor and the Dyea historic town site. This unit extends from the northern end of Lynn Canal to the Canadian border. The White Pass unit, about 3,300 acres, includes sections of trails, roads, and railroad right-of-way dating from the time of the gold rush (KLGO 2000). It borders Canada to the north and extends south through a portion of the Skagway River valley.

KLGO's geographic location results in precipitation patterns unique to the area. Other areas south of KLGO receive significantly more rainfall, but KLGO lies in the rain shadow of the Chilkat Mountains to the west and southwest of the park. The drier climate in KLGO provides a unique environment for plants and animals. There are still areas considered temperate rainforest, but they experience more moderate climate conditions than most of the southeast Alaska coastal rainforest. In fact, it can get dry enough in the Taiya and Skagway watersheds for forest fires to occur, an ecological disturbance that is extremely unusual throughout the rest of southeast Alaska.

The landscape of the park is attributed to glaciation, specifically the Cordilleran ice sheet that once covered the entire park over 10,000 years ago (Paustian et al. 1994). As the ice sheet retreated, U-shaped valleys, alpine glaciers, and scoured alpine summits remained (Paustian et al. 1994). Some important landforms include the Taiya and Skagway valleys, Lynn Canal, and Taiya River (KLGO 2000).

Photo 4. Visitors to Skagway.

2.1.3 Visitation Statistics

Over 13 million people have visited KLGO since 1982 (NPS 2010). In recent years, more than 800,000 people have visited annually. Over 90% of visitors come to the park during the summer months (May through September), with the vast majority of visitors arriving on cruise ships. Other visitors arrive by air, boat, or via the Klondike Highway and White Pass Railroad. In 2009, overnight visitors in the park numbered 5,006. Approximately 25% of the overnight visitors were roadside campground campers and 75% were backcountry campers (NPS 2010). The Skagway Unit receives the most visitors, as it is in an urban location with many tourism amenities. The White Pass Unit receives the fewest visitors, largely due to the difficulty accessing the unit.

2.2 Natural Resources

2.2.1 Ecological Units and Watersheds

In addition to being a place of historic significance, Klondike Gold Rush Historical Park is ecologically significant. Within its boundaries, subarctic, alpine, coastal, intertidal, and boreal ecosystems converge, providing diverse habitats for flora and fauna. KLGO stretches from sea level to the summits of White and Chilkoot passes. The Taiya and Skagway valleys provide the most northerly, interior-most ice free corridor for ecological exchange between the coastal rainforest ecosystem and the interior continental ecosystem. Since these pathways occur at the end of Lynn Canal, an extensive saltwater fjord that ultimately opens to the Pacific Ocean, the KLGO area has been an important avenue for plant and animal migration in the past, and continues to be the site of species interchange today.

Klondike Gold Rush National Historical Park includes segments of two main rivers: the Skagway River and the Taiya River. The Skagway River watershed is approximately 375 km^2 in size, with the river flowing through the southern portion of the White Pass Unit and continuing down the valley past the community of Skagway (Paustian et al. 1994). The Skagway River flow regime is largely driven by runoff from glaciers and snowfields. The Taiya River drainage is approximately 16 miles long and includes the entire Chilkoot Trail Unit of the park (Hood et al. 2006). With its headwaters in the snow and glaciers of the mountains, the streamflow of the Taiya is also heavily influenced by seasonal runoff. Four subwatersheds comprise the Taiya River watershed, the largest being the Nourse River subwatershed (approximately 205 km^2) (Capps 2004). The remaining three are West Creek (~115 km^2), Lower Taiya (~111km^2), and Upper Taiya (~59km^2) (Capps 2004). The watershed spans from sea level to a maximum elevation of over 2,500 meters, including the highest mountains and largest glaciers in the western portion of the Nourse subwatershed (Capps 2004). The Taiya River enters the Taiya Inlet at Dyea. This area is largely composed of estuarine intertidal and riverine wetlands (Hood et al. 2006).

2.2.2 Resource Descriptions

KLGO's location at a focal point for ecological exchange between the interior and the coast, as well as environmental conditions unique in the southeast Alaska rainforest system, has created a unique area of local biodiversity. The climatic gradient and diverse ecosystems result in high vascular and non-vascular plant diversity. According to the NPSpecies database and the Skagway Bird Club, KLGO is home to 880 vascular plant species, 201 bird species, 45 mammals, 11 fish, and two amphibian species (Lenz et al. 2002, Skagway Bird Club 2010). A recent lichen inventory also revealed 766 species, including some species never before documented (Spribille et al. 2010).

Large mammals such as the mountain goat (*Oreamnos americanus)*, moose (*Alces alces*), caribou (*Rangifer tarandus*) black bear (*Ursus americanus*), and grizzly bear (*Ursus arctos*) reside in KLGO, along with smaller mammals like pika (genus *Ochotonidae*), wolverine (*Gulo gulo*), marmot (genus *Marmota*), porcupine (*Erethizon dorsatum*), marten (*Martes Americana*), arctic ground squirrel (*Urocitellus parryii*), and coyote (*Canis latrans*) (KLGO 2000, KLGO 1996). The KLGO watershed is home to three species of Pacific salmon: chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbuscha*), and coho salmon (*Oncorhynchus kisutch*) (Hood et al. 2006). The anadromous and resident Dolly Varden char (*Salvelinus malma malma*) is also found in KLGO. The two amphibian species in KLGO are the western toad (*Bufo boreas*) and the Columbian spotted frog (*Rana luteiventris*) (KLGO 2010). Among the 201 bird species found in KLGO are the bald eagle (*Haliaeetus leucocephalus*), marbled murrelet (*Brachyramphus marmoratus)*, great horned owl (*Bubo virginianus*), and several species of waterbirds, shorebirds, and passerines (Skagway Bird Club 2010). A complete list of expected bird species is included as Appendix B.

2.2.3 Resource Issues Overview

The diverse landscape and the park's location also contribute to many of the threats faced by its natural resources. Some habitats are restricted to small areas as the elevation and ecological gradient changes rapidly proceeding up the Skagway and Taiya valleys. The western toad, for example, relies on wetlands in the Dyea area for breeding habitat. Breeding at only a few ponds each year, the entire population can be significantly impacted by a single outburst flood from a proglacial lake, a change in the hydrological regime, or a disease outbreak. Some plant species also occupy a small ecological niche in the Dyea area and are threatened by isostatic rebound and encroaching forest due to natural plant succession (Paustian et al. 1994). The many available ecological niches also present an opportunity for exotic species to establish and spread into native vegetation.

The park's proximity to Skagway enables hundreds of thousands of people to visit the park each year. KLGO received more visitors in 2009 than any other national park in Alaska (NPS 2010). The majority of the visitors arrive on cruise ships, which present an air and water quality hazard. Cruise ships operate diesel and bunker fuel powered generators while in port, releasing visible exhaust. Additional transportation, facilities, and services necessary to support the large summer population emit visibility imparing compounds into the air. Visitors may also unknowingly introduce exotic species to the park, and high visitation increases the likelihood of bear-human encounters.

Climate is an additional factor which presents a potential stress to many ecosystem components. Changes in climate can alter habitats by modifying vegetation and hydrology regimes. Ice cover in the park's watershed has declined over the last fifty years, and climate models predict continued warming in the coming decades (Feierabend and Schirokauer 2008, Scenarios Network for Alaska Planning 2009). This has important implications for several resources. Glacial melt influences the quantity and timing of stream discharge and also impacts water quality, which in turn affects the abundance, hydrology, and distribution of wetlands. Plant and animal species dependent upon wetland resources, including western toads and various fish species, face possible habitat declines. Receding glaciers can leave proglacial lakes in their wake, which threaten natural and cultural resources with the potential of outburst flood events. Warming temperatures may also alter the composition of plant communities and allow for exotic species from warmer regions to establish themselves in the park.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

In addition to NPS staff recommendations, two current programs guided the selection of key natural resources for this report: the Southeast Alaska Network Inventory and Monitoring (I&M) Program, and KLGO's Resource Stewardship Strategy. During the development of each program and associated planning documents, important resources in KLGO were identified.

<u>Southeast Alaska Inventory and Monitoring Program</u>

In an effort to improve park management through expanded use of scientific knowledge, the I&M Program was established to collect, organize, and provide natural resource data as well as information derived from data through analysis, synthesis, and modeling (NPS 2009). The primary goals of the I&M Program are to

- inventory the natural resources under National Park Service stewardship to determine their nature and status;
- monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other altered environments;
- establish natural resource inventory and monitoring as a standard practice throughout the National Park System that transcends traditional program, activity, and funding boundaries;
- integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making;
- share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives. (NPS 2009)

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. KLGO is part of the Southeast Alaska Network (SEAN), which also includes Sitka National Historical Park and Glacier Bay National Park and Preserve. Through a rigorous multi-year, interdisciplinary scoping process, each network selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as ‘vital signs,’ and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources. For the SEAN, 12 core vital signs (network led and funded) and six additional secondary vital signs (park led, network supported) have been identified and monitoring plans are presently being developed and implemented (Table 1). In addition to the vital signs monitoring program, the national I&M program supports the completion and delivery of 12 baseline inventories – ranging from base cartography and landcover mapping, to species occurrence and climate.

Table 1. Vital signs of the Southeast Alaska Inventory and Monitoring Program (Moynahan and Johnson 2008). Vital signs in bold text indicate the 12 core vital signs.

			Applicable SEAN Park		
Level 1	Level 2	SEAN Vital Sign	GLBA	KLGO	SITK
Air and Climate	Air Quality	**Airborne Contaminants**	X	X	X
	Weather and Climate	**Weather and Climate**	X	X	X
Geology and Soils	Geomorphology	**Glacial Dynamics (extent)**	X	X	
	Hydrology	**Streamflow**	X	X	X
		Oceanography	X		
Water	Water Quality	Freshwater Benthic Macroinvertebrates and Algae	X	X	X
		Freshwater Contaminants	X	X	X
		Freshwater Water Quality	X	X	X
		Marine Contaminants	X	X	X
Biological Integrity	Invasive Species	Invasive/Exotic Plants	X	X	X
	Focal Species or Communities	**Intertidal Communities**	X		X
		Marine Predators	X		
		Kittlitz’s Murrelets	X		
		Western Toads	X	X	
	At-risk Biota	Humpback Whales	X		
Human Use	Visitor and Recreation Use	Human Uses and Mode of Access	X	X	X
	Soundscape	Underwater Sound	X		
Landscapes (Ecosystem Patterns & Processes)	Landscape Dynamics	**Landform and Landcover**	X	X	X

<u>Resource Stewardship Strategy</u>

Each national park is directed to develop a Resource Stewardship Strategy (RSS) as part of the park management planning process. Indicators of resource condition, both natural and cultural, are selected by the park. After each indicator is chosen, a target value is determined and the current condition is compared to the desired condition. Management plans are then developed for the next 15 to 20 years in order to achieve or maintain the desired condition for each indicator.

The development of KLGO’s RSS coincided with the NRCA project. Efforts were made to achieve consistency between indicators and measures included in each document when possible. A draft listing of RSS indicators and measures was available during the NRCA scoping process, and several of the indicators and measures for natural resources identified in this document were incorporated into the NRCA framework. Communication with the RSS development team continued during the project in an effort to maintain consistency.

2.3.2 Status of Supporting Science

Available data and reports varied significantly depending on the resource. The existing data for each indicator that were used to assess condition or inform reference condition are described in each indicator summary in chapter four. One important source of data was the Southeast Alaska I&M Network. Part of the Southeast Alaska I&M Program's mission is to collect, manage, analyze and report long-term ecological data to support each park in determining the status, condition, and trend of important natural resources (Moynahan and Johnson 2008). In addition to data from the I&M Program and reports and data supplied by park staff, the U.S. Geological Survey provided significant hydrology and breeding bird survey data. The National Park Service NPSpecies and NatureBib (now part of NRInfo) resources were also utilized.

Literature Cited

Capps, D. L. 2004. Geohazards of the Taiya watershed. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Klondike Gold Rush National Historical Park. 1996. General management plan development concept plan and environmental impact statement. U.S. Department of Interior, National Park Service, Skagway, Alaska and Seattle, Washington.

Klondike Gold Rush National Historical Park. 2000. Klondike Gold Rush National Historical Park - Resource Management Plan, 2000. Final. Klondike Gold Rush National Historical Park.

Klondike Gold Rush National Historical Park. 2009. Klondike Gold Rush National Historical Park - Foundation statement. Klondike Gold Rush National Historical Park, Alaska/Washington.

Klondike Gold Rush National Historical Park. 2010. Amphibian monitoring. National Park Service, U.S. Department of the Interior. (http://www.nps.gov/klgo/naturescience/upload/Amphibian%20Newletter%20-%20KLGO.pdf). Accessed 20 May 2010.

Lenz, J., T. Gotthardt, R. Lipkin, and M. Kelly. 2002. Compilation of existing species data In Alaska's national parks. Final Report 9910-00-013. National Park Service, Inventory & Monitoring, Alaska Natural Heritage Program, Environment and Natural Resources Institute, University of Alaska Anchorage. Online. (http://www.arlis.org/docs/vol1/174290941.pdf). Accessed 20 May 2010.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2009. Program brief: Inventory and monitoring program. U.S. Department of the Interior, National Park Service, Natural Resource Program Center, Inventory and Monitoring Division, Fort Collins, Colorado.

National Park Service. 2010. Klondike Gold Rush National Historical Park Alaska Reports. National Park Service Public Use Statistics Office. Online. (www.nature.nps.gov/stats). Accessed 22 July 2010.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/ downloads/climate-change-summary-reports). Accessed 7 July 2010.

Skagway Bird Club. 2010. Birds of Skagway, AK. Skagway Bird Club, Skagway, Alaska.

Spribille, T., S. Pérez-Ortega, T. Tønsberg, and D. Schirokauer. 2010. Lichens and lichenicolous fungi of the Klondike Gold Rush National Historic Park, Alaska, in a global biodiversity context. The Bryologist 113(3): 439-515.

U.S. President. 1998. Designating Klondike Gold Rush International Historical Park. Proclamation 7114.

Chapter 3 Study Scoping and Design

This NRCA is a collaborative project between the National Park Service (NPS) and Saint Mary's University of Minnesota Geospatial Services (SMUMN GSS). Stakeholders in this project include the KLGO park resource management team and Alaska Regional Inventory and Monitoring Program staff. Before embarking on the project, it was necessary to identify the specific roles of the National Park Service and SMUMN GSS. Preliminary scoping meetings were held, and a task agreement and a scope of work document were created cooperatively between the National Park Service and SMUMN GSS.

3.1 Preliminary Scoping

Preliminary scoping meetings were held on 25 and 26 August 2009. At this meeting, SMUMN GSS and NPS staff confirmed that the purpose of the KLGO NRCA was to evaluate and report on current conditions, critical data and knowledge gaps, and selected existing and emerging resource condition influences of concern to KLGO managers. Certain constraints were placed on this NRCA, including the following:

- Condition assessments are conducted using existing data and information.
- Identification of data needs and gaps is driven by the project framework categories.
- The analysis of natural resource conditions includes a strong geospatial component.
- Resource focus and priorities are primarily driven by KLGO park resource management.

This condition assessment provides a "snapshot-in-time" evaluation of the condition of a select set of park natural resources that were identified and agreed upon by the project team. Project findings will aid KLGO resource managers in the following objectives:

- Develop near-term management priorities.
- Engage in watershed or landscape scale partnership and education efforts.
- Conduct park planning (e.g., general management plan, compliance, Resource Stewardship Strategy).
- Report program performance (e.g., Department of Interior Strategic Plan's "land health" goals).

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available park data, reports, and spatial information from appropriate sources including: KLGO Resource Staff, scientific literature, the Park Permanent Data Set, NatureBib, NPSpecies, Inventory and Monitoring Vital Signs and available third-party sources. The NRCA report will provide the resource assessment and a summary of pertinent data evaluated in this project and subsequently stored in the appropriate sites.

- Define an appropriate description of reference condition for each of the key natural resource components and indicators so that statements of current condition can be developed for the NRCA report. The statements will describe the current state of a particular resource with respect to an agreed upon reference point.

- Develop a reporting format that reflects the spatial delineation of park specific human and ecological focus areas. This format will facilitate the extraction of a specific reporting area's resource information and analysis for use in support of other reports or projects. This format may result in some redundancies between resources that span reporting zones but will allow sections of the report to be updated independently.
- Resource assessment should clearly identify "management critical" data. This will drive the data mining and gap definition process.
- Where applicable, develop GIS products that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually.
- Conduct analysis of specific existing data sets for river hydrology, waterbird surveys and on/off road breeding bird surveys in order to develop descriptive statistics about key natural resource indicators. Data collection and analysis for these indicators can be carried forward to subsequent condition assessment projects.
- Discuss the issue of key natural resource indicators that are not contained within the park or controlled directly by park management activities (e.g., proglacial lakes, glacial recession). There are important stressors that impact key natural resource components in the park but are not under NPS jurisdiction.
- Describe the relationship between selected human uses and key natural resources at the reporting scales including but not necessarily limited to visibility, soundscape and dark night skies.
- Utilize "gray literature" and reports from third party research to the extent practicable.

Expectations for KLGO staff involvement were detailed in the project scoping meetings. Park staff participated in project development and planning, reviewed interim and final products, and participated in ecological assessments. They were also expected to fully participate and collaborate with Saint Mary's University of Minnesota to identify sources of information, define an appropriate resource assessment structure, identify appropriately scaled resources, threats, and stressors, and identify measures for these resources.

Park staff collaborated with the SMUMN GSS NRCA team during data mining and condition assessment to ensure the synthesis was consistent with the project goals. Additionally, KLGO staff members assisted in developing recommendations for additional analysis to fulfill information needs that would aid in the assessment of park resource conditions. They were also expected to review and comment on draft findings and all publishable material submitted from the project in a timely fashion. Finally, park staff collaborated with SMUMN GSS staff in a ninety-day wrap-up period following the due date of the last project product. Involvement of KLGO staff in this project ensured that the true needs of the park were being met through the efforts of SMUMN GSS.

In addition to park resource staff, Alaska NPS regional staff were involved in the development of this NRCA. The NPS Agreement Technical Representative, Sara Wesser, coordinated the efforts of the Principal Investigator, the project work group, KLGO personnel, and the NPS Alaska Regional Office.

The National Park Service was responsible for informing the SMUMN GSS Principal Investigator of the specific activities required to comply with the "NPS Interim Guidance Document Governing Code of Conduct, Peer Review, and Information Quality Correction for National Park Service Cultural and Natural Resource Disciplines" or any subsequent guidance issued by the NPS Director to replace this interim document.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources and Indicators

The KLGO Natural Resource Condition Assessment utilizes an assessment framework adapted from "*The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States"*, by the H. John Heinz III Center for Science, Economics and the Environment. The use of this framework was endorsed by the National NRCA Program Manager as an appropriate vehicle for framing resource components, indicators, measures and resource condition. Each NRCA project represents a unique assessment of key natural resource components that are important to the specific park that is being assessed. As a result, the project framework is adapted by the project oversight team to reflect the specifics of the individual project.

For the purpose of this NRCA, key park resources were identified by NPS staff and are represented as indicators in the framework (Table 2). While this list of indicators is not all inclusive, it includes natural resources and processes that are currently of the greatest concern to park management in KLGO. This is conceptually similar to the Southeast Alaska Network's Vital Signs Program.

For each key resource, measures that define the current condition of that resource were also identified. The selection of measures for the indicators was completed through collaborative discussion with, and feedback from, KLGO resource staff. Effort was made to incorporate measures that had already been identified by the Resource Stewardship Strategy planning process.

During the scoping process, KLGO staff prioritized three key indicators (hydrology, breeding birds, and coastal waterbirds) for more detailed analysis. Data for these indicators were available but had not been fully analyzed by park staff. SMUMN GSS was asked to focus additional analysis efforts on datasets for these indicators.

Reference conditions in this project were identified cooperatively by SMUMN GSS and NPS stakeholders with the intent of providing a benchmark to which the current condition of each measure could be compared. Generally, this condition represents a historical reference in which human activity and disturbance were not major drivers of population and ecological processes. Attempts were made to utilize existing research and documentation to identify reference conditions; however, many of the indicators lack a quantifiable reference condition according to literature and data reviewed for this project. When a specific reference condition for the park was unknown, an attempt was made to include state and federal standards or data from other relevant locations in order to provide some context for interpreting results.

An initial project framework was accepted following NPS review in November 2009. During follow-up meetings between SMUMN GSS and NPS staff, some modifications to the organization of the framework were agreed upon to improve the report writing process. The final project framework contains 20 indicators (Table 2). This framework outlines the resources (indicators), measures, and the reference condition when available. In anticipation of new data in the near future through the Southeast Alaska Network Inventory and Monitoring (I&M) Program, NPS staff determined that an assessment of landscape condition was not recommended at this time; however, the three landscape indicators are included in the framework in recognition of their importance to the park.

Table 2. Final KLGO NRCA Framework.

Klondike Gold Rush National Historical Park
Natural Resource Condition Assessment Framework

	Indicators	*Measure*	*Reference Condition*
Extent and Pattern			
Landscape Composition			
	Landcover Extent	Area of plant community types	
	Landcover Pattern	Diversity Index	
		Number and density of patches	
		Mean patch size	
	Landform	Areal extent and configuration	
Biological Components			
Biotic Composition			
	Lichens	Lichen community plot scores	
	Invasives and Exotics	Area infected	0
		Weighted invasive score	0
	Flora	Percent of species present that are expected	100%
		Number of rare species or species at the edge of their range	
	Breeding Birds	Number of species	Skagway Bird Club Checklist
		Diversity index	
	Coastal Birds	Number of species	Skagway Bird Club Checklist
		Diversity index	
	Bears	Number of bear/human incidents	0
		Number of bears moved as a nuisance	0
		Number of bear-human incidents where bears get human food	0
		Bear population and distribution	
	Western Toads	Percent of core sites occupied by breeding toads	
		Abundance	
		Percent of sites where toads are successfully recruited	
		Percent of core sites in Dyea (occupied) that have toads with chytrid fungus	
		Presence / absence of other amphibian species park-wide	
Habitat			
	Wetlands	Area of wetland types	

Table 2. Final KLGO NRCA Framework. (continued).

Indicators	Measure	Reference Condition
Chemical and Physical Characteristics		
Air Quality		
Air Quality	Particulates	Annual state and federal ambient air quality threshold
	Sulphur and nitrogen oxides	NPS Air Resource Division definitions of significant concern, moderate condition, and good
	Lichen contaminants	Baseline from unpolluted areas of Southeast Alaska or Pacific Northwest 97.5 quantile threshold concentrations
	Visibility	
Soundscape	Noise free interval	
	Percent time of audible extrinsic sound	
	Percent time dB levels of extrinsic sound exceeding threshold	
Dark Night Skies	V Magnitude	
Water Quality		
Chemistry	pH	Alaska Water Quality threshold for "growth and propagation of fish, shellfish, other aquatic life, and wildlife"
	Specific conductance	
	Dissolved oxygen	Alaska Water Quality threshold for "growth and propagation of fish, shellfish, other aquatic life, and wildlife"
Trace Inorganic and Organic Chemicals	Mercury	Mussel Watch Project; References used for comparison in the freshwater study
	Persistant organic pollutants (POPs)	Mussel Watch Project; References used for comparison in the freshwater study
	Polycyclic aromatic hydrocarbons (PAHs)	Mussel Watch Project
Physical Properties	Turbidity	Alaska Water Quality standard for "growth and propagation of fish, shellfish, other aquatic life, and wildlife"
	Temperature	Alaska Water Quality standard for "growth and propagation of fish, shellfish, other aquatic life, and wildlife"
Hydrology		
Hydrology	Total annual discharge	1970-1977
	Average daily discharge	1970-1977
	Peak discharge and timing	1970-1977
	Center of mass date	1970-1977
	Date of spring pulse onset	1970-1977
	Fractional flows	1970-1977
Proglacial Lakes	Number of proglacial lakes upstream from KLGO	
	Number of proglacial lakes upstream from KLGO that are hazardous	
Ice Cover	Extent of ice cover	1948
	Percent change in ice cover	1948

3.2.2 Reporting Zones

Due to the diverse landscape of KLGO, defining the condition of a particular resource at a park-wide scale is difficult and often not appropriate. For this reason, dividing the park into smaller subsections was necessary to define KLGO resources in a manner that provided simplicity and greater spatial accuracy. These smaller subsections, entitled reporting zones, provide a structure for discussing and assessing the resources in KLGO without generalizing to the full-park scale. It is important to note that the reporting zones are not intended to imply any focus for management directives or regulatory designations.

In consultation with KLGO staff, it was determined that the three official park units represent the most effective reporting zones. The three units are unique in terms of ecology, management, existing data, and visitor use. A brief description of each is provided below:

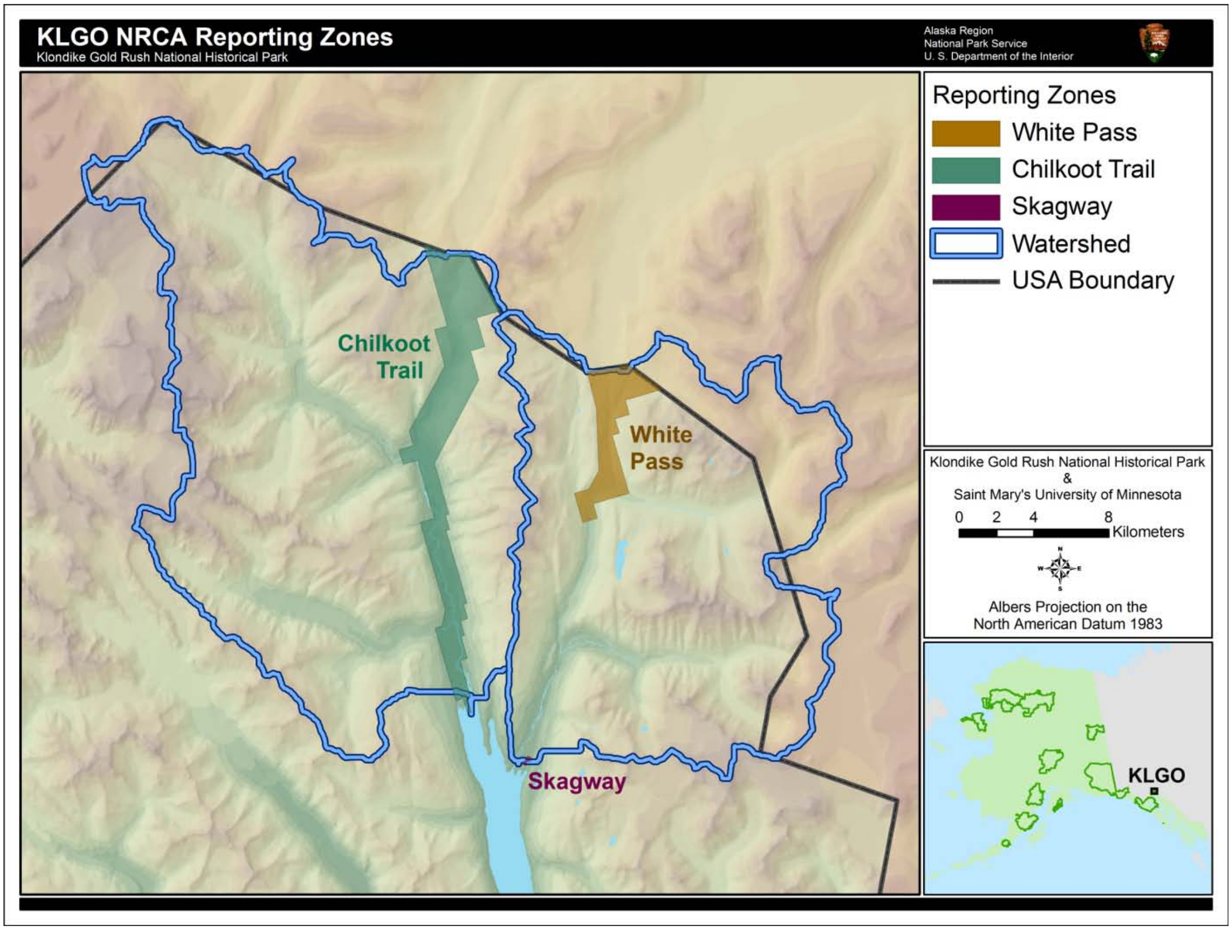


Figure 2. Reporting zones used in KLGO NRCA (NPS 2009).

<u>Chilkoot Trail Reporting Zone</u>

The majority of the park, nearly 4,000 hectares, lies in the Chilkoot Trail Unit (KLGO 1996). This unit includes tidal flats, the historic town of Dyea, the Chilkoot Trail, and the Taiya River. Transitioning from sea level to approximately 1700 meters in less than 30 kilometers, the unit is home to a steep climatic and ecological gradient resulting in diverse habitats for several species of plants and animals.

Photo 5. Images of the Chilkoot Trail Unit.

White Pass Reporting Zone

The White Pass Unit is approximately nine kilometers long and is located in the White Pass Fork drainage of the Skagway River watershed. The widest point, close to the northern end of the unit, is approximately six kilometers wide. The actual White Pass is at an elevation of 873 meters. The steep and rugged landscape is not easily accessible by foot, and the unit is completely undeveloped. The primary access point is the White Pass Railroad which passes through the eastern edge of the unit. In 2008 over 400,000 visitors experienced the White Pass Unit by train. No established trails exist to reach the unit or travel through the unit (KLGO 1996). Partly due to the difficulty of access by foot and the rugged terrain, this unit has not been as extensively studied as the Chilkoot Trail Unit.

Photo 6. White Pass Unit.

Skagway Reporting Zone
The Skagway Unit is an urban park unit in downtown Skagway. Approximately twelve city blocks, the unit protects historic buildings remaining from the gold rush period. While not rich in natural resources, some indicators are relevant for this unit. Air quality is important due to its location in the city and its proximity to the cruise ship docks. For some indicators, data collected near the Skagway Unit are discussed using this reporting zone if the data are relevant to the condition of the park as a whole. These indicators include water quality, air quality, bears, and invasive and exotic species.

Photo 7. Downtown Skagway.

Skagway and Taiya River Watersheds
KLGO park staff also recognize the importance of events occurring within the watershed but outside of the park boundary. Specifically, landscape, proglacial lakes, and ice cover in KLGO's watersheds have the potential to dramatically affect park resources. For these indicators, the watershed is considered the primary reporting zone and the individual park units inherit the condition of the watershed. The Skagway and Taiya River watersheds are discussed together, because the available data did not support separate assessments.

3.2.3 General Approach and Methods
This study involved reviewing existing literature and data for each of the indicators in the framework, and, where appropriate, analyzing the data in order to provide summaries or to create new spatial representations. After gathering data regarding current condition of indicator

measures, a qualitative statement was developed comparing the current conditions to the reference condition when possible.

Data Mining

Data mining began during the first scoping meeting. At that time KLGO staff provided SMUMN GSS with data and literature in multiple forms: NPS reports and monitoring plans, other reports from various state and federal agencies, published and unpublished research documents, non-governmental organization reports, databases, and tabular data. Spatial data were provided in the form of the Alaska NPS Permanent Data Set and other data were provided directly from KLGO NPS staff. Access was also granted to various NPS online data and literature sources, such as NatureBib and NPSpecies. Supplemental data were also acquired by GSS through online literature searches and various state and federal government websites.

Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality pertaining to the indicators identified in the project framework. The project team realized there may be information outside the reach of the investigative time frame and the reasonable scope of consideration for this project; however, all reasonably accessible and relevant data were used to conduct this assessment. The data mining process culminated in the development of indicator specific summary texts, which outlined the thoroughness and relevancy of the available literature and data. These interim summary documents were forwarded to NPS Staff for recommendations regarding most relevant literature and data analysis direction.

Data Analyses and Development

Data analysis and development tasks were performed for specific indicators based on summary texts developed in the data mining process and recommendations provided by NPS staff in response to these texts. Data analyses and development were indicator specific, and methodology for individual analyses can be found within chapter four.

Geographic information systems (GIS) technology was utilized to graphically depict the status and distribution of considered resources. It was also used to depict relationships between resources, between resources and human use, and to model resource/stressor relationships. GIS facilitates the spatial display of species extents, physical characteristics, priority resources, reporting areas, and other resource perspectives that are unavailable from more traditional sources. GIS products incorporated in this report will also be integrated into the park permanent dataset to facilitate future access.

Indicator Assessment Development

Final indicator assessments were developed by incorporation of comments provided by KLGO staff during the review of data assessment summaries and during project meetings. Additionally, continued contact with KLGO staff to address questions and comments pertaining to each indicator was maintained throughout the data analysis and report writing phase to ensure accurate representation of KLGO staff knowledge. The final indicator assessments represent the most relevant and timely data available for each indicator based on the recommendations and insight provided by KLGO staff.

Indicator Assessment Format

Indicator assessments are presented in a standard format and their structure, by major heading, is as follows:

Condition Graphic

The condition graphic provides a visual representation of the condition of the indicator with respect to the reporting zones described in section 3.2.2. This graphic, intended to give readers a quick interpretation of the authors' assessment of condition, does not replace the written statements of condition, which provide a more in-depth description of an indicator's condition in KLGO.

Figure 3 shows the condition designations used to describe condition at the reporting zone level. Circle colors provide indication of condition or concern. Red circles signify that a resource is of significant concern to park management for a specific reporting zone. Yellow circles signify that a resource is of moderate concern to park management, and blue circles denote that an indicator is currently in good condition. Gray circles signify that there is insufficient data to make a statement about concern or condition of the indicator.

Arrows inside of the circles signify the trend of the condition or concern of a particular indicator. Upward pointing blue arrows signify that the indicator is improving in recent history. Right pointing yellow arrows signify that the indicator's condition is currently stable. Downward pointing red arrows specify that the indicator's condition is worsening in recent history. Gray triple arrows specify that the trend of the indicator's condition is currently unknown.

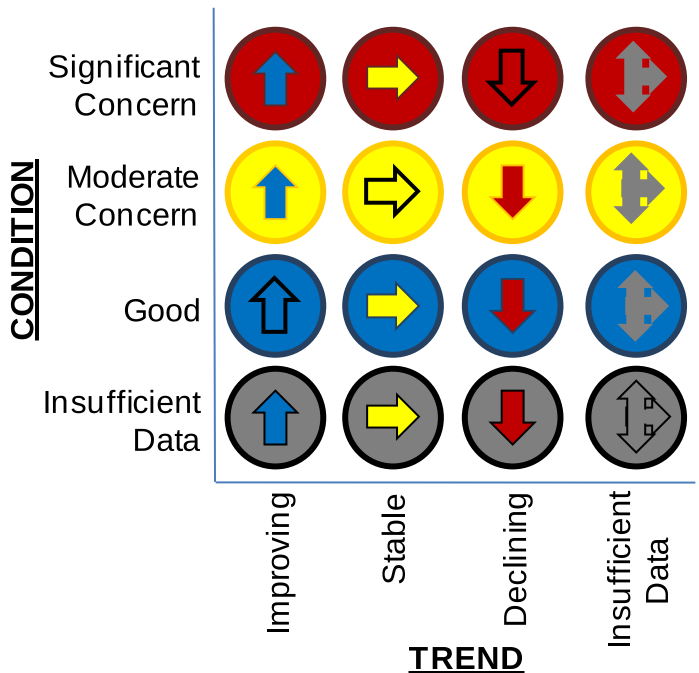


Figure 3. Designation symbols used for individual indicator assessments. Condition or concern designations along the vertical axis and trend designations along the horizontal.

Figure 4 (below) is an example of the final condition graphic used in the indicator assessments. As shown in the above graphic, condition designations are made at the reporting zone level, but on occasion, an indicator is not present in a particular reporting zone resulting in the designation of N/A. Defining condition to the reporting zone level helps to avoid generalization of a particular resource. For the three indicators assessed at the watershed level (landscape, proglacial lakes, and ice cover), the watershed reporting zone is added to the graphic, and the three park unit reporting zones inherit the condition of the watershed.

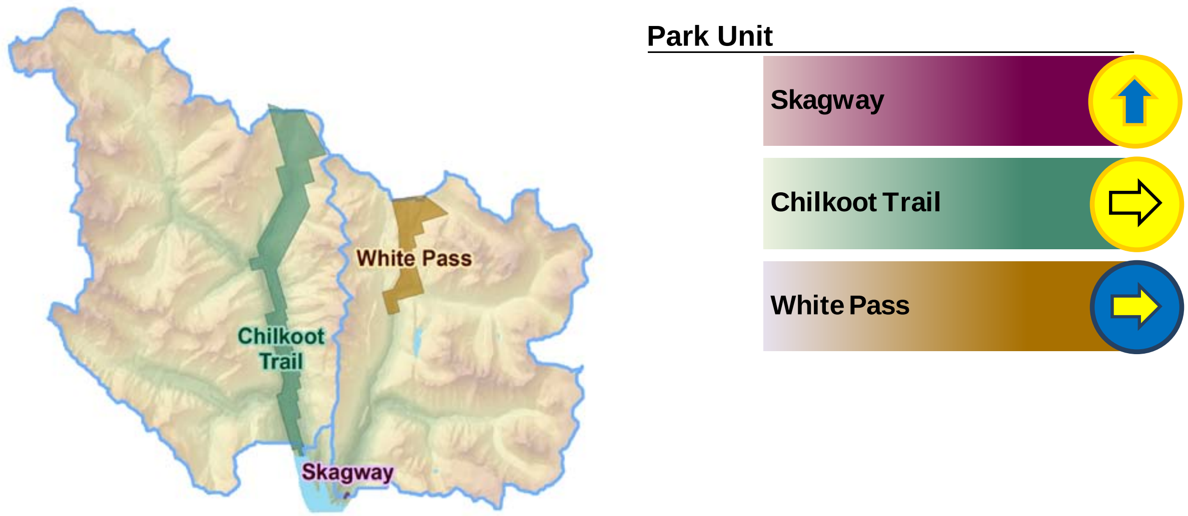


Figure 4. Example of the final condition graphic used in the indicator assessments.

Background
This section provides information regarding the relevance of the resource in KLGO and, where applicable, informs the reader of the distribution of that resource in the park. This section explains characteristics of the indicator that help the reader understand subsequent sections of the document. Common topics covered in this section include management history, relationships to other indicators, and life history (for biota).

Reference Condition
This section explains the reference condition, as defined in the framework, for the indicator. Additionally, explanations of available data and literature that speak to the reference condition are located in this section.

Data
This section describes the existing datasets used for evaluating the indicator. Methods used for processing or evaluating the data are also discussed where applicable.

Measures (multiple sub-sections)
These sections provide summaries of the available data and literature that speak to the specific measures used to define the condition of the indicator. Indicator measures were defined in the scoping process and are outlined in the framework (Table 2).

Stressors
This section provides a summary of the stressors to an indicator based on available data and literature, and expert opinion.

Condition
The condition section of the indicator assessment provides a summary of the condition of the indicator based on available literature, data, and expert opinions by park staff. This one to two paragraph section highlights the key elements used in defining the condition assignments in the condition graphic.

Data Needs

This section outlines data needs, which if addressed, would be beneficial in determining the condition of a given indicator in the future.

Literature Cited

Klondike Gold Rush National Historical Park. 1996. General management plan development concept plan and environmental impact statement. U.S. Department of Interior, National Park Service, Skagway, Alaska and Seattle, Washington.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Chapter 4 Natural Resource Conditions

This chapter presents the background, analysis, and condition summaries for the 20 key resource indicators in the project framework. The following sections discuss the key resources and their measures, stressors, and reference conditions. The order of indicators follows the project framework (Table 2). The three indicators within the Landscape Composition component are included as placeholders in the framework for future NRCA projects and are discussed together in this report as section 4.1. The summary for each indicator is arranged around the following sections:

1. Condition Graphic

2. Background

3. Reference Condition

4. Data

5. Topic Specific Measures (multiple sections)

5. Stressors

6. Reporting Zones

7. Condition

8. Data Needs

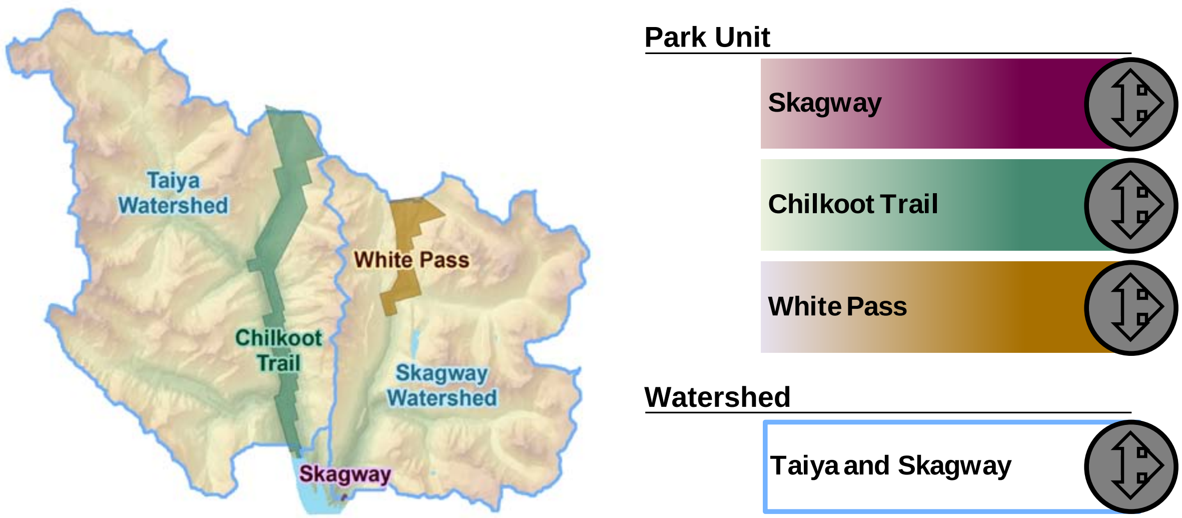
9. Literature Cited

4.1 Landscape Composition

Indicators*

Landcover Extent
Landcover Pattern
Landform

* Landscape composition is included in the framework in recognition of its ecological importance. An assessment of landcover and landform was not conducted as part of the NRCA due to limited resources and higher priorities. Upcoming work by the SEAN I&M Program will address landcover and landform in KLGO. For this reason, landscape composition is summarized at the component level rather than for each individual indicator. The indicators identified act as placeholders to highlight their importance and recommended inclusion in future natural resource condition assessment projects.



Background

Landscape is a combination of abiotic and biotic features and is the foundation for functioning physical and ecosystem processes (EPA 2002; Moynahan and Johnson 2008). The extent and pattern of landcover and landform controls the flow of energy and materials, habitat availability, and the movement of wildlife (Moynahan and Johnson 2008). The entire landscape is important for maintaining diverse flora and fauna (EPA 2002).

Preservation of the physical and cultural landscape and associated stories of the Klondike Gold Rush is an essential component of the park’s purpose (KLGO 2009). The glaciated valleys, braided streams, steep slopes and dense forests that comprise the physical landscape of KLGO are the setting and historical record for one of the most significant cultural events in Alaskan and North American history. The ecological and geologic forces that are continually working to form and reform the natural landscape are also at work on the evidence of the boom and bust gold rush that humans imprinted on the land. Natural processes are reclaiming the cultural and historic landscapes (KLGO 2009). The history of the area cannot be truly appreciated without an understanding of the challenges and opportunities that the natural landscape of this area created for the gold rush stampeders.

In addition to the cultural significance of the landscape, the natural setting of KLGO is also one of environmental importance. Within the Taiya and Skagway watersheds, subarctic, alpine, coastal and boreal ecosystems converge and create an environment suitable for unique flora and fauna (KLGO 2009).

Landform and landcover is a vital sign for the SEAN I&M Program (Moynahan and Johnson 2008). Of the 36 total vital signs, landform and landcover is one of twelve core vital signs, indicating that it is a top priority which will be addressed in the first five years of the program (Moynahan and Johnson 2008).

Reference Condition

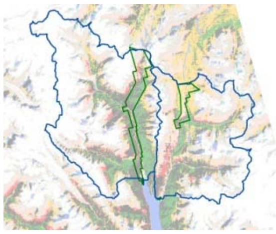
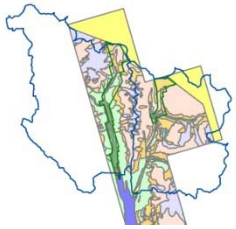
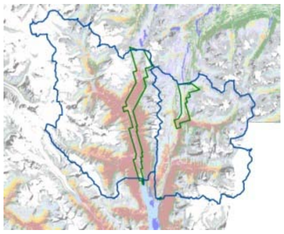
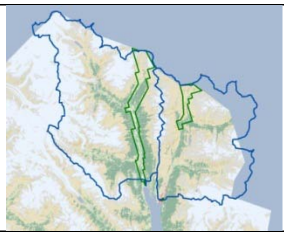
Landscape is a naturally dynamic component of ecosystems. Natural events such as changes in ice cover extent, glacial outburst floods, fire, insect and disease infestation, and vegetative succession can change landscape characteristics temporarily or permanently. These dynamics pose a serious challenge when trying to determine a reference condition for landscape. The SEAN I&M Program plans to use classified maps from recent and previous monitoring events to determine status and trends for the landcover component (Moynahan and Johnson 2008). The landcover dataset created by the U.S. Geological Survey in 1989 (Table 3) is the earliest digital landcover dataset that encompasses the entire park.

Data

Spatial Datasets

There have been several studies and data collection efforts related to landscape composition in KLGO. Table 3 summarizes the digital landcover datasets available for the park. The datasets vary in extent, resolution, and method of classification; therefore, comparing the datasets to detect change or determine trends is impractical. The national Inventory and Monitoring Program will be conducting a vegetation inventory for KLGO as one of 12 inventories common to all parks with significant natural resources. The baseline established by this inventory will be used to monitor landcover in the future. The Southeast Alaska Network is developing a long-term monitoring plan for landcover and landform using high-resolution spacebourne imagery (Moynahan and Johnson 2008). The first dataset is expected within the next few years. In anticipation of this new data becoming available, park resource staff deemed an assessment of existing landcover datasets not practical at this time.

Table 3. Landcover datasets for Klondike Gold Rush National Historical Park (Green outline denotes park boundary; Blue outline denotes watershed boundary). All datasets are available in the NPS Permanent GIS Dataset (NPS 2009a,b,c,d).

Name	Description	Coverage
Landcover Skagway (NPS 2009a)	*Published Year:* 1989 *Data Year:* 1989 *Cell Size:* 62.229844 meters *Creator:* USGS/EROS *Classification:* Alaska Interim Land Cover Mapping Program land cover classes (USGS, 1987; Shasby and Carneggie 1986; Fitzpatrick-Lins and others 1989)	
Eco Inventory-Primary Plant Associations (NPS 2009b)	*Published Year:* 1994 *Data Year:* 1994 *Cell Size:* NA (vector data) *Creator:* National Park Service, Alaska Regional Office *Classification:* Vegetation types classified based on previous work on plant associations in the Chatham Area portions of Admiralty, Baranof, and Chichagof (ABC) Islands.	
Land Cover-2002 DU Haines (NPS 2009c)	*Published Year:* 2002 *Data Year:* 1999 *Cell Size:* 30 meter *Creator:* National Park Service, Alaska Regional Office, Ducks Unlimited, Inc., Bureau of Land Management *Classification:* 26 earth cover categories based on Viereck et al. (1992) and revised through a series of meetings coordinated by the BLM – Alaska and DU.	
Alaska National Land Cover Database (NPS 2009d)	*Published Year:* 2003 *Data Year:* 1985-2002 *Cell Size:* 30 meters *Creator:* U.S. Geological Survey *Classification:* National Land Cover Classification	

<u>Additional Landcover Information</u>

Various other projects have produced landcover information either directly or indirectly. Information related to ice coverage is discussed in a separate section of this report. Additional site specific landscape data are included in the following studies:

Ecological Inventory: The results of an ecological reconnaissance inventory were published in 1994 (Paustian et al. 1994). This report contains a description of geology, geomorphology, soils, climate, hydrology, vegetation, disturbance, succession, vegetation health, and introduced species.

The Coastwalker Project: The Coastwalker project performed a systematic characterization of biota, substrate, morphology and exposure of shore using a protocol developed at Glacier Bay

National Park and Preserve (Moynahan and Johnson 2008). The entire park intertidal zone was mapped in 1999. The resulting data layers are part of the NPS Permanent GIS Dataset. Although not intended to be used as baseline data, reference photographs of each shore segment could be used to document large changes in landcover and shore morphology (Moynahan and Johnson 2008).

LIDAR: The majority of KLGO was imaged using LIDAR (light detection and ranging) technology in 2003. A high-resolution elevation dataset has been developed using these data. Multi-return data have not been analyzed (KLGO D. Schirokauer pers. comm. 22 March 2010). These high resolution data have potential to be valuable for monitoring vegetation and geomorphology but do not meet the park's need to understand and track influences that originate outside the park boundary (Moynahan and Johnson 2008).

Repeat Photography: In 2005, Richard Carstensen and Cathy Pohl revisited and photographed sites from which historical photographs had been taken (Moynahan and Johnson 2008). These photographs included retakes of seven late 1890s and early 1900s photographs from vantages in the Taiya and Skagway River valleys. Additional historical surface and aerial photographs of the park exist at various scales and extents. These have been systematically curated in a collection housed at KLGO. These photographs "have great potential for monitoring change at various scales" (Moynahan and Johnson 2008).

Taiya River Erosion: In 2002, Rick Inglis published the results of an assessment of bank erosion of the Taiya River in the Dyea townsite from 1979 to 2002. The purpose of this project was to inform KLGO about the quantity of erosion occurring along a meander of the Taiya River at Dyea and provide information valuable to the design of stabilization projects (Inglis 2002). Most erosion is believed to have occurred prior to 1992. At one monitoring station as much as 68 feet of bank had been lost to erosion (Inglis 2002).

Indicators

The following landscape indicators have been identified as placeholders within the NRCA framework in recognition of their importance and inclusion in future condition assessment projects.

<u>Landcover Extent</u>

The size and shape of landcover types is important because landcover is associated with habitat. The reduction in size of available habitat is often correlated with a decline in species richness (EPA 2002). In addition to habitat size, some species are also sensitive to the shape of available habitat (edge to core ratio). Habitat fragmentation or aggregation changes the size and configuration of habitat patches, altering species abundance patterns and potentially threatening biodiversity (EPA 2002).

The SEAN Vital Signs Monitoring Plan includes the objective of determining status and long-term trends in the areal extent and configuration of plant community types at broad botanical levels within and on lands influencing SEAN parks (Moynahan and Johnson, 2008). Areal extent of plant community types is a placeholder measure for future NRCA projects.

Landcover Pattern

In addition to the extent of available habitat, the spatial pattern of habitat types is also important for maintaining species diversity (EPA 2002). The spatial relationship between patches of similar habitat type, as well as events occurring in surrounding areas, affects ecosystem structure and function (EPA 2002). Habitat fragmentation can potentially alter the competitive balance among species and alter regional community composition and species diversity (EPA 2002). A species limited to a specific habitat type that becomes isolated due to habitat fragmentation is most at risk for extirpation (EPA 2002). Natural causes of fragmentation include wildfire, avalanches, glaciation, and windthrow, which often create habitat patches with irregularly shaped edges (EPA 2002). Human caused fragmentation generally results in more geometrically regular patch edges (EPA 2002). "Changes in ecosystem structure and function often depend as much on what happens in the area around the habitat of concern as they do on the size of the habitat and its relationship to other similar habitat (EPA 2002)."

The SEAN Vital Signs Monitoring Plan includes the objective of determining the status and long-term trends of selected key landscape metrics (e.g., proportion of area in different cover types, number and density of patches, mean patch size) of NPS lands within and on adjacent lands influencing SEAN parks (Moynahan and Johnson 2008). Configuration of plant community types, proportion of area in different cover types, number and density of patches, and mean patch size are considered placeholder measures for future NRCA projects.

Landform

Landforms are uniquely important to parks in the Southeast Alaska Network for many reasons, including their exceptionally dynamic nature (Moynahan and Johnson 2008). Rapid glacial retreat, isostatic rebound rates among the highest in the world, tsunami-affected coast-line, tectonic activity, climate change, and glacial outburst floods are all drivers of landcover and landform change in SEAN parks (Moynahan and Johnson 2008). Succession occurs on previously ice covered land, watercourse morphology evolves, and habitats change in size and juxtaposition (Moynahan and Johnson 2008).

The SEAN Vital Signs Monitoring Plan includes the objective of determining long-term status and decadal trends in the areal extent and configuration of key landforms within, and on lands influencing SEAN parks (Moynahan and Johnson 2008). Areal extent and configuration of key landforms is considered a placeholder measure for future NRCA projects. The key landform types targeted for change detection in the SEAN monitoring plan are:

a. Moraine deposits
b. Glacier extent*
c. Firn-lines
d. Terraces
e. Fluvial deposits
f. Proglacial lakes*
g. Alluvial deposits
h. Accretion zones on river systems
i. Shoreline features
j. Erosion zones on river systems
k. River channel migration
l. Plant communities

* Ice cover and proglacial lakes are addressed as individual indicators within this report.

Stressors

Natural and anthropogenic events throughout history have affected the landscape and will continue to influence the landscape into the future. Beginning at the end of the 19th century, thousands of gold rush stampeders had a substantial impact on vegetation in certain areas of the park. Much of the Dyea area and Chilkoot Trail were cleared of trees and are now a second-growth forest. The stampeders also left behind various artifacts of their presence throughout the Skagway and Dyea areas and en route to the goldfields (Paustian et al. 1994). Some of the exotic species still present in the park may have been introduced through the use of horses and mules to transport men and equipment during the gold rush and as part of construction activities (Paustian et al. 1994). Visitors continue to use the Chilkoot Trail and White Pass areas for recreational activities today. Hikers and campers can impact landcover by trampling vegetation and potentially introducing exotic species (Paustian et al. 1994).

The SEAN I&M Program has identified anthropogenic influence adjacent to parks as another possible driver of landscape change (Moynahan and Johnson 2008). Examples include stream bank hardening, development, road construction, and timber production (Moynahan and Johnson 2008). This type of change is believed to occur at a lower intensity and rate in Alaska than at parks in more developed regions of the continental United States (Moynahan and Johnson 2008). However, one example of this type of cause and effect are landslide-generated tsunami events. Two of these events occurred in the Skagway Harbor in 1966 and 1994 (Hood et al. 2006), and investigations of these events found coastal construction activities are an ongoing tsunami risk for the area around Skagway Harbor (Hood et al. 2006). Both a landslide and a tsunami could temporarily or permanently alter the landscape (Hood et al. 2006).

Climate is an important driver of landcover and landscape processes. Global climate warming trends have been detected and documented in parts of Alaska (Moynahan and Johnson 2008). Indicators of climatic warming in Alaska include rapid changes in the thaw cycle of many glaciers and permanent snowfields, changes in seasonal snowfall, and shorter river, lake, and sea ice seasons. One effect of receding glaciers that is particularly important to KLGO is the formation of proglacial lakes and related outburst flood events. These are discussed in greater detail in the proglacial lakes section of this report. Another impact of receding glaciers is isostatic rebound, which, amongst other impacts, has moved former beaches inland. Climate change can also alter vegetation through impacts on growing seasons and related influences on vegetative community composition.

Landscape processes such as insect outbreaks, fire, floods, avalanches, glacial retreat and plant succession can change the landscape gradually or suddenly. These may occur naturally, but some process regimes such as insect outbreaks, fire, and floods can also change as a result of climate modification. Erosion along the banks of the Taiya River in the Dyea townsite is a documented example of a landscape process changing landform in KLGO. Most of the erosion likely occurred prior to 1992, but since Dyea is home to many cultural resources, erosion is an ongoing concern (Inglis 2002).

Reporting Zones

Events adjacent to and upstream from the park boundary have the potential to influence the KLGO landscape. Therefore, the entire park watershed is the reporting zone for landscape composition.

Condition
Due to the lack of current data and the anticipated landcover and landform data from the SEAN I&M Program in the near future, a condition assessment was not made as part of the present NRCA.

Data Needs
Ongoing inventory and monitoring pertaining to landscape condition in KLGO is planned as part of the SEAN I&M Program. High resolution satellite imagery, such as IKONOS and GeoEye, will be obtained for the park and adjacent areas that have the potential to influence park lands (e.g., watersheds) (Moynahan and Johnson 2008). Classification of vegetation and identification of specific landforms (e.g., moraine deposits, glacier extent, firn lines, terraces, fluvial deposits, proglacial lakes, alluvial deposits, accretion zones on river systems, shoreline features, erosion zones on river systems, river channels) will be completed to monitor landscape condition and detect change (Moynahan and Johnson 2008). Medium-resolution imagery every five years will be considered as a possible source for enhancement of temporal change resolution.

Knowledge of a historic reference condition for landscape is incomplete. A historic landscape record would be valuable to the park. There is a significant photographic record of the Klondike Gold Rush, including aerial imagery dating back to the early 1940's, and some land cover and ice cover information could be gleaned from these photographs as a future project.

Data collection at collocated sites overtime is one way to monitor landscape change. The ecological inventory by Paustian et al. (1994) included several sampling sites within the park. Revisiting these sites would be worthwhile for repeat sampling and long term monitoring.

Literature Cited

Environmental Protection Agency. 2002. A framework for assessing and reporting on ecological condition. EPA-SAB-EPEC-02-009. Science Advisory Board, Washington, DC, USA.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Inglis, R. 2002. Assessment of bank retreat monitoring data from 1979 to 2002 for the Taiya River at Klondike Gold Rush National Historical Park. USGS Water Resources Division, Fort Collins, Colorado.

Klondike Gold Rush National Historical Park. 2009. Klondike Gold Rush National Historical Park - Foundation statement. Klondike Gold Rush National Historical Park, Alaska/Washington.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2009a. Interim land cover mapping program – Skagway QM quad. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009b. Primary plant associations. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009c. Land cover map of Haines Alaska area 2002 - Ducks Unlimited and BLM. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009d. National land cover database zone ak01 land cover layer. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

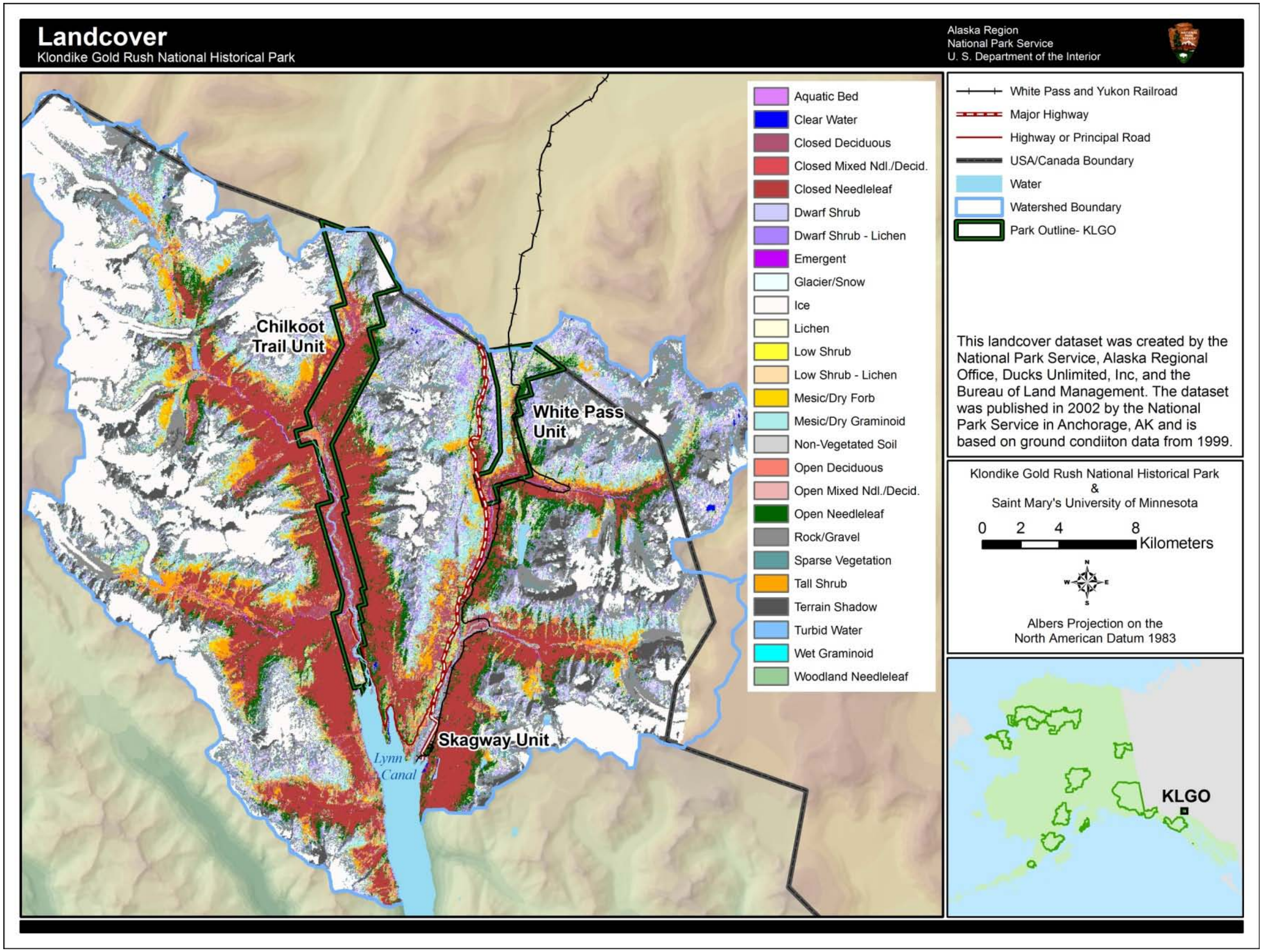
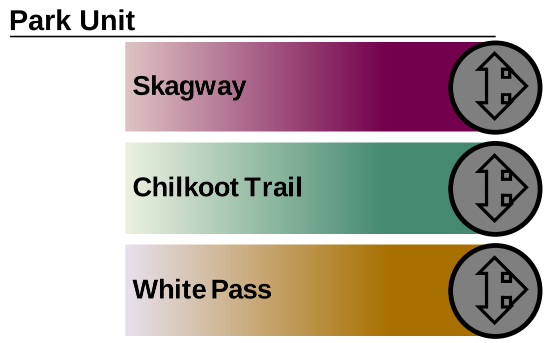


Plate 1. Landcover within the Taiya and Skagway watershed (NPS 2009c).

4.2 Lichens

Measures
Lichen Community Plot Scores



Background
KLGO's landscape diversity is reflected in the species richness of its lichen population. Results of a recent lichen inventory found that the park is home to over 766 species of lichens, including a few previously undescribed species and species previously unknown in North America (Spribille et al. 2010). This number of species is more than is attributed to any other national park in the U.S. according to a national park lichen database published in 2005 (Bennett and Wetmore 2005). It is also one of the largest numbers of lichenized and lichenicolous fungi per unit area ever reported (Spribille et al. 2010).

Lichens grow on trees, the ground, and even on bare rock (Furbish et al. 2000). Since lichens absorb nutrients directly from their surroundings, they are sensitive indicators of air quality. Some particularly sensitive species decline in abundance or disappear at low levels of air pollution; therefore, information gathered from monitoring community composition of lichen plots can indicate changes in air quality (Furbish et al. 2000). A relationship between lichen community composition and climate has also been noted in various studies, further supporting the importance of lichens as indicators of community health (van Herk et al. 2002, Aptroot and van Herk 2007, Ellis and Coppins 2007). In fact, Aptroot and van Herk (2007) conclude that lichens are among the organisms most sensitive to changes resulting from global warming.

Reference Condition
A historic reference condition for lichens cannot be established because lichen community plot data were not collected in KLGO prior to 2008. Monitoring of lichen community plots is occurring elsewhere throughout southeast Alaska (Dillman et al. 2007). Data from KLGO can be compared to these sites in the future in order to inform statements of condition (Schirokauer and Geiser 2010).

Data

Lichen community plots have been installed at eight sites in and around KLGO using established methods from the Tongass National Forest (Geiser at al. 1994, USFS 2004). These sites are collocated with passive deposition samplers measuring nitrogen and sulfur ions (Shirokauer and Geiser 2010). Passive ambient air samplers are also present at some of the lichen community plots. Community plot data were collected in 2008 & 2009, but analysis of the data is not available for this report. Trends in lichen communities will be assessed after 2019 when lichen community plots are reassessed.

Measures

<u>Lichen Community Plot Scores</u>

Lichen community plot data collected in 2008 had not been analyzed at the time of this report. Analysis of lichen plots will likely follow methods used in Geiser et al. (1994), U.S. Forest Service (2004), and Geiser and Neitlich (2007). Another objective of lichen community plot monitoring is to model the relationship between lichen community plots and element concentrations using measurements obtained at collocated sites (Shirokauer and Geiser 2010).

Stressors

Air pollution and climate are two primary factors influencing lichen communities. Sources of air pollution are discussed in the air quality indicator section. Literature suggests that climate and the interaction of climate and habitat are important to understanding lichen diversity (van Herk et al. 2002, Aptroot and van Herk 2007, Ellis and Coppins 2007). Available moisture, associated vegetation, and metabolism are all important factors to lichens that are affected by temperature (Geiser et al. 1994). Increasing temperatures were correlated with changes in lichen communities monitored in the Netherlands for 22 years (van Herk et al. 2002). As average temperatures increased, arctic-alpine/boreo-montane species appeared to decline while (sub)tropical species increased. A study by Aptroot and van Herk (2007) found additional evidence that global warming is changing lichen populations and distributions.

Reporting Zones

Lichen community plots are located in or near the Skagway and Chilkoot Trail reporting zones. Lichen community plots are not established in the White Pass Unit. Analysis of data for the Skagway and Chilkoot Trail reporting zones is not available at this time.

Condition

Data collection of lichen community plots has occurred, but final analysis of the data is not complete at the time of this report; therefore, insufficient information

Photo 8. Lichen along the Chilkoot Trail.

is available to make a statement of condition or trend.

Data Needs
Data collected at lichen community plots in 2008 need to be fully analyzed. Community plots and additional inventory work in high altitude and crust alpine areas would be useful for a more complete understanding of lichen community health.

Literature Cited

Aptroot, A., and C. M. van Herk. 2007. Further evidence of the effects of global warming on lichens, particularly those with *Trentepohlia* phycobionts. Environmental Pollution 146(2):293-298.

Bennett, J. P., and C. M. Wetmore. 2005. Lichens of the U.S. national parks. The Bryologist 108(4):544-553.

Dillman, K., L. Geiser, and G. Brenner. 2007. Air quality bio-monitoring with lichens: The Tongass National Forest. U.S. Forest Service. Online. (http://gis.nacse.org/lichenair/?page=reports#R10). Accessed 30 March 2010.

Ellis, C. J., and B. J. Coppins. 2007. Changing climate and historic-woodland structure interact to control species diversity of the '*Lobarion*' epiphyte community in Scotland. Journal of Vegetation Science 18:725-734.

Furbish, C. E., L. Geiser, and C. Rector. 2000. Lichen-air quality pilot study for Klondike Gold Rush National Historical Park and the city of Skagway, Alaska. Klondike Gold Rush National Historical Park Natural Resources Management Program.

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

Geiser, L. H., C. C. Derr, and K. L. Dillman. 1994. Air quality monitoring on the Tongass National Forest. Methods and baselines using lichens. USDA Forest Service, Alaska Region, Technical Bulletin R10-TB-46. Online. (http://gis.nacse.org/lichenair/doc/TNF_AQ_Report.pdf). Accessed 30 March 2010.

Schirokauer, D., and L. Geiser. 2010. Monitoring air quality in the Southeast Alaska Network: linking ambient and depositional pollutants with ecological effects: Assessment of conditions, trends, and refinement of passive sampling and lichen bio-monitoring protocols. 2009 Progress Report. Alaska.

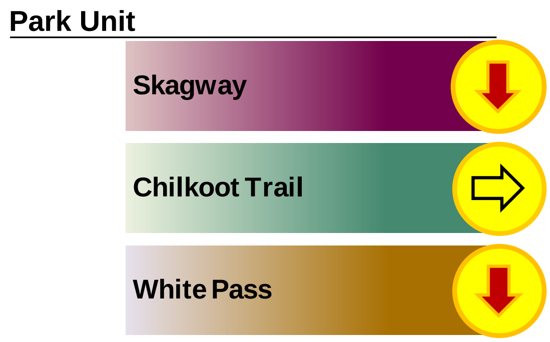
Spribille, T., S. Pérez-Ortega, T. Tønsberg, and D. Schirokauer. 2010. Lichens and lichenicolous fungi of the Klondike Gold Rush National Historic Park, Alaska, in a global biodiversity context. The Bryologist 113(3): 439-515.

U.S. Forest Service. 2004. Lichen communities. Forest inventory and analysis national core field guides. Online. (http://fia.fs.fed.us/library/field-guides-methods-proc/docs/p3_2-0_sec10_3_04.pdf). Accessed 29 March 2010.

van Herk, C. M., A. Aptroot, and H. F. van Dobben. 2002. Long-term monitoring in the Netherlands suggests that lichens respond to global warming. Lichnologist 34(2):141-154.

4.3 Invasives and Exotics

Measures
Area Infected
Weighted Invasive Score



Background
Exotic plants are those whose presence in a given area is due to accidental or intentional introduction by humans. Invasive plants are exotic species that produce viable offspring in large numbers, having the potential to establish and spread in natural areas (Alaska EPMT 2010b). Environmental characteristics of KLGO cause the park to be susceptible to exotic and invasive species. KLGO is already home to a great diversity of flora, due in large part to the variety of habitats spanning from the Lynn Canal to the Chilkoot and White Passes. The same conditions that allow so many native plants to flourish also provide ecological niches for invasive plants to gain hold. Some exotic species may actually have arrived during the gold rush through the use of horses and mules for transportation and persist due to slow vegetative succession or continued site disturbance (Paustian et al. 1994).

Invasive species are considered second only to habitat loss as a threat to global biodiversity (Moynahan and Johnson 2008). Invasive plants compete with native plant species for space, soil, light, and water (Alaska EPMT 2010c). As a result, native plant populations can decline or even face extirpation from invasive species competition. Less direct, but no less important, consequences of invasive species establishment include disrupting natural patterns of vegetation succession, changing soil chemistry and groundwater availability, and affecting the frequency and severity of wildfires (Alaska EPMT 2010c). The establishment of invasive species in native plant communities can also disrupt wildlife habitat. According to NPS policy, “Exotic species will not be allowed to displace native species if displacement can be prevented (NPS 2006).” Japanese knotweed (*Polygonum cuspidatum*), which is not yet present in KLGO, spotted knapweed (*Centaurea stoebe*),which was eradicated from the park in the late 1990’s, and reed canary grass (*Phalaris arundinacea*), which is present in low numbers, represent three species of particular concern for the park (KLGO D. Schirokauer pers. comm. 25 August 2009).

Reference Condition

Reference condition for a natural ecosystem is the presence of no invasive species. Some species, however, may have been brought to the area deliberately during the gold rush and can be considered culturally significant. The park does not specifically manage for these species, and they do not appear to be invasive (KLGO D. Schirokauer pers. comm. 29 June 2010). In addition, there are exotic species planted in gardens by citizens of Skagway that are not of concern unless they display invasive tendencies.

Data

In an effort to control the threat of invasive plants, the National Park Service created the Exotic Plant Management Program (EPMT) which supports 16 field-based teams, one of which is based in Alaska. The Alaska EPMT trains existing park staff, partially funds seasonal park staff, and supports internship positions in each park (Million and Rapp 2010). The Alaska EPMT also funds Southeast Alaska Guidance Association AmeriCorps crews who provide further assistance treating invasive species infestations. In addition to eradicating infestations and completing restoration projects, the EPMT maps accessible areas where invasive species are present.

The EPMT officially started data collection for invasive plants in KLGO in 2004. The area in and around KLGO was divided into seven reporting areas: Chilkoot Trail, Dyea, White Pass, Skagway, Dyea Road, Klondike Highway, and White Pass Railroad (Plate 2). The area surveyed and the level of survey effort has varied from year to year. The following table reports the total area mapped each year, including those areas with and without invasive species (Table 4). The Skagway reporting area extends significantly beyond the Skagway park unit. Therefore, the Skagway reporting area is considered outside of the park boundary when calculating total area statistics for inside and outside the park.

Table 4. Area surveyed by year and location (hectares) (Data from Alaska EPMT 2010a). NM = Not Mapped.

Location	In Park	2004	2005	2006	2007	2008	2009
Chilkoot Trail	Yes	1.50	0.23	23.82	0.58	NM	12.22
Dyea	Yes	1.04	0.23	28.27	0.46	3.37	1.32
White Pass	Yes	13.15	NM	NM	NM	0.06	<0.01
Total Inside Park:		15.68	0.46	52.09	1.04	3.43	13.54
Skagway	Part	1.89	2.33	2.14	1.33	2.62	7.08
Dyea Road	No	0.89	0.15	0.05	0.17	0.92	0.70
Klondike Highway	No	NM	NM	NM	NM	0.94	0.01
White Pass Railroad	No	8.09	NM	NM	NM	NM	NM
Total Outside Park:		10.88	2.48	2.18	1.50	4.48	7.79
Grand Total:		26.56	2.94	54.27	2.54	7.91	21.33

Not all exotic species pose the same danger to native flora. Some are more invasive and difficult to control than others. In recognition of this, the NPS follows an Alaska invasive plant ranking system developed by Carlson et al. (2008). The rank considers the ecological impact, biological characteristics, distribution, and feasibility of control for each exotic plant species. Scores range from 0 to 100, with 100 considered most invasive.

It should be noted that, prior to the EPMT program, surveys of invasive species at various sites in KLGO were conducted. In 2000, the Chilkoot Trail and Dyea area were divided into polygons and species presence and abundance were recorded for each area (Furbish 2001, Moynahan and Johnson 2008). Twenty-seven exotic species were identified (Delost 2004). Carlson et al. (2006) identified general locations where exotic species were found during the 2002-2003 vascular plant inventory. Most locations were along roadsides and railways; however common eyebright (*Euphrasia nemorosa*) was discovered along a slough north of the Dyea tidal flats. More information regarding the species that were found and their site locations is available in Carlson et al. (2006) and the park's annual EPMT reports.

Measures

<u>Area Infested</u>

For years 2004 to 2009, gross area infested by invasive species was calculated using ESRI ArcGIS software and spatial data from the Alaska EPMT (2010a) (Table 5). Gross area infested does not take into account percent cover. The locations surveyed and survey effort each year varied due to management priorities and available staff (Table 4). This must be considered when interpreting the results. Most recently, in 2009, invasive species were found in 8.87 hectares of the total 21.3 hectares surveyed. Of the total area infested, 1.34 hectares are within the park boundaries. Detailed reports of surveyed areas, management efforts, and species locations are found in annual EPMT reports for KLGO (Delost 2004, Schultz 2005 and 2006, Feierabend 2007, Feierabend and Schirokauer 2008, Wilbarger and Feierabend 2009).

Table 5. Gross area infested by year and location (hectares) (Data from Alaska EPMT 2010a). NM = Not Mapped.

Location	In Park	2004	2005	2006	2007	2008	2009
Chilkoot Trail	Yes	1.49	0.23	0.28	0.06	NM	0.03
Dyea	Yes	1.04	0.23	0.38	0.46	0.81	1.31
White Pass	Yes	13.15	NM	NM	NM	0.06	<0.01
Total Inside Park:		15.67	0.46	0.66	0.52	0.87	1.34
Skagway	Part	1.89	2.33	2.14	1.33	0.98	6.82
Dyea Road	No	0.89	0.15	0.05	0.17	0.92	0.70
Klondike Highway	No	NM	NM	NM	NM	0.94	0.01
White Pass Railroad	No	8.09	NM	NM	NM	NM	NM
Total Outside Park:		10.88	2.48	2.18	1.50	2.84	7.53
Grand Total:		26.55	2.94	2.84	2.02	3.71	8.87

A complete list of species presence by reporting area and year can be found in Appendix A. One location in the Dyea area which has received particular attention is the Nelson Slough. In 2004, fill was brought in for the Nelson Slough wetland restoration site. The fill unknowingly contained seeds of several invasive species. Twenty-one invasive species have been identified in this location since 2004. Recent management efforts appear to be containing the problem, and native plants in a restoration site in Nelson Slough are thriving (Wilbarger and Feierabend 2009).

<u>Weighted Invasive Score</u>

Methodology for calculatating a weighted invasive score (WIS) is currently under development in KLGO. For the purpose of this report and to further the development process, the following methods were used to calculate an invasive score weighted by the areal extent of each plant species for each park unit and all of KLGO. The methods described here were used to provide an indication of the general state of invasive plants and could be used to measure change in the future. The equation for calculating the WIS might change in the future pending review and/or new information.

The GIS database from the Alaska EPMT (2010a) was used to calculate total gross infested area for each plant species in each EPMT reporting area. To account for the variation in areas surveyed each year, the GIS dataset representing the maximum infestation extent through 2009 was used. The invasive rank for each species was provided in Carlson et al. (2008). Not all species found in KLGO were assigned a ranking in Carlson et al (2008). This lack of ranking does not imply a lack of invasiveness; rather, some species were not prioritized for ranking in this report. Species without an invasive ranking were excluded from the calculation of the weighted invasive score. The equation used to calculate the weighted score is:

$$\text{Weighted Invasive Score (WIS)} = \frac{\sum(\text{Area}_{sp} * \text{Rank}_{sp})}{\sum(\text{Area}_{sp})}$$

In addition to the weighted invasive score, the number of invasive species found in each reporting area was determined and the five species with the highest invasive scores were identified.

The weighted invasive scores range from 45 to 59, with the Skagway reporting area having the highest score (Table 6). Of the three locations inside the park, Dyea reports the highest number of invasive species but has the lowest weighted invasive score. Reed canary grass is the highest ranked invasive species and has been found in White Pass, as well as along Dyea Road and Klondike Highway.

Table 6. Weighted invasive score (WIS), number of invasive species, and top five invasive species (by rank) for each EPMT reporting area (Data from Alaska EPMT 2010a). Invasive ranking (in parentheses) from Carlson et al. (2008).

Reporting Area	WIS	Species	Top Five by Invasive Rank
Chilkoot Trail	55	8	1. white clover *(Trifolium repens)* (59)
			2. dandelion *(Taraxacum officinale ssp. officinale)* (58)
			3. tall buttercup *(Ranunculus acris)* (54)
			4. creeping buttercup *(Ranunculus repens)* (54)
			5. Kentucky bluegrass *(Poa pratensis)* (52)
Dyea	45	22	1. yellow toadflax *(Linaria vulgaris)* (69)
			2. oxeye daisy *(Leucanthemum vulgare)* (61)
			3. white clover *(Trifolium repens)* (59)
			4. dandelion *(Taraxacum officinale ssp. officinale)* (58)
			5. Alsike clover *(Trifolium hybridum)* (57)
White Pass	56	17	1. reed canary grass *(Phalaris arundinacea)* (83)
			2. yellow toadflax *(Linaria vulgaris)* (69)
			3. foxtail barley *(Hordeum jubatum)* (63)
			4. smooth brome *(Bromus inermis)* (62)
			5. oxeye daisy *(Leucanthemum vulgare)* (61)

Table 6. Weighted invasive score (WIS), number of invasive species, and top five invasive species (by rank) for each EPMT reporting area (Data from Alaska EPMT 2010a). Invasive ranking (in parentheses) from Carlson et al. (2008). (continued).

Reporting Area	WIS	Species	Top Five by Invasive Rank
Skagway	59	33	1. ornamental jewelweed *(Impatiens glandulifera)* (82) 2. white sweet-clover *(Melilotus alba)* (81) 3. Canada thistle *(Cirsium arvense)* (76) 4. perennial sowthistle *(Sonchus arvensis)* (73) 5. bird vetch *(Vicia cracca)* (73)
Dyea Road	54	14	1. reed canary grass *(Phalaris arundinacea)* (83) 2. oxeye daisy *(Leucanthemum vulgare)* (61) 3. white clover *(Trifolium repens)* (59) 4. dandelion *(Taraxacum officinale ssp. officinale)* (58) 5. common tansy *(Tanacetum vulgare)* (57)
Klondike Highway	55	20	1. reed canary grass *(Phalaris arundinacea)* (83) 2. perennial sowthistle *(Sonchus arvensis)* (73) 3. foxtail barley *(Hordeum jubatum)* (63) 4. smooth brome *(Bromus inermis)* (62) 5. oxeye daisy *(Leucanthemum vulgare)* (61)
White Pass Railroad	56	6	1. yellow toadflax *(Linaria vulgaris)* (69) 2. white clover *(Trifolium repens)* (59) 3. dandelion *(Taraxacum officinale ssp. officinale)* (58) 4. sheep sorrel *(Rumex acetosella)* (51) 5. plantain *(Plantago major)* (44)
Inside Park	54	28	1. reed canary grass *(Phalaris arundinacea)* (83) 2. yellow toadflax *(Linaria vulgaris)* (69) 3. foxtail barley *(Hordeum jubatum)* (63) 4. smooth brome *(Bromus inermis)* (62) 5. oxeye daisy *(Leucanthemum vulgare)* (61)
Outside Park	58	41	1. reed canary grass *(Phalaris arundinacea)* (83) 2. ornamental jewelweed *(Impatiens glandulifera)* (82) 3. white sweet-clover *(Melilotus alba)* (81) 4. Canada thistle *(Cirsium arvense)* (76) 5. perennial sowthistle *(Sonchus arvensis)*; bird vetch *(Vicia cracca)* (73)
All Reporting Areas	56	46	1. reed canary grass *(Phalaris arundinacea)* (83) 2. ornamental jewelweed *(Impatiens glandulifera)* (82) 3. white sweet-clover *(Melilotus alba)* (81) 4. Canada thistle *(Cirsium arvense)* (76) 5. perennial sowthistle *(Sonchus arvensis)*; bird vetch *(Vicia cracca)* (73)

The above methodology does not consider percent cover in the calculation of the weighted invasive score. The GIS dataset representing the gross maximum infestation extent through 2009 does not include percent cover information, perhaps because percent cover can change from year to year. Weighted invasive scores calculated for each year would not necessarily be comparable due to variations in survey area and effort; however, to explore the consideration of percent cover, a weighted invasive score was calculated for 2009 using the following revised equation:

$$\text{Weighted Invasive Score (WIS)} = \frac{\sum(\text{Area}_{sp} * \text{Percent Cover}_{sp} * \text{Rank}_{sp})}{\sum(\text{Area}_{sp} * \text{Percent Cover}_{sp})}$$

The results for 2009 are presented in Table 7.

Table 7. Weighted invasive score (WIS) for 2009 using the revised equation including percent cover, number of invasive species, and top five invasive species (by rank) for each EPMT reporting area (Data from Alaska EPMT 2010a). Invasive ranking (in parentheses) from Carlson et al. (2008).

Reporting Area	WIS	Species	Top Five by Invasive Rank
Chilkoot Trail	57	2	1. dandelion *(Taraxacum officinale ssp. officinale)* (58) 2. tall buttercup *(Ranunculus acris)* (54)
Dyea	54	10	1. yellow toadflax *(Linaria vulgaris)* (69) 2. oxeye daisy *(Leucanthemum vulgare)* (61) 3. white clover *(Trifolium repens)* (59) 4. dandelion *(Taraxacum officinale ssp. officinale)* (58) 5. bigleaf lupine (*Lupinus polyphyllus*) (55)
White Pass	83	1	1. reed canary grass *(Phalaris arundinacea)* (83)
Skagway	58	24	1. ornamental jewelweed *(Impatiens glandulifera)* (82) 2. white sweet-clover *(Melilotus alba)* (81) 3. Canada thistle *(Cirsium arvense)* (76) 4. perennial sowthistle *(Sonchus arvensis)* (73) 5. bird vetch *(Vicia cracca)* (73)
Dyea Road	56	7	1. reed canary grass *(Phalaris arundinacea)* (83) 2. oxeye daisy *(Leucanthemum vulgare)* (61) 3. dandelion *(Taraxacum officinale ssp. officinale)* (58) 4. common tansy *(Tanacetum vulgare)* (57) 5. *Crepis tectorum, Ranunculus acris,* and *Rananculus repens* (54)
Klondike Highway	83	2	1. reed canary grass *(Phalaris arundinacea)* (83) 2. perennial sowthistle *(Sonchus arvensis)* (73)
Inside Park	54	11	1. reed canary grass *(Phalaris arundinacea)* (83) 2. yellow toadflax *(Linaria vulgaris)* (69) 3. oxeye daisy *(Leucanthemum vulgare)* (61) 4. white clover *(Trifolium repens)* (59) 5. dandelion *(Taraxacum officinale ssp. officinale)* (58)
Outside Park	58	25	1. reed canary grass *(Phalaris arundinacea)* (83) 2. ornamental jewelweed *(Impatiens glandulifera)* (82) 3. white sweet-clover *(Melilotus alba)* (81) 4. Canada thistle *(Cirsium arvense)* (76) 5. perennial sowthistle *(Sonchus arvensis)*; bird vetch *(Vicia cracca)* (73)
All Reporting Areas	57	26	1. reed canary grass *(Phalaris arundinacea)* (83) 2. ornamental jewelweed *(Impatiens glandulifera)* (82) 3. white sweet-clover *(Melilotus alba)* (81) 4. Canada thistle *(Cirsium arvense)* (76) 5. perennial sowthistle *(Sonchus arvensis)*; bird vetch *(Vicia cracca)* (73)

Stressors
Several vectors for invasive species exist in or near KLGO, many of which are related to tourism (Moynahan and Johnson 2008). Thousands of people from all over the world visit Skagway each year. Visitors travel through the park and on adjacent land by foot, rail, car, plane, horseback, and bicycle (Wilbarger and Feierabend 2009). The White Pass and Yukon Route Railroad travels from Skagway through the White Pass Unit, and railroads are a well known vector of invasive species (Carlson et al. 2006). The long corridors of disturbed ground can harbor invasive species, from which seed can spread into adjacent native plant communities (Carlson et al. 2006). The invasive species Splitlip hempnettle (*Galeopsis bifida*) was found during the 2002 and 2003 vascular plant surveys along the White Pass Railroad near Heney (Carlson et al. 2006).

The presence of invasive species on land adjacent to KLGO is also a threat. KLGO's three units are surrounded by land that is owned by a variety of entities and is used in multiple ways. As a result, addressing invasive species before they reach the park boundary requires the coordination of several landowners.

Climate change is likely to influence the further establishment of invasive species (Moynahan and Johnson 2008). Climate warming trends have been observed in much of Alaska, and climate models project continued warming in the future (Moynahan and Johnson 2008, Scenarios Network for Alaska Planning 2009). Alaska's relatively cold climate has provided some protection from invasives, but as climate warms the threat of these species is likely to increase (Moynahan and Johnson 2008).

Reporting Zones
Seven Alaska EPMT reporting areas exist in and near KLGO (Plate 2). The White Pass reporting zone is equivalent to the Alaska EPMT White Pass reporting area. The Chilkoot Trail reporting zone is comprised of the Dyea and Chilkoot Trail Alaska EPMT reporting areas. The Skagway reporting zone is part of the much larger Alaska EPMT Skagway reporting area. Klondike Highway and White Pass Railroad EPMT reporting areas are adjacent to the White Pass reporting zone but not within the park boundary. The Dyea Road Alaska EPMT reporting area is adjacent to the Chilkoot Trail Unit but not in the park.

Condition
Invasive plants have been found in all three park units. According to Wilbarger and Feierabend (2009), most invasive plants are in disturbed areas, along roads, and in places where fill material has been imported. In some locations, however, non-native plants are spreading from these disturbed sites into native vegetation communities, and this is a concern. In the Chilkoot Trail reporting zone, some new locations of invasive plants were found in 2009, but some sites with previously established invasive plants were greatly reduced or even locally eradicated. New locations of invasives were managed to prevent seed dispersal, and native species in the Nelson Slough area were thriving (Wilbarger and Feierabend 2009). This management of invasives has resulted in a generally stable trend for the Chilkoot Trail Unit.

Although almost 45% of the mapped exotic species areas occur in the Skagway Alaska EPMT unit, very little of the actual Skagway park unit has been affected by exotic species. The Skagway Unit is assigned a declining trend, however, to draw attention to the condition of invasives in the Skagway area surrounding the unit. Within the Alaska EPMT Skagway reporting area seven new invasive species were found in 2009, and some aggressive species identified in previous years had spread. According to Wilbarger and Feierabend (2009), invasive plants in Skagway "have become an overwhelming problem." The White Pass reporting zone also has a declining trend. Seven new species were found when the unit was last surveyed extensively in 2008. Oxeye daisy and white sweet clover were controlled in portions of the White Pass reporting zone along the Klondike Highway in 2010, and exotic species in the unit remain a concern.

Data Needs
'Invasive/Exotic plants' is a vital sign in the SEAN I&M Program, but the monitoring protocol is still under development (Moynahan and Johnson 2008). Ongoing consistent mapping of invasive species is needed in KLGO to determine changes in condition. An effort is currently underway to rank the remaining species, which is necessary to calculate accurate weighted invasive scores (KLGO D. Schirokauer pers. comm. 2 June 2010).

Literature Cited

Alaska Exotic Plant Management Team. 2010a. AKR_Exotic_Plant_Mgt. GeoDatabase. Dataset. Online. (http://science.nature.nps.gov/nrdata/index.cfm). Accessed 4 June 2010.

Alaska Exotic Plant Management Team. 2010b. Definitions. Online. (http://www.nps.gov/akso/NatRes/EPMT/definitions.html). Accessed 9 July 2010.

Alaska Exotic Plant Management Team. 2010c. Impacts. Online. (http://www.nps.gov/akso/NatRes/EPMT/impacts.html). Accessed 9 July 2010.

Carlson, M. L., Lapina, I. V., Shephard, M., Conn, J. S., Densmore, R., Spencer, P., Heys, J., Riley, J. and J. Nielsen. 2008. Invasiveness ranking system for non-native plants of Alaska. R10, R10-TP-143. USDA Forest Service, Anchorage, Alaska.

Carlson, M. L., M. Sturdy, R. Lipkin, and J. A. Michaelson. 2006. Klondike Gold Rush National Historical Park vascular plant inventory final technical report. NPS Report NPS/AKRSEAN/NRTR-2006/01.

Delost, J. 2004. Exotic plant inventory of Klondike Gold Rush National Historical Park. Natural Resources Management Program, Skagway, Alaska.

Feierabend, D., and D. Schirokauer. 2008. Exotic plant management: Klondike Gold Rush National Historical Park. Natural Resources Management Team, Skagway, Alaska.

Feierabend, D. 2007. Exotic plant management: Klondike Gold Rush National Historical Park. Natural Resources Management Team, Skagway, Alaska.

Furbish, E. 2001. Exotic plant survey of the Chilkoot Trail, KLGO. NPS/RM.

Million, B., and W. Rapp. 2010. Alaska Exotic Plant Management Team 2010 field protocol. National Park Service, Alaska Regional Office, Anchorage, Alaska.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2006. Management policies 2006. ISBN 0-16-076874-8. U.S. Department of the Interior. National Park Service, Washington, D.C., USA.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/downloads/climate-change-summary-reports). Accessed 7 July 2010.

Schultz, D. 2005. Exotic plant management: Klondike Gold Rush National Historical Park. Natural Resources Management Team, Skagway, Alaska.

Schultz, D. 2006. Exotic plant management: Klondike Gold Rush National Historical Park. Natural Resources Management Team, Skagway, Alaska.

Wilbarger, J., and D. Feierabend. 2009. Exotic plant management: Klondike Gold Rush National Historical Park. Natural Resources Management Team, Skagway, Alaska.

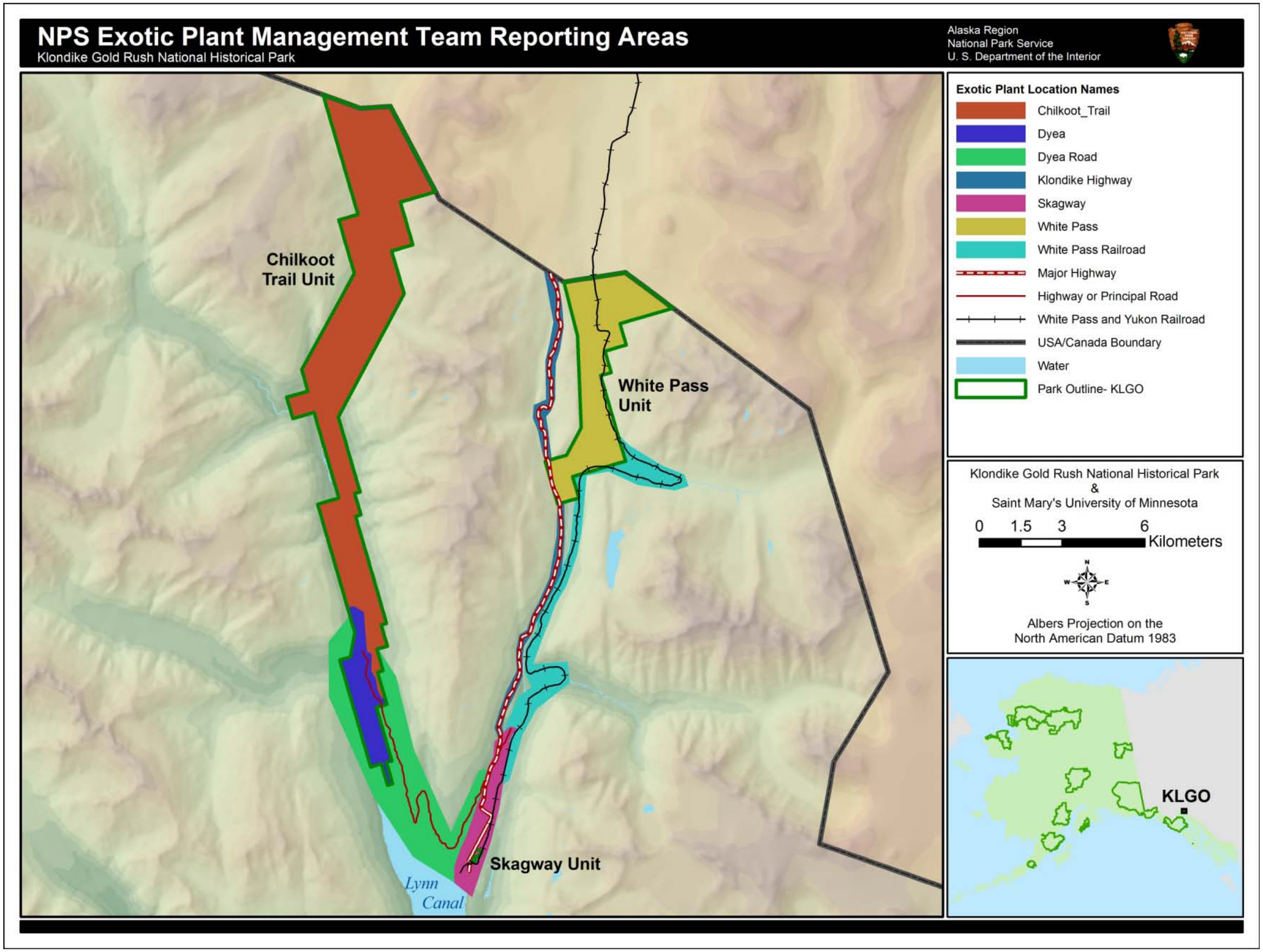
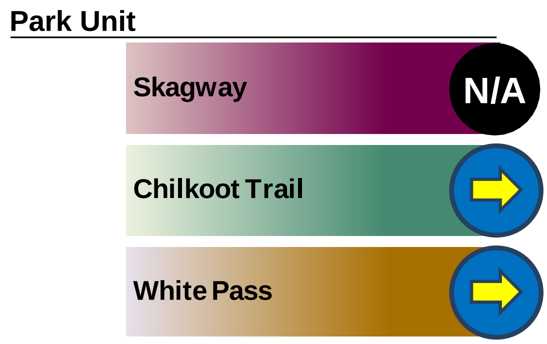


Plate 2. NPS Exotic Plant Management Team reporting areas (Alaska EPMT 2010a, NPS 2009).

4.4 Flora

Measures

Percent of Species Present That are Expected
Species of Concern and Species at the Edge of their Range



Background

The flora of the KLGO area is an integral component of the natural landscape that the park was established to preserve. The flora of this area is exceptionally diverse and also provides context to the historic events of the gold rush as both a challenge to stampede travel and as a raw material for development (Pojar and MacKinnon 2004). The Skagway and Taiya River valleys that gold seekers used to access the interior are also ecologically important locations for species development and exchange. The ice free corridors connecting maritime and intertidal areas to the continental interior, a drier climate compared to most of southeast Alaska, and the park's wetlands are all factors that contribute to floral diversity. The area is home to many boreal species from interior Canada and species with disjunct populations (Pojar and MacKinnon 2004). In addition, the overlap of Beringian plant species migrating southeast from historically unglaciated interior Alaska, as well as species migrating northwest following the retreat of the Laurentide Ice Sheet, add to the species richness in KLGO (Carlson et al. 2006).

KLGO contains areas of forested and non-forested vegetation. Paustian et al. (1994) describes the primary plant communities of KLGO and includes more detailed descriptions than what is summarized here for the purpose of this report. The most common forested vegetation type in KLGO is the western hemlock series (Paustian et al. 1994). Western hemlock (*Tsuga heterophylla*) dominates upland sites that are characterized by unrestricted drainage and lack of exposed mineral soil. The two main understory types within western hemlock communities are blueberry (*Vaccinium spp.*), which occurs primarily on well drained mountain sides with slopes less than 50% and elevation less than 350 meters, and rusty menziesia (*Menziesia ferruginea*), which is also found on mountain sides but at higher elevations (200 to 475 meters).

Mountain hemlock (*Tsuga mertensiana)* replaces western hemlock in the subalpine zone, becoming more and more stunted as conditions become colder and windier (Paustian et al. 1994). Subalpine fir (*Abies lasiocarpa),* which is a species found in greater abundance in KLGO than in the rest of the Tongass forest, can also be found in the subalpine zone. Other species occurring in this community include western hemlock, Sitka spruce (*Picea sitchensis),* which along with cottonwood (*Populus trichocarpa*) dominates the lowlands, paper birch (*Betula papyrifera*), rusty menziesia, and blueberry.

Sites experiencing periodic disturbance events such as floods or avalanches are often home to the Sitka spruce series, which require mineral soil and more sunlight than hemlock. The primary locations for the Sitka spruce series in KLGO are in floodplains, alluvial fan areas, second growth stands where mineral soils have been exposed by windthrow, logged or cleared openings, and in the uplift areas of the Dyea estuary area. Other vegetation in these areas includes devil's club (*Oplopanax horridus),* rusty menziesia, black cottonwood (*Populus trichocarpa*)*,* Sitka alder (*Alnus viridis ssp. sinuate*)*,* and red-osier dogwood (*Cornus stolonifera*).

The final forest series Paustian et al. (1994) describes is subalpine fir. This series is most abundant in higher elevation areas of the White Pass Unit. Two understory types sampled within this series were rusty menziesia, occurring on well drained mountain sides from 430 to 630 meters in elevation, and devil's club, occurring on mountain slopes and foot slopes in well drained areas from 460 to 570 meters in elevation.

Non-forested vegetation communities also exist in KLGO in areas of frequent disturbance and above timberline (Paustian et al. 1994). Beach fringe, comprised of salt and flood tolerant herbs, occur along the seaward boundary of the Chilkoot Trail Unit and are vulnerable to major storms, shifting sands, and continued uplift of the Dyea estuary. The uplifted estuary community is dynamic. Uplift has restricted flooding disturbances, allowing succession to occur. Shrubs and Sitka spruce are encroaching from forested areas into communities of yarrow (*Achillea millefolium*)*,* silverweed (*Potentilla anserina*)*,* beach pea (*Lathyrus japonicas*), sedges *(Cyperaceae* family*),* American dune grass (*Elymus mollis*) and grasses (*Poaceae* family). Additional succession in this area from meadow to scrub/shrub to forest is possible as uplift continues.

Additional non-forested plant communities occur near and above timberline where soil depth and productivity, as well as wind exposure and aspect, affect vegetation distribution and structure (Paustian et al. 1994). At lower more protected locations stunted subalpine fir and mountain hemlock form krummholz communities, which also contain crowberry (*Empetrum nigrum*), starry cassiope (*Cassiope stelleriana*), mountain heather (*Cassiope lycopodioides*), and bunchberry (*Cornus canadensis*). In the harshest environments, especially in the White Pass Unit, communities are primarily rock and lichens. Small forbs are abundant in alpine meadows. Specific species identified in KLGO's alpine meadows include fireweed (*Epilobium angustifolium*), burnet (*Sanguisorba stipulata*), bluejoint grass (*Calamagrostis canadensis),* long-awn sedge (*Carex macrochaeta),* and lady fern (*Athyrium felix-femina*). Heath communities found in KLGO include crowberry, luetkea (*Luetkea pectinata*), mountain heather, and starry cassiope species.

Reference Condition

The numerous natural factors that affect flora composition and health, the lack of complete historical knowledge of flora in KLGO, and the park's unique geographic location make it difficult to quantify reference condition at this time. An important quality of KLGO flora is its well documented diversity. In fact, Pojar and MacKinnon (2004) claim the head of the Lynn Canal to be Alaska's greatest center for plant diversity. Following an extensive vascular plant survey in 2002 and 2003, the list of expected species in KLGO grew to 747 taxa with 86% confirmed (Carlson et al. 2006). With that number of taxa, KLGO has more expected and confirmed vascular plant species within its 13,191 acres than nearby Glacier Bay National Park and Preserve has in over three million acres (Carlson et al. 2004, Carlson et al. 2006). A flora database for KLGO is currently under development which combines information from the Carlson et al. (2006) report, the collection database for the park's herbarium, and other selected sources. This database will provide an important resource for tracking confirmed and expected species in the future.

Data

Botanist Robert S. Williams and naturalist Wilfred H. Osgood made the first known botanical collections in KLGO in 1898 and 1899 (Carlson et al. 2006). Swedish botanist Sven Johan Enander made additional extensive collections in the 1920s, but the majority of collections in and around KLGO were not made until the late 1980s and early 1990s (Carlson et al. 2006). Batton and Juday published a report in 1988 of collections on the east side of the Lynn Canal and south of the Skagway River, and in 1994 Paustian et al. (1994) sampled plots in several habitats as part of an ecological reconnaissance inventory. A range of additional information about KLGO flora exists in the form of field study notes, historic plant species lists, and natural history observations by staff and visitors.

The most recent and significant data collections of flora in KLGO occurred in 2002 and 2003 when the I&M Program supported vascular plant surveys "to document the occurrence, distribution, and relative abundance of plants occurring in the Southeast Alaska Network" in order to provide baseline information for future monitoring and management (Carlson et al. 2006). The Alaska Natural Heritage Program from the University of Alaska, Anchorage conducted field inventories in each SEAN park. The goal was to document 90% or more of the vascular plant species expected to occur in these parks and improve understanding of species distributions. After developing a list of expected plant taxa for KLGO (747 taxa), site visits were made to locations chosen to represent diverse habitats. Multiple collection sites were visited within each of ten eco-geographic regions: Dyea/West Creek, Finnegan's Point, West Canyon City, North Canyon City/Pleasant Camp, Sheep Camp, Long Hill, The Scales/Chilkoot Summit, South Wales Pass, West White Pass/Dead Horse Gulch, and East White Pass. More than 280 plant specimens, including 55 new park records, were collected, identified, and pressed (Carlson et al. 2006).

It is worth noting that a GIS database was created as a result of the 2002 and 2003 vascular plant inventory (Michaelson et al. 2004). This database includes several shapefiles depicting collection site locations (Plate 3). Some shapefiles depict historical collection locations by the University of Fairbanks Herbarium and a park collection by Claudia Rector, former Natural Resources Program Manager at the park. Also included are data collection spreadsheets and site photos. This is a useful resource for anyone investigating flora in KLGO.

A wetland inventory by Bosworth (2000) included compilation of a list of 'rare or sensitive' plant species that would potentially be present in the wetland study area near Dyea. A list of the plant species that were found and not found is included as an appendix to the report. This information is not summarized as part of the NRCA but is a resource which could be evaluated for its potential contribution to the understanding of flora in KLGO.

Measures

Percent of Species Present That are Expected

During the 2002 and 2003 vascular plant surveys, 283 specimens representing 174 taxa were collected, recorded, pressed, and curated (Carlson et al. 2006). Fifty-five taxa were new park records, and ten were confirmations of taxa previously reported but unvouchered. The new collections increased the number of confirmed taxa relative to expected taxa to 86% (Carlson et al. 2006). This was an increase from 78% of confirmed expected taxa prior to the 2002 and 2003 inventories. Carlson et al. (2006) believes five to ten additional taxa could likely be added to the confirmed taxa list with an additional field season collecting plants in novel habitats and geographic regions. The flora database under development currently contains 1,006 species (KLGO 2010). See Appendix B for the draft species list.

Species of Concern and Species at the Edge of Their Range

Carlson et al. (2006) defines plant species of concern as those that are threatened, endangered, rare, and exotic. Exotic species are identified in Carlson et al. (2006) and are addressed separately in the invasives and exotics section of this report.

Carlson et al. (2006) identified two taxa of conservation concern within KLGO: pink mountain-heather *(Phyllodoce empetriformis)* and Kamtchatka spike rush *(Eleocharis kamtschatica)*. Pink mountain-heather, a low, matted, evergreen shrub, was found during a survey in the White Pass area. The plant's open nodding flowers are rose-pink, and its leaves are shiny and needlelike (Carlson et al. 2006). The Alaska Natural Heritage Program (2008) considers this taxon to be demonstrably secure globally but with cause for long-term concern. It is ranked as imperiled to critically imperiled within the state of Alaska (Alaska Natural Heritage Program 2008). The distribution of the taxon includes occasional sites in the mountains of California and Wyoming and northwest through Washington and British Columbia, only entering Alaska at the head of the Lynn Canal (Carlson et al. 2006). Despite a relatively large range, the plant is found exclusively in specific and uncommon high-elevation habitats. Although scientists are not certain what mechanism explains the taxon's current distribution, its existence in KLGO highlights the importance of

Photo 9. Pink mountain-heather (Source: Gary A. Monroe, USDA-NRCS PLANTS Database).

the park as a corridor for species interchange (Carlson et al. 2006).

Kamtchatka spike rush is ranked by the Alaska Natural Heritage Program (2008) as imperiled to rare or uncommon in Alaska and apparently secure globally but with cause for long-term concern (Carlson et al. 2006). About 30 cm tall and loosely stoloniferous, its culms are tufted and spikes are terminal with a large basal scale encircling the base of the spike (Carlson et al. 2006). The tubercle is nearly the size of the achene, and the stem bases are bright purplish-brown (Carlson et al. 2006). The collection in Dyea is one of several locations the taxon has been found in Alaska. Similar to pink mountain-heather, Kamtchatka spike rush also has a relatively large geographic range (northern Japan, Alaska, British Columbia, Hudson Bay, and the Saint Lawrence River) but few known populations (Carlson et al. 2006). The explanation for this phenomenon is not well understood, and more research is needed to determine the factors which limit its distribution (Carlson et al. 2006).

Photo 10. Kamtchatka spike rush. Herbarium image. Herbarium record by M. Carlson and A. Bethe (2003).

One regionally rare plant that was specifically searched for during the 2002 and 2003 vascular plant surveys but not found was Western saxifrage *(Saxifraga occidentalis)* (Carlson et al. 2006). Western saxifrage is ranked by the Alaska Natural Heritage Program (2008) as demonstrably secure globally but critically imperiled in Alaska. Although relatively common along seasonally moist drainages in British Columbia and south along the sides of the Cascades into Oregon, Idaho, and Nevada, a collection along the Taiya River in KLGO in 1995 and a collection near Ketchikan are the only two known collections in Alaska (Carlson et al. 2006).

Carlson et al. (2006) identified two taxa collections that were moderate range extensions: ryegrass sedge (*Carex loliacea*) and the Beringian species longpod stitchwort (*Minuartia macrocarpa*). Ryegrass sedge is typically found in mires, wet forests, and mossy streams (Carlson et al. 2006). In KLGO, ryegrass sedge was found along muskeg ponds at Sheep Camp and in a small wooded sphagnum fen along Bridal Veil Falls. The two populations in KLGO are located 170 km south of its previous known range, which extended from southwestern Alaska, northeast into the Alaska Range, and then east into the Yukon (Carlson et al. 2006). Not only is this a range extension, but having crossed over the coastal mountains, the locations represent a new physiographic province for the species (Carlson et al. 2006). The ryegrass sedge locations in KLGO suggest that its range expanded from the interior after the retreat of the Boundary Range ice sheets (Carlson et al. 2006).

Longpod stitchwort was collected near Pleasant Camp on a river bar along the Taiya River, which represents a range extension of approximately 150 km to the southeast of locations in the St. Elias Range (Carlson et al. 2006). The only other collection of the taxon in southeast Alaska on the southern side of the Coast Range was made in Glacier Bay (Carlson et al. 2006).

Stressors

A primary threat to flora in national parks is the presence of exotic species (Million and Rapp 2010). Without the competitors and diseases which limit distribution in their home ranges, some exotic plant species can reproduce quickly and disrupt the natural balance of native plant communities (Million and Rapp 2010). Increased development, intermodal transportation, and a warming climate have created conditions in recent years which are more favorable for the spread of exotic species into what was previously considered a relatively protected and pristine state (Million and Rapp 2010). High rates of natural disturbance (floods, avalanches) in KLGO also provide habitat for exotic invasive species. Carlson et al. (2006) discovered several exotic species new to KLGO during the 2002 and 2003 vascular plant surveys. Exotics and invasives are discussed in more detail in the previous section of this report.

Insect and disease outbreaks also stress native plant communities. *Inonotus tomentosus*, a fungus which causes Tomentosus root disease, and spruce bark beetles (*Dendroctonus rufipennis* Kirby) have both been found in the Taiya River Flats near Dyea (Schultz et al. 2007). Although slow spreading, *I. tomentosus* is capable of killing spruce (*Picea spp.)* of all ages and remaining active in the roots of dead trees for up to thirty years, potentially infecting neighboring seedlings and saplings (Schultz et al. 2007). Tomentosus root rot can weaken root systems to the point of causing trees to uproot, thus becoming a public safety issue in addition to a plant health concern (Schultz et al. 2007).

Following the initial discovery of Tomentosus root disease near Dyea in 2004, several plots were established in 2006 to determine the extent of the disease (Schultz et al. 2007). Fourteen of 27 plots and 38 of 142 Sitka spruce (*Picea sitchensis*) trees examined were infected, with the highest infection rates occurring in younger and southern trees (Schultz et al. 2007). Nine percent of all trees inspected had died from Tomentosus root disease. Hardwood trees are not susceptible to Tomentosus root disease, and therefore the proportion of hardwood trees will likely increase in the Taiya Flats area as the disease progresses, with cottonwoods (*Populus spp.*) and willows (*Salix spp.*) likely in wetter areas, and birch (*Betula spp.*) and dogwood (*Cornus spp.*) likely in the drier locations (Schultz et al. 2007). Spruce bark beetle was found on four trees in four separate plots, but researchers believed the population was endemic and not causing significant tree mortality (Schultz et al. 2007).

Reporting Zones

The Skagway reporting zone is considered not applicable for this indicator. Although plants do exist in the Skagway Unit, the unit has been heavily impacted by humans and consists primarily of historic structures. It does not appear that any collections were made within the Skagway Unit during the 2002 and 2003 inventories, but there were a few sample sites close to the unit that were labeled as ‘Skagway’ in the locality attribute.

Carlson et al. (2006) includes detailed discussion of the results of the 2002 and 2003 inventories organized by collection site and by park unit. These discussions include site photographs, maps, site descriptions, and lists of dominant species, which do not lend themselves to brief summarization. The Chilkoot Unit includes the following collection sites: Dyea/West Creek, Finnegan's Point, West Canyon City, North Canyon City/Pleasant Camp, Sheep Camp, Long Hill, and The Scales/Chilkoot Summit. The White Pass Unit contains the South White Pass, West White Pass/Dead Horse Gulch, and East White Pass collection sites. The relationship between park units and plant collection sites is depicted on Plate 3. It appears that spruce bark beetle and Tomentosus root disease have only been observed and studied in Dyea, which is within the Chilkoot Trail reporting zone.

Condition

The condition of flora in the Chilkoot Trail and White Pass reporting zones is good with a stable trend. Spruce bark beetle does not appear to be of significant concern at this time (Schultz et al. 2007). Although Tomentosus root disease has been documented in Dyea, Schultz et al. (2007) were not able to determine the proportion of healthy vs. diseased roots or if the disease was decreasing overall tree growth and health. Despite the unknowns, changes in vegetation within the Taiya River flats are likely as the root disease progresses (Schultz et al. 2007). At this time, the disease has not caused changes substantial enough to elevate condition of flora to a level of concern. Although invasive and exotic plants are an issue in KLGO, they are being actively managed and there have been no reports of native species lost as a result of their presence. The most recent large scale inventory of plants in the park revealed rich species diversity. Skagway is a highly urbanized park unit where vegetation is actively managed and not necessarily natural. Therefore, this reporting zone is considered not applicable for this indicator.

Data Needs

Carlson et al. (2006) recommended three locations and habitats in KLGO for additional vascular plant surveys in an effort to compile a more complete list of park species: the Central White Pass Unit around Dead Horse Gulch, high elevation areas along the borders of the Chilkoot Unit, and White Pass border areas. The primary challenge for surveying these areas is accessibility. Two rare plant species found during the 2002 and 2003 vascular plant surveys, *Phyllodoce empetriformis* and *Eleocharis kamtschatica*, would benefit from increased knowledge regarding their population dynamics and distribution within KLGO (Carlson et al. 2006). Determining the extent of Tomentosus root disease and its relationship (if any) to bark beetle infestation would be useful for understanding potential changes in vegetation within the Taiya River flats area.

Data collection at collocated sites over time is one way to monitor changes in flora. The ecological inventory by Paustian et al. (1994) included numerous sampling sites within the park spanning a range of habitat types. Sampling teams recorded species present and collected specimens for the park's herbarium. Determining the location of these sample sites would be worthwhile for repeat sampling and long term monitoring. The park is also hoping to install Global Observation Research Initiative in Alpine environemnt (GLORIA 2010) plots in the future. These plots are designed to detect climate driven changes in alpine plant communities.

Literature Cited

Alaska Natural Heritage Program. 2008. Rare vascular plant tracking list. Online. (http://aknhp.uaa.alaska.edu/botany/pdfs/2008/Rare%20PLant%20List%202008.pdf). Accessed 7 June 2010.

Bosworth, K. S. 2000. Wetlands of the Dyea area of the Lower Taiya River Valley. Klondike Gold Rush National Historic Park. Skagway, Alaska.

Carlson, M. L., K. Boggs, R. Lipkin, and J. A. Michaelson. 2004. Glacier Bay National Park and Preserve vascular plant inventory final technical report. Alaska Natural Heritage Program, Anchorage, Alaska and National Park Service, Alaska Region Inventory and Monitoring Program, Anchorage, Alaska.

Carlson, M. L., M. Sturdy, R. Lipkin, and J. A. Michaelson. 2006. Klondike Gold Rush National Historical Park vascular plant inventory final technical report. NPS Report NPS/AKRSEAN/NRTR-2006/01.

Global Observation Research Initiative in Alpine Environments. 2010. GLORIA: About GLORIA. Online. (http://www.gloria.ac.at/?a=2). Accessed 17 November 2010.

Klondike Gold Rush National Historical Park. 2010. Plant species inventory. Microsoft Access Database. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Michaelson, J., M. L. Carlson, and R. Lipkin. 2004. User's guide for floristic survey of Klondike Goldrush NP GIS database. Prepared for Alaska National Park Service Inventory and Monitoring Program, Anchorage, Alaska.

Million, B., and W. Rapp. 2010. Alaska exotic plant management team 2010 field protocol. National Park Service, Alaska Regional Office, Anchorage, Alaska.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Pojar, J., and A. MacKinnon. 2004. Plants of the Pacific Northwest coast: Washington, Oregon, British Columbia & Alaska. Rev. ed. Lone Pine Publishing, Canada.

Schultz, M., L. Trummer, and P. Adkins. 2007. Assessment of tomentosus root disease near Dyea, Alaska. R10-S&PF-FHP-2007-1. U.S. Forest Service, Alaska Region, Juneau, Alaska.

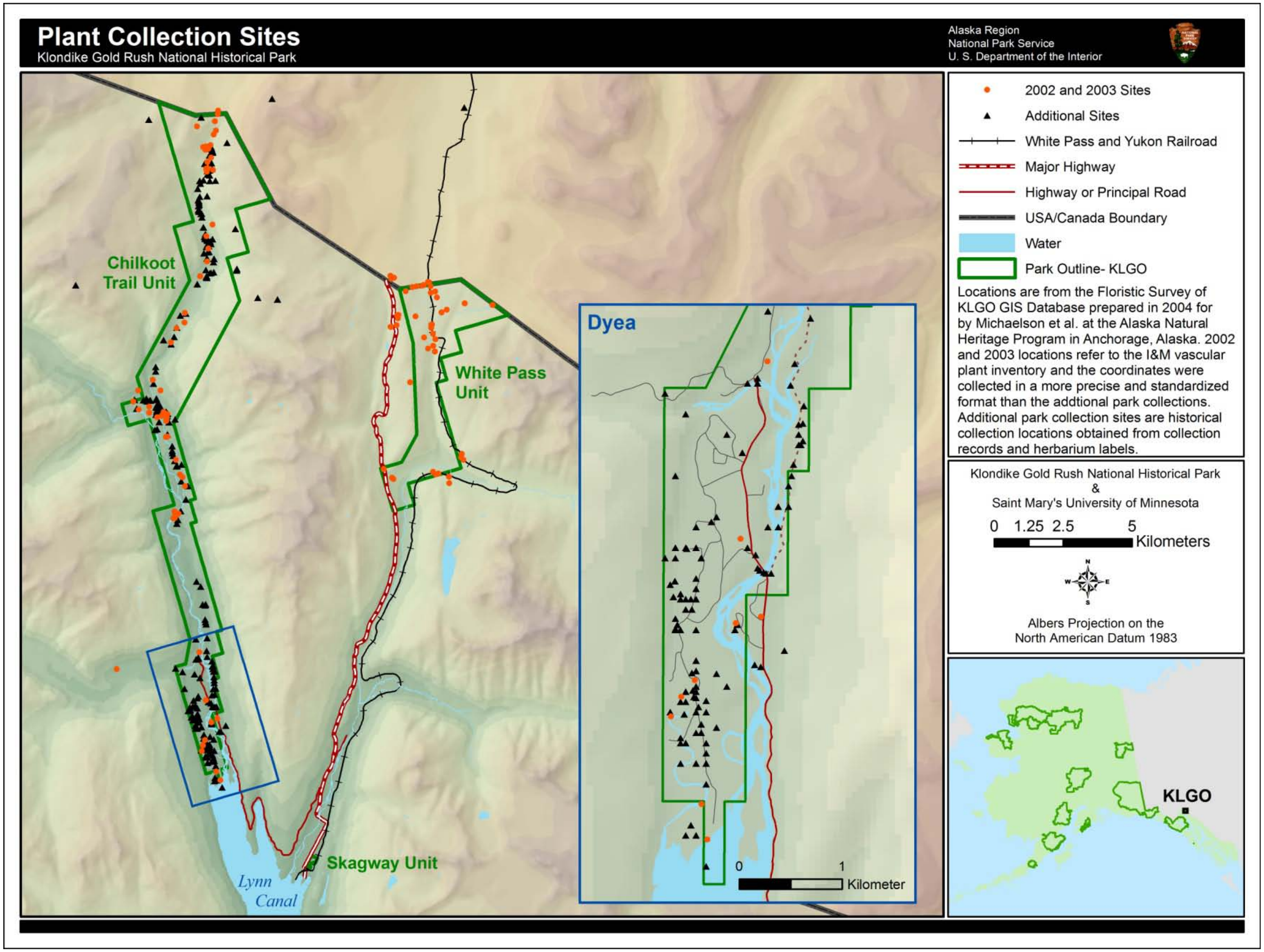
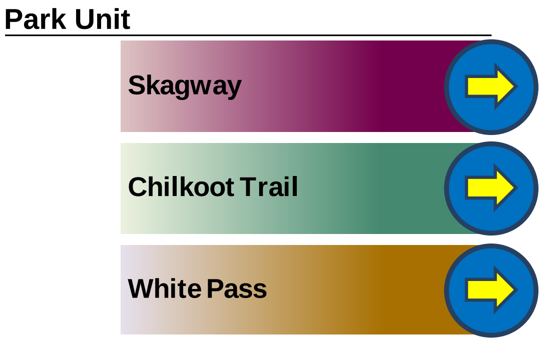


Plate 3. Plant collection sites in KLGO (Michaelson et al. 2004, NPS 2009).

4.5 Breeding Birds

Measures
Number of Species
Diversity



Background
Birds contribute to the overall biological diversity of KLGO and are sensitive indicators of ecosystem change (Hahr and Trapp 2004). KLGO is located within the Northern Pacific Rainforest Bird Conservation Region (BCR) but also borders the Northwestern Interior Forest BCR. Situated in this transition area between regions of varying topography, climate, and vegetation, the park provides habitat for diverse avifauna populations (Hahr and Trapp 2004). Waterbirds and landbirds find breeding habitat in KLGO's river valleys, estuaries, and freshwater wetlands (Hahr and Trapp 2004). Land bordering KLGO in the Northwestern Interior Forest BCR contains high-elevation, mountainous terrain, and alpine vegetation, which provide breeding sites for species that would otherwise rarely breed in the coastal rainforests of southeast Alaska (Hahr and Trapp 2004). Since bird species utilize many ecological niches in KLGO, monitoring bird population health and diversity is important for detecting ecosystem change.

Reference Condition
Knowledge regarding reference condition is limited by the record of bird survey data available. Each bird survey in KLGO, with the exception of the coastal waterbird survey, occurs only once a year. Variability between years is expected, so a long period of record is needed to determine trends. For the NRCA, results from recent years are compared to the entire period of record available for each survey. As surveys continue into the future, a multiyear moving metric could be developed for trend assessment.

A bird species list has been compiled by the Skagway Bird Club and represents the best reference for expected bird species in the park (Skagway Bird Club 2010). The list includes observations from the Skagway Bird Club, Alaska Breeding Bird Survey data, and the KLGO coastal waterbird survey data. Of 201 total species, 18 are confirmed breeders and 17 are probable breeders. This includes eight confirmed or probable breeding waterbirds. A complete list of expected species and their scientific names is provided as Appendix C.

Data

Four ongoing monitoring programs survey birds in and around KLGO each year. The coastal waterbird survey is reported within the coastal bird indicator section of this report. The remaining three surveys occur once a year and are described in more detail below. A summary of survey record and sample design is provided in Table 8. Data for each survey were analyzed using Microsoft Excel and the Biodiversity Calculator (Danoff-Burg and Xu 2005) to calculate measures and statistics reported below.

On Road Breeding Bird Survey (On Road BBS)

The KLGO breeding bird survey route (Route 425) is part of the large-scale international North American Breeding Bird Survey (BBS), which began in 1966 and is coordinated by the USGS and the Canadian Wildlife Service. The standard BBS survey route is approximately 25 miles long with survey points every half mile, resulting in 50 survey points. The survey begins one half hour before the official sunrise, and at each survey point, all birds seen and heard within a quarter mile radius during a three minute interval are recorded. The KLGO route was surveyed once each year by the same observer from 1993 to 1999 and then from 2004 to the present.

The only adjustment made to the BBS data for analysis was in the 2009 dataset. Results for dark-eyed junco (Oregon junco) and dark-eyed junco (slate-colored junco) were combined to create consistency with the other surveys. The Oregon junco and slate-colored junco are regional variations of the same species (*Junco hyemalis*) (USGS 2010d).

Off Road Breeding Bird Survey (Off Road BBS)

The off road breeding bird surveys follow the Alaska Landbird Monitoring System protocols (Handel and Cady 2004). There are two off road breeding bird survey routes in KLGO. Each route has 12 sample locations located at least 250 m apart. At each location, all species detected by sight and sound within a given time period are recorded (KLGO 2009). One survey is conducted each year, typically in mid to late June, and each survey starts one half hour before official sunrise (around 4:00 a.m.). From 2003 to the present, each location was surveyed for ten minutes. Results are divided into zero to three, three to five, five to eight, and eight to ten minute periods for reporting purposes (KLGO 2009). The off road BBS conducted from 1995 to 2002 consisted of a five minute count (divided into zero to three minute and three to five minute intervals).

For analysis of the off road BBS data, some data were omitted to create consistency between survey years. 1995 and 1997 data were omitted, because only one route was surveyed each year. Surveys from 1998 to 2002 were five minutes long, so only the first five minutes of 2003 to 2009 data were used. In 2003, some additional locations were surveyed, but only the routes consistent with the other survey years were included (routes 817 and 818). As in the on road BBS, the Oregon junco was relabeled as dark-eyed junco to create consistency with the other surveys. Any records with the following labels were removed from analysis: no birds, unknown species, unknown woodpecker, unknown corvid, unknown gull, unknown owl, unknown passerine, unknown sandpiper, and red squirrel.

Christmas Bird Count

The Skagway Christmas Bird Count is part of the international Christmas Bird Count, which started in 1900 and is coordinated internationally by the Audubon Society and locally by the Skagway Bird Club. The count has occurred in Skagway from 2003 to the present. Multiple volunteers survey a 15 mile radius on one day between 14 December and 5 January (Figure 5). The number of each species and the total number of survey hours are recorded each year. While this survey does not occur during the breeding season, it still provides useful information regarding bird populations in the park.

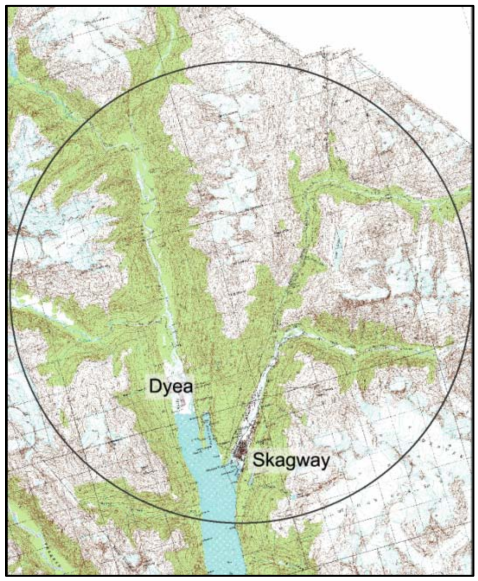


Figure 5. Skagway Christmas Bird Count circle (KLGO, Schirokauer, pers. comm. 21 May 2010).

For analysis of Christmas Bird Count data, some adjustments were made to create consistency. All of the following records were relabeled as dark-eyed junco (Oregon, Slate): dark-eyed junco, dark-eyed Oregon junco, and dark-eyed slate-colored junco. Birds noted as observed during the week of the count but not during the official count day were excluded. All entries without a specific species identification (e.g., merganser sp., gull sp., etc.) were removed for analysis.

Owl Survey

In addition to the three bird surveys above, owl surveys were conducted along the Klondike Highway from 2005 to 2008 as part of a larger southeast Alaska owl study (Kissling and Lewis 2009). The full study includes estimates of detectability, habitat investigations, and the detection of decadal changes in occupancy. Details regarding the protocol and results are available in Kissling and Lewis (2009).

Table 8. Summary of bird surveys in KLGO (KLGO 2009, Audubon Society 2010, USGS 2010a).

Survey	Year of Record	Surveys Per Year	Number of sample sites	Time Per Sample
On Road BBS	1993-1999, 2004-2010	1	25 (one route)	Three minutes
Off Road BBS	1995, 1997 (one route only) 1998-2010 (2 routes)	1	24 to 26 (two routes, 12-13 points each) Extra routes in 2003: White Pass Alpine, Chilkoot Shrub 1, Chilkoot Mid-elevation 2, and Chilkoot Alpine 2	Five minutes for 1995-2002 (zero to three and three to five minute periods reported separately) Ten minutes for 2003-2009 (zero to three, three to five, five to eight, and eight to ten minute periods reported separately)
Christmas Bird Count	2002/3-2009/10	1	One 15-mile radius circle	Within one 24-hour calendar day
Owl	2005-2008	~5	15	Approximately 12 minutes

Measures

<u>Number of Species</u>

In 2003, a park-wide survey of waterbirds and breeding landbirds was conducted. The goal of the inventory was to document the presence of 90% of the waterbird and breeding landbird species likely to occur in KLGO (Hahr and Trapp 2004). In addition to the two established off road BBS routes, twenty-eight survey points were added. These additional points were distributed across the park's elevation and ecological gradients, including six of the seven primary plant associations. Fifty-six bird species were observed during the breeding landbird inventory, including two new species records: merlin (*Falco columbarius*) and American three-toed woodpecker (*Picoides dorsalis*). Forty bird species were observed during the waterbird inventory. Nine new species were confirmed on KLGO's expected species list, and 12 new species were identified that were not on the expected species list (Hahr and Trapp 2004). In total, 158 out of 174 (91%) of the expected waterbird and breeding landbird species in KLGO were confirmed (Hahr and Trapp 2004).

In 2010, an updated expected bird species list was published by the Skagway Bird Club, which included 201 species (excluding varieties and subspecies) (Skagway Bird Club 2010). A complete list of expected species is included as Appendix C. Of the 201 expected species, the presence of approximately 105 unique bird species were documented in 2009 as part of the breeding bird surveys, coastal waterbird surveys, and Christmas Bird Count.

Following any adjustments made to the data described above, species counts for each year for each survey were determined (Figure 6). There does not appear to be a decreasing or increasing trend in species richness observed each year.

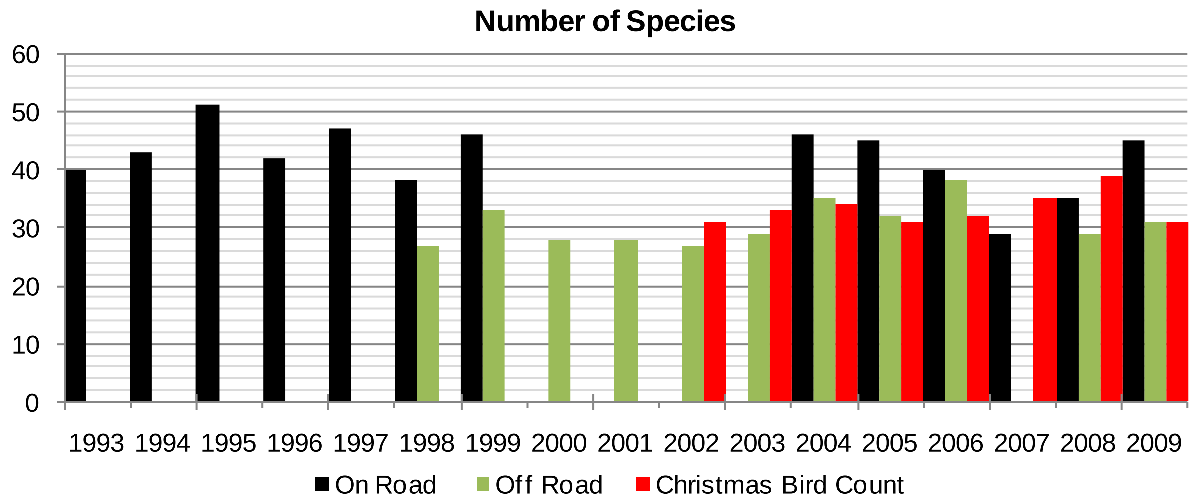


Figure 6. On road BBS, off road BBS, and Christmas Bird Count: Number of species per year (Handel 2009, Audubon Society 2010, USGS 2010a).

In addition to the breeding bird surveys and Christmas Bird Count, five species of owls were observed between 2005 and 2008 (Table 9). This included sightings during 19 owl surveys as well as nine owl sightings reported from the community of Skagway (Skagway Bird Club).

Table 9. Number of owl observations, 2005-2008 (Kissling and Lewis 2009). Results include surveys on 19 nights and nine owl sightings submitted from the community (Skagway Bird Club).

Species:	Barred Owl (*Strix varia*)	Boreal Owl (*Aegolius funereus*)	Northern Pygmy-Owl (*Glaucidium gnoma*)	Northern Saw-whet Owl (*Aegolius acadicus*)	Short-Eared Owl (*Asio flammeus*)
Number:	7	5	6	4	1

The number of individual birds identified during each survey was also determined (Figure 7, Figure 8). In 2009, the largest number of individuals in recent years was observed during the on road BBS (476 birds), but this value was within the range observed from 1993 to 1999. The largest number of birds documented during the off road BBS occurred in 2005 (310 birds). The exceptionally large number of birds identified during the 2007 Christmas Bird Count (4,608 birds) was partly due to a record number of 2,447 Bohemian waxwings (*Bombycilla garrulous*) (Cremata 2008). To normalize by survey effort, the number of birds documented each year during the Christmas Bird Count was divided by the number of survey hours (Figure 8 right).

Photo 11. Bohemian waxwing (NPS 2010).

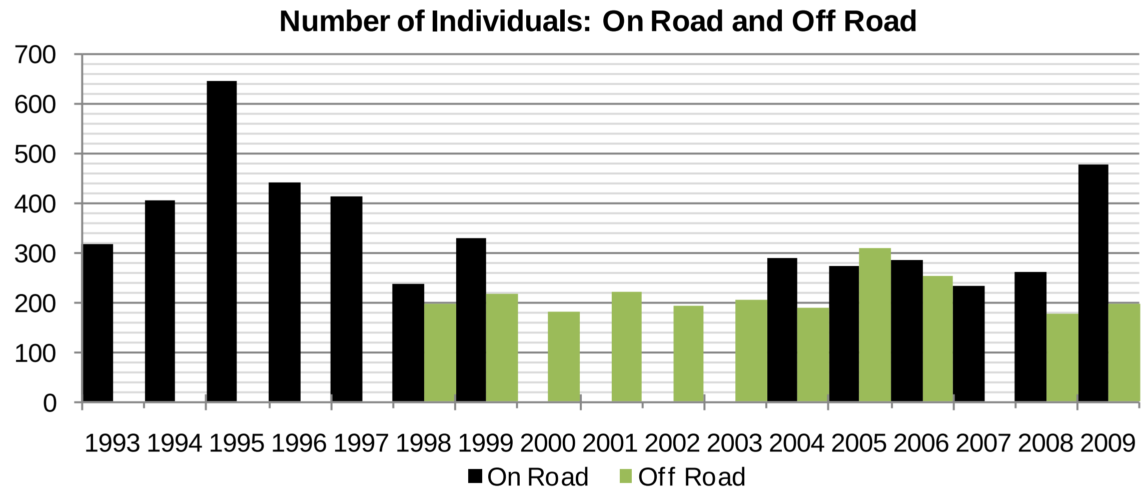


Figure 7. On road BBS and off road BBS: Number of individuals per year (Handel 2009, USGS 2010a).

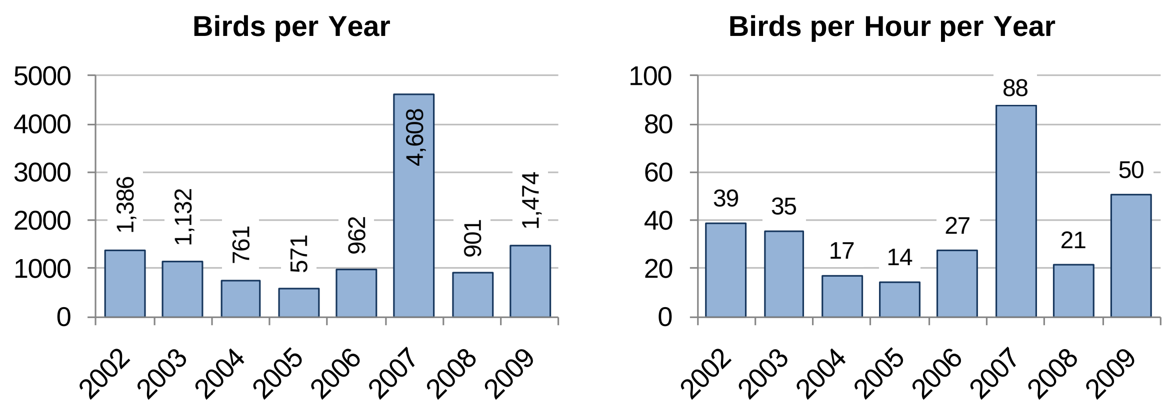


Figure 8. Skagway Christmas Bird Count: Number of individuals per year (left) and average number of birds per survey hour per year (right) (Audubon Society 2010). The spike in 2007 is partly due to an unusually high count of Bohemian waxwings (2,447).

Diversity Index

The Simpson diversity index was calculated for each year and each survey (Figure 9). Considered one of the most meaningful and robust diversity measures available, the Simpson diversity index (D) represents the probability of any two individuals drawn randomly from a community belonging to the same species (Magurran 2004). As D increases, diversity decreases; this is why the index is often reported as 1/D. The value of 1/D will increase as the community becomes more even.

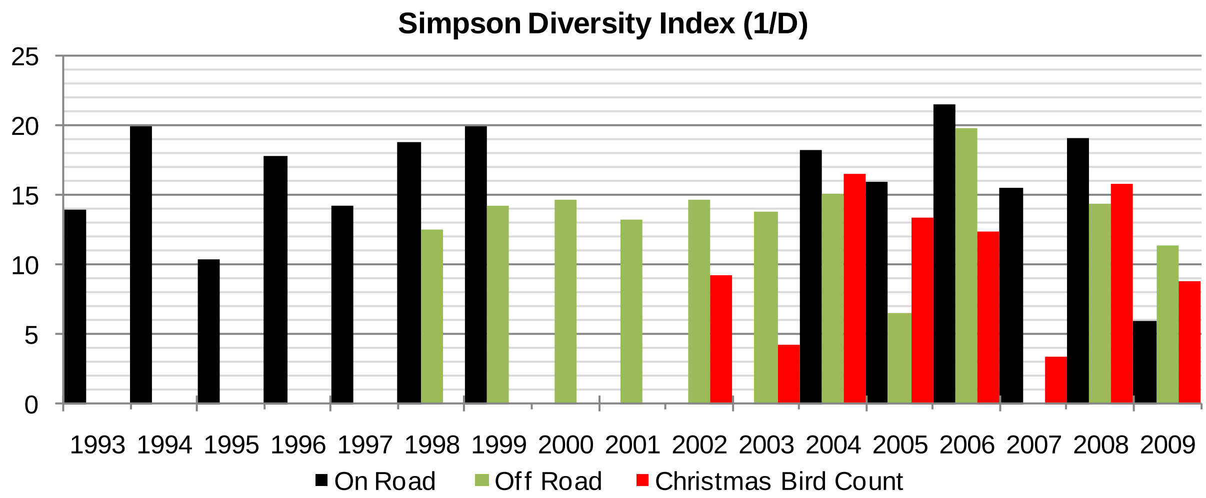


Figure 9. On road BBS, off road BBS, and Christmas Bird Count: Simpson diversity index (1/D) per year (Handel 2009, Audubon Society 2010, USGS 2010a).

The most abundant species in a community strongly influence the Simpson index. As an alternative measure of diversity for comparison, the Q statistic was also calculated (Figure 10). The Q statistic is calculated from the interquartile slope of the cumulative species abundance curve, and therefore is not biased by the very abundant or very rare species in the community (Magurran 2004). A higher value indicates a more diverse assemblage. Values of the Q diversity statistic in recent years were within the range of values reported during the entire period of record (Figure 10).

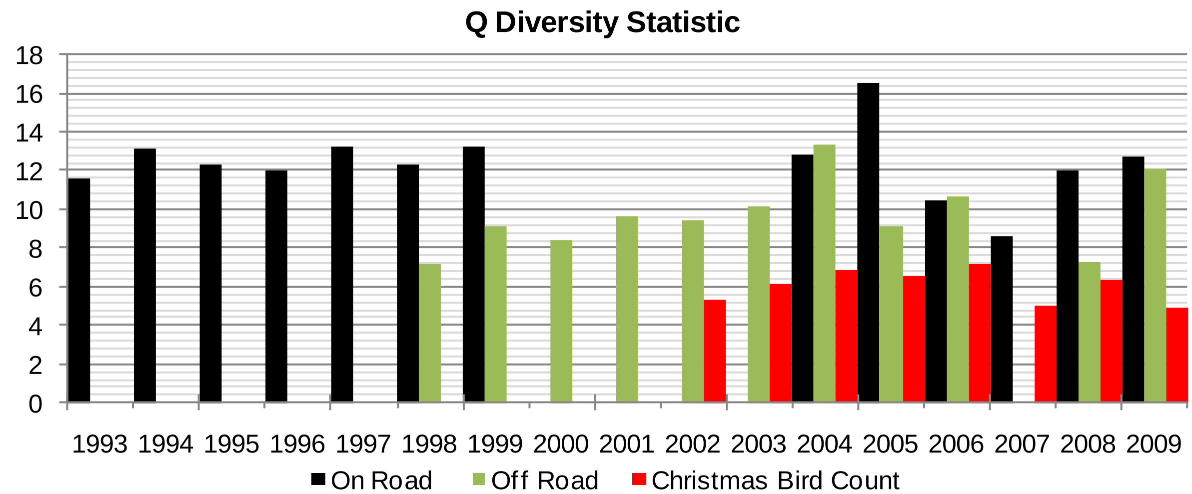


Figure 10. On road BBS, off road BBS, and Christmas Bird Count: Q diversity statistic per year (Handel 2009, Audubon Society 2010, USGS 2010a).

Jackknifing is a method which improves the estimate of many statistics and can be applied to the Simpson diversity measure (Magurran 2004). A jackknifed estimate of Simpson diversity was calculated for each off road BBS survey year using results from each survey point (Figure 11). An abnormally high number of northwestern crows (*Corvus caurinus*) observed at one point in 2005 greatly skewed the result. This value was replaced by the average number of northwestern crows observed at the same point every other year, and the statistic was recalculated. This adjustment is reflected in Figure 11. Except for 2006, all jackknifed values of Simpson diversity were within one standard error of every other year.

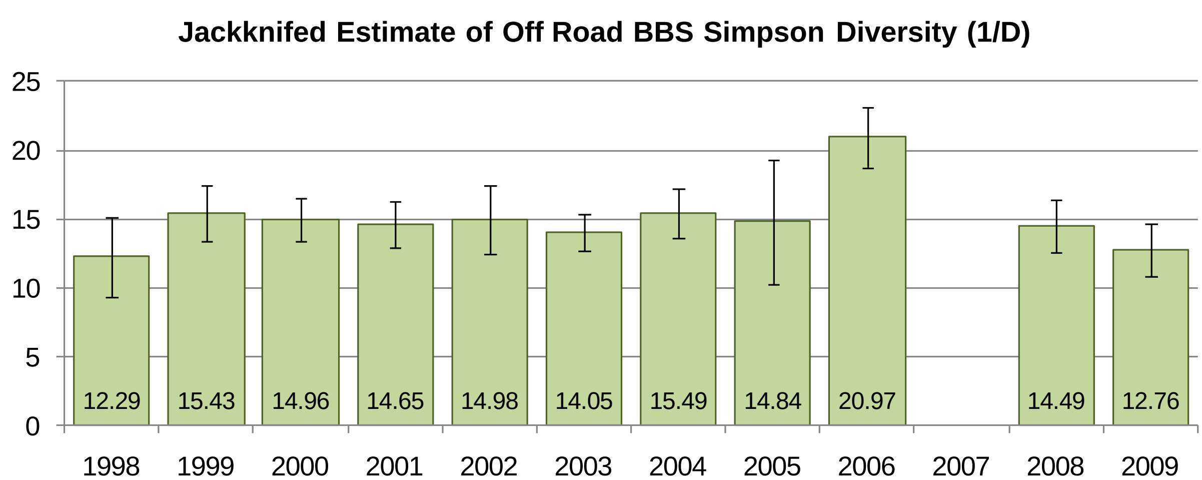


Figure 11. Off road BBS: Jackknifed estimate of Simpson diversity (1/D), 1998-2009 (Handel 2009). Bars represent plus and minus one standard error.

To further explore diversity, the Simpson evenness measure was calculated for each census year (Figure 12). Evenness is calculated by dividing the reciprocal of D by the number of species in the sample (Magurran 2004):

$$\text{Simpson Evenness } (E_{1/D}) = \frac{(1/D)}{\text{the number of species in the sample}}$$

The value of Simpson evenness ranges from zero to one, with one having a completely even distribution of individuals among species. As the value of the measure moves closer to zero, there is a less equal distribution of individuals per species in the sample. The measure is not sensitive to species richness (Magurran 2004). Results show a high variation between years and no discernable trend.

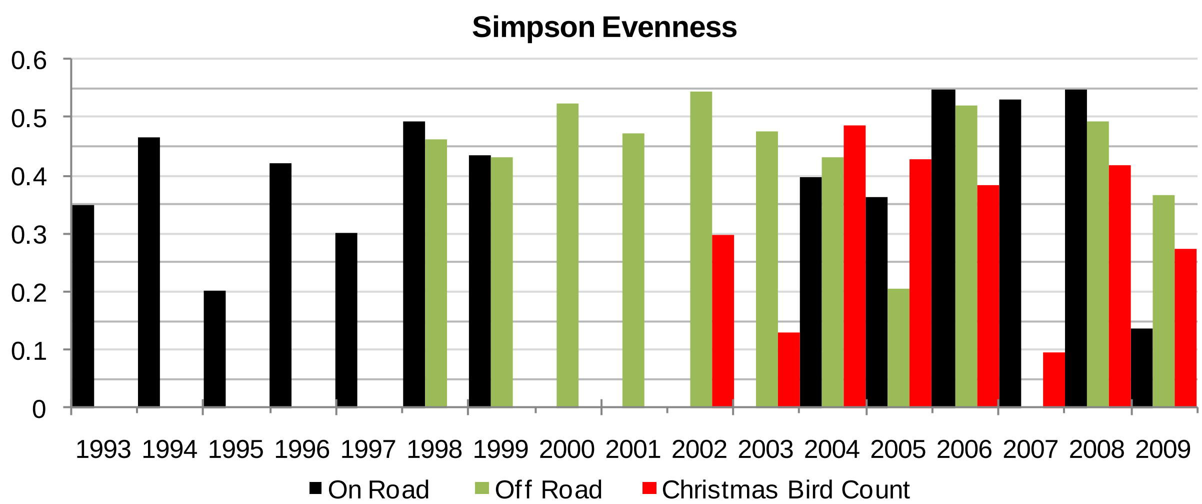


Figure 12. On road BBS, off road BBS, and Christmas Bird Count: Simpson evenness per year (Handel 2009, Audubon Society 2010, USGS 2010a).

<u>Change in Abundance</u>

To investigate trends in individual species abundance, a regression analysis was conducted using the off road BBS data and the on road BBS data. This was only an exploratory exercise to discern which species may be deserving of further study. Many problems exist with using a single BBS route to detect change in abundance; sample sizes are very small, relative abundances are low, and trends are imprecise (USGS 2010b). For this analysis, only those species with an annual average abundance per survey greater than one were included. Coefficients of determination (R^2) were generally low. Each survey reported five species with R^2 values greater than 0.30 and either a slope greater than one or a slope greater than ten percent of the species' average abundance (Figure 13, Figure 14).

Fewer hermit thrush *(Catharus guttatus)*, MacGillivray's warbler *(Oporornis tolmiei)*, fox sparrow *(Passerella iliaca)*, and orange-crowned warbler *(Vermivora celata)* were observed in recent years when compared to the past. None of these species are listed on the Audubon WatchList as a species of concern or the USFWS Alaska region list of birds of conservation concern (USFWS 2008, Kirchhoff and Padula 2010). In addition, no significant trends for these birds have been documented in Alaska using available on road BBS route data for the state (USGS 2010c). More research is needed to determine if this local decline in observations is a concern, a reflection of natural variability, or a result of sampling error. Arctic tern *(Sterna paradisaea)* abundance appears to have increased since the survey began. This species is on the USFWS list of birds of conservation concern for Alaska, but it is not listed on the Audubon WatchList (USFWS 2008, Kirchhoff and Padula 2010). A regional breeding bird survey trend for arctic tern in Alaska is not available (USGS 2010c).

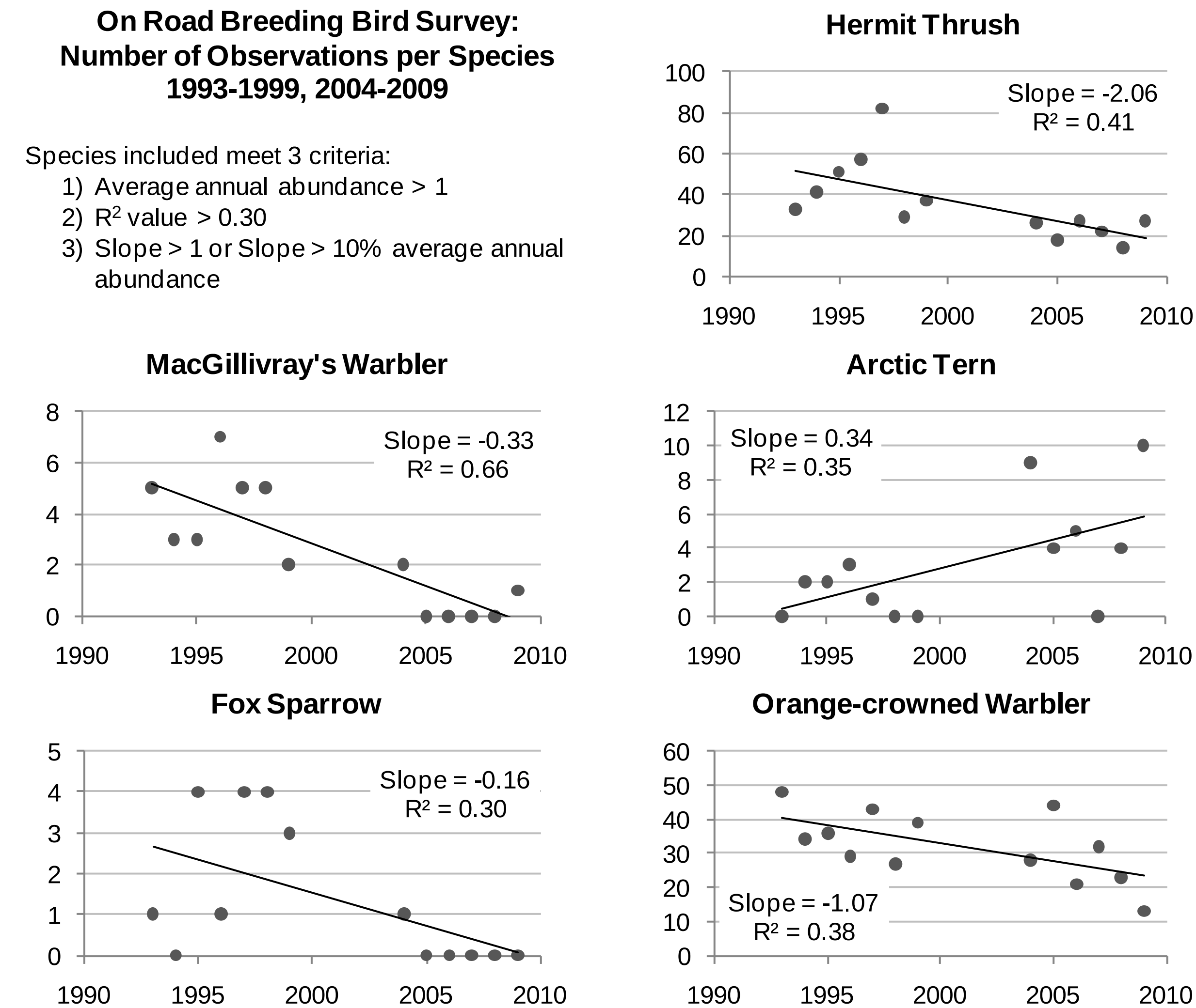


Figure 13. On road BBS: Number of observations per species, 1993 to1999 and 2004 to 2009 (USGS 2010a). Only those species with an average abundance greater than one, R^2 greater than 0.30, and a slope greater than one or a slope greater than 10% of its average annual abundance are included.

A lower number of northern waterthrush *(Seiurus noveboracensis)*, Myrtle warbler *(Dendroica coronata coronata)*, and American robin (*Turdus migratorius*) were observed during the off road BBS in recent years compared to the past. These three species are not birds of conservation concern in Alaska, and on road breeding bird surveys in Alaska have found no significant trend since 1980 for these species (USFWS 2008, Kirchhoff and Padula 2010, USGS 2010c).

Observed abundance of Townsend's warbler *(Dendroica townsendi)* and glaucous-winged gulls *(Larus glaucescens)* has increased since 1999. A similar trend has not been found in Alaska using multiple on road BBS routes (USGS 2010c).

The apparent decline of the Myrtle warbler may actually be a result of a change in reporting. Until recently, the Myrtle warbler and the Audubon's warbler (*Dendroica coronata auduboni*) were thought to be two distinct species, but now they are both referred to as yellow-rumped warblers (*Dendroica coronata*) (Audubon Society 2009). Observations of yellow-rumped warblers appear to have increased around 2003 when the Myrtle warbler apparently declined suggesting a change in name rather than a change in abundance.

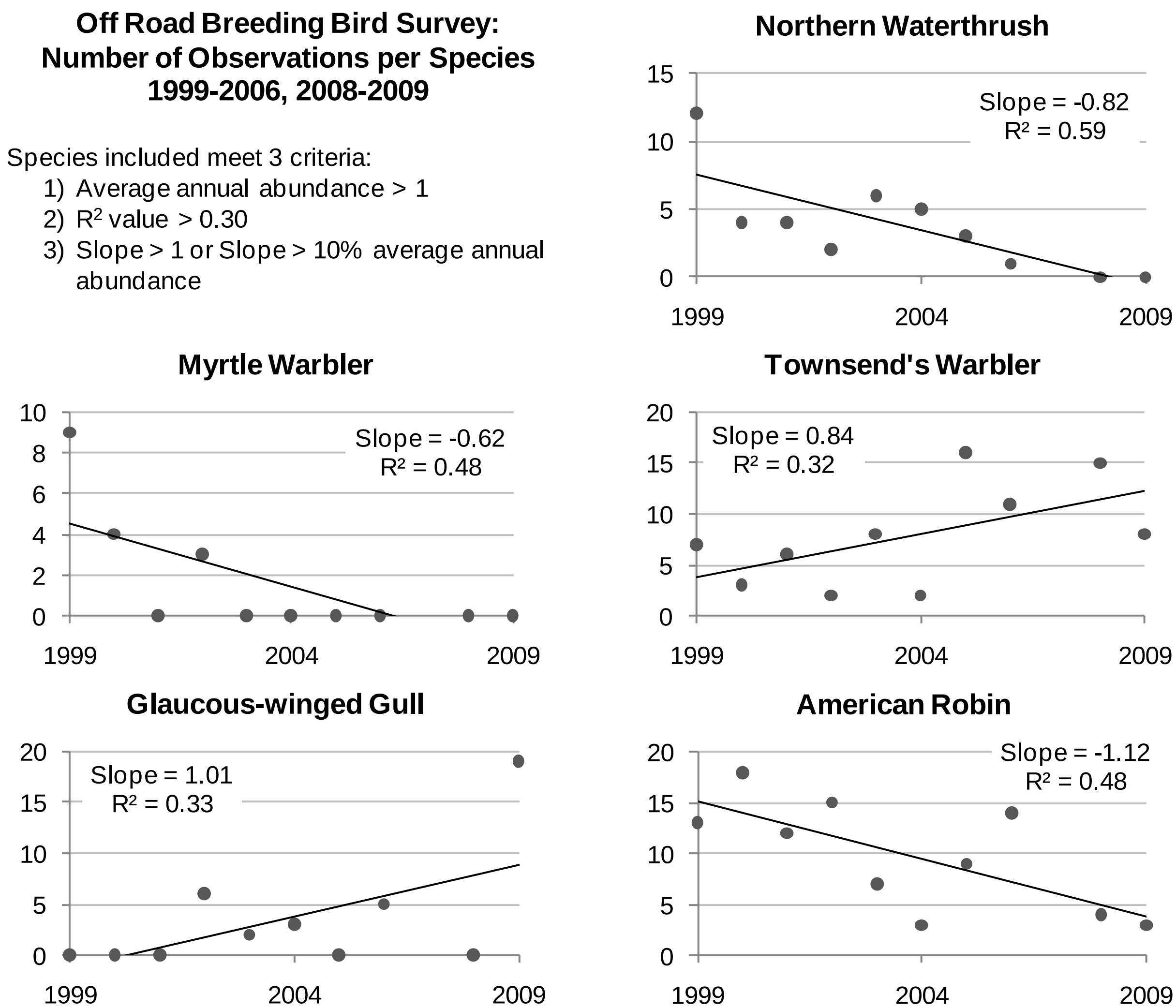


Figure 14. Off road BBS: Number of observations per species, 1999 to 2006 and 2008 to 2009 (Handel 2009). Only those species with an average abundance greater than one, R^2 greater than 0.30, and a slope greater than one or a slope greater than 10% of its average annual abundance are included.

Comparison of Off Road Routes

Two routes are surveyed each year as part of the off road breeding bird survey: route 818 in the Dyea area and route 817 at the south end of the Chilkoot Trail (Plate 4). The routes are both located in the Chilkoot Trail Unit but include different habitat types. Route 818 (Dyea) includes a substantial amount of graminoid-forb meadow. This results in less tree cover than route 817, which is dominated by Sitka spruce-cottonwood riparian forest (Hahr and Trapp 2004). A Student's t-test was used to compare average annual abundance of each species per route. Average annual abundance was significantly different between routes for eighteen species at a probability greater than 95% (Figure 15). Therefore, although the routes are within a few kilometers of each other, surveying both is important for capturing the full diversity of the area. The total number of birds observed on each route was also significantly different ($p < .05$). On average, 83 birds were observed each year on route 817 and 131 on route 818.

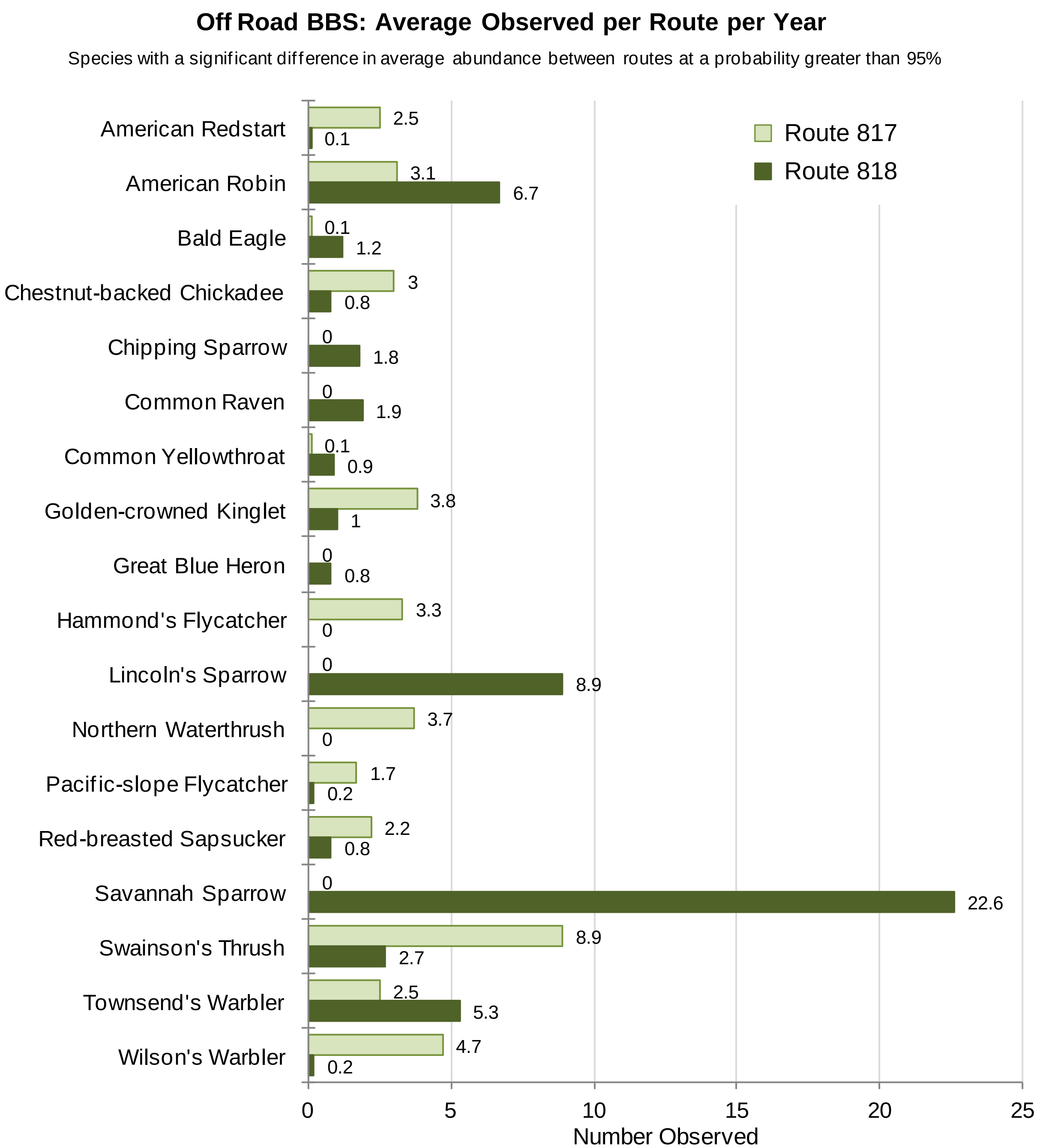


Figure 15. Off road BBS: Average observed per route per year (Handel 2009). Figure only includes species with a significant difference in average abundance per route at a probability greater than 95%. Latin names can be found in Appendix C.

Species of Concern

Audubon Alaska publishes a list of species of concern. The list indicates species that are vulnerable or declining and deserving special conservation attention (Kirchhoff and Padula 2010). The number of each Audubon WatchList species recorded during each year by each survey was determined (Table 10). Most species do not have enough records to determine a recent trend; however, it is worth noting that the highest numbers of varied thrush *(Ixoreus naevius)* ever observed during the on road and off road BBS were reported in 2009 (Handel 2009, USGS 2010a).

Table 10. On road BBS, off road BBS, and Christmas Bird Count: Number of each species of concern recorded each year (Handel 2009, Audubon Society 2010, Kirchhoff and Padula 2010, USGS 2010a).

Species	Survey	Observed During Period of Record	Number per Year				
			2005	2006	2007	2008	2009
Blackpoll Warbler *(Dendroica striata)*	On Road	Yes	1	-	-	-	-
	Off Road	Yes[1]	-	-	-	-	-
	CBC	No	-	-	-	-	-
Marbled Murrelet *(Brachyramphus marmoratus)*	On Road	Yes	-	-	-	2	1
	Off Road	No	-	-	-	-	-
	CBC	Yes	89	70	207	26	106
Northern Goshawk* (Queen Charlotte) *(Accipiter gentilis laingi)*	On Road	No	-	-	-	-	-
	Off Road	No	-	-	-	-	-
	CBC*	Yes	-	1	1	1	1
Olive-sided Flycatcher *(Contopus cooperi)*	On Road	Yes	1	-	-	-	-
	Off Road	Yes[2]	-	-	-	-	-
	CBC	No	-	-	-	-	-
Wandering Tattler *(Tringa incana)*	On Road	Yes	-	-	-	-	3
	Off Road	No	-	-	-	-	-
	CBC	No	-	-	-	-	-
Varied Thrush *(Ixoreus naevius)*	On Road	Yes	14	17	20	25	33
	Off Road	Yes	19	26	22	41	284
	CBC	Yes	-	-	≥1	≥1	-

* Data did not specify if northern goshawks observed were of the Queen Charlotte subspecies.
[1] two in 2000; one in 2001
[2] one in 2004

Also of concern in KLGO is the highly pathogenic avian influenza (HPAI H5N1). The Alaska Natural Heritage Program has identified 36 species as probable carriers of HPAI H5N1 (Feierabend and Schirokauer 2009 citing Gotthardt pers. comm. 2008). No cases of HPAI H5N1 have been reported in KLGO, but the following possible carriers identified by the Alaska Natural Heritage Program have been sighted in the park (Feierabend and Schirokauer 2009). This list includes both confirmed and unconfirmed sightings that may or may not have been part of a waterbird survey:

- Yellow-Billed Loon *(Gavia adamsii)*
- Glaucous-Winged Gull *(Larus glaucescens)*
- Dunlin *(Calidris alpina)*
- Glaucous Gull *(Larus hyperboreus)*
- Northern Pintail *(Anas acuta)*
- Gyrfalcon *(Falco rusticolus)*
- Blackpoll Warbler *(Dendroica striata)*
- Lesser Sandhill Crane (*Grus canadensis canadensis)*
- Bar-Tailed Godwit (*Limosa lapponica*)
- Lesser Snow Goose (*Chen caerulescens caerulescens)*
- Pectoral Sandpiper (*Calidris melanotos)*
- Olive-Sided Flycatcher *(Contopus cooperi)*
- Tundra Swan *(Cygnus columbianus)*
- Rusty Blackbird *(Euphagus carolinus)*
- Long-Tailed Duck *(Clangula hyemalis)*
- Long-Billed Dowitcher *(Limnodromus scolopaceus)*

Stressors

Birds are sensitive indicators of ecosystem change (Hahr and Trapp 2004). Several migratory species pass through or breed in KLGO each year, and events occurring in other parts of their range can affect the health of bird populations in the park. Bird species are susceptible to habitat loss and fragmentation, ecosystem contaminants, and over-exploitation (Hahr and Trapp 2004). For example, loss of wintering habitat for the olive-sided flycatcher *(Contopus cooperi)* is thought to contribute to the species' declining population numbers (Kirchhoff and Padula 2010). Possible stressors of marbled murrelet *(Brachyramphus marmoratus)* populations in Alaska include predation, incidental bycatch in gillnet fisheries, loss of habitat due to logging activity, and changes in food supply as a result of marine regime shifts (Kirchhoff and Padula 2010).

Photo 12. Crow with a bill deformity (photo by Dennis Corrington used with permission).

Avian influenza has not been detected in KLGO, but it is a potential stressor. The sampling protocol for Asian H5N1 avian influenza in migratory birds for Alaska can be found in Alaska Interagency HPAI Bird Surveillance Working Group (2006). A summary of HPAI H5N1 surveys in KLGO is found in Feierabend and Schirokauer (2009).

Another stressor garnering recent attention is beak deformities. At least 27 species of birds in Alaska have documented cases of beak deformities, primarily in the south-central portion of the state (Handel et al. 2006). The cause of this phenomenon is not well understood, but the following possible factors have been identified: disease, parasites, trauma, extreme heat, genetic abnormalities, nutritional deficiencies, and exposure to contaminants (Handel et al. 2006). Two northwestern crows and one Steller's Jay *(Cyanocitta stelleri)* were found in KLGO in 2007 with beak deformities (Schirokauer 2008). No additional beak deformities were discovered in 2008 or 2009.

Reporting Zones

Both off road breeding bird survey routes are located in the Chilkoot Trail reporting zone. Data available for the on road breeding bird survey and the Christmas Bird Count do not allow for division into reporting zones. The on road breeding bird survey route includes sites in all three reporting zones, but the data were reported as route totals, not by sample site. The extent of the Christmas Bird Count circle encompasses the entire park and includes areas outside the park boundary as well.

Condition
The number of bird species and bird diversity observed in recent years appears consistent with values reported since each survey began. No trends in recent years were detected; however, using data collected only once a year could mask important changes in individual species populations. The good condition and stable trend were assigned to each reporting zone, because the extent of the on road breeding bird survey route and Christmas Bird Count circle include portions of each park unit.

Data Needs
More data regarding the breeding success, phenology, and population age structure of birds in KLGO would better inform the statement of condition (Hahr and Trapp 2004). This is especially important for species of concern. Collaborating with other agencies that collect bird survey data may also provide for better estimates of regional bird populations and diversity.

A significant weakness in the analysis of the bird survey data is the omission of species detectability information. The analysis assumes all species had an equal chance of being detected during every survey and in every survey unit. Several published articles have concluded this is an unfounded assumption (McCallum 2005, Farmer and Durbian 2006). Several factors can affect the detectability of a species: the behavior of the species, including how often it is audible and conspicuous movements, the vegetative cover of the survey area, the actual percent of survey area visible from the observer's position, the length of stay for migratory birds, and observer bias (McCallum 2005, Farmer and Durbian 2006). Methods are available to estimate detectability using the time intervals reported as part of the off road BBS. This could be explored in order to improve estimates of bird populations.

Individual results for each on road BBS survey point are available. These data could be used to calculate a jackknifed estimate of diversity for each year. This would allow for calculation of standard error and improved comparison between years.

Literature Cited
Alaska Interagency HPAI Bird Surveillance Working Group. 2006. Sampling protocol for highly pathogenic Asian H5N1 avian influenza in migratory birds in Alaska. Interagency planning report, Anchorage, Alaska.

Audubon Society. 2009. Yellow-rumped warbler *Dendroica coronata*. Online. (http://www.audubonguides.com/species/Birds/Yellow-rumped-Warbler.html). Accessed 16 July 2010.

Audubon Society. 2010. Christmas bird count data for Skagway, Alaska. Online. (http://audubon2.org/cbchist/count_table.html). Last accessed 31 March 2010.

Cremata, A. 2008. Christmas ornaments and bird count. Skagway News. Online. (http://www.skagwaynews.com/012508Christmasornabirds.html). Accessed 19 November 2009.

Danoff-Burg, J. A., and Xu C. 2005. Biodiversity calculator. Online. (http://www.columbia.edu/itc/cerc/danoff-burg/MBD_Links.html). Accessed 13 June 2010.

Handel, C. M., and M. N. Cady. 2004. Alaska landbird monitoring survey: Protocol for setting up and conducting point count surveys. Boreal Partners in Flight and USGS Alaska Science Center, Anchorage, Alaska.

Farmer, A. and F. Durbian. 2006. Estimating shorebird numbers at migration stopover sites. The Condor 108:792-807.

Feierabend, D., and D. Schirokauer. 2009. 2009 bird surveys summary: Breeding bird survey, off road breeding bird surveys, waterbird surveys, and eagle nest monitoring. Klondike Gold Rush National Historical Park. Skagway, Alaska.

Hahr, M., and T. W. Trapp. 2004. Waterbird and breeding landbird inventories in Klondike Gold Rush National Historical Park. SE Alaska Inventory and Monitoring Network, National Park Service, Alaska Region. Inventory and Monitoring Program Final Report, Klondike Gold Rush National Historical Park, Skagway, Alaska.

Handel, C. 2009. Off road breeding bird survey data. Spreadsheets. Summary prepared 9 September 2009. U. S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Handel, C. M., L. M. Pajot, S. M. Matsuoka, K. A. Trust, J. M. Stotts, J. Terenzi, and S. L. Talbot. 2006. Potential role of environmental contaminants in the pathology of beak deformities among black-capped chickadees in south-central Alaska. Unpublished final report. Project ID: 1130-7F22. U. S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Kirchhoff, M., and V. Padula. 2010. The Audubon Alaska WatchList 2010. Audubon Alaska, Anchorage, Alaska.

Kissling, M. L., and S. B. Lewis. 2009. Distribution, abundance, and ecology of forest owls in Southeast Alaska. U.S. Fish and Wildlife Service, Juneau Field Office, Alaska, and Alaska Department of Fish and Game, Division of Wildlife Conservation, Douglas, Alaska.

Klondike Gold Rush National Historical Park. 2009. Off road breeding bird survey protocol for Klondike Gold Rush National Historical Park, Skagway, Alaska: Standard operating procedure (SOP) #1 conducting surveys and data management. Version 1.00. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Magurran, A. E. 2004. Measuring biological diversity. Blackwell Publishing, Malden, Massachusetts, USA.

McCallum, D. A. 2005. A conceptual guide to detection probability for point counts and other count-based survey methods. Gen. Tech. Rep. PSW-GTR-191. U.S. Department of Agriculture, Forest Service, Washington, D.C.

National Park Service. 2009a. Skagway breeding bird survey route 425. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009b. Chilkoot off-road breeding bird survey points. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009c. Dyea off-road breeding bird survey points. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2010. Grant-Kohrs Ranch National Historic Site: Bird photos. Online. (http://www.nps.gov/grko/naturescience/Bird-Photos.htm). Accessed 22 November 2010.

Schirokauer, D. 2008. Natural resources program summary report FY2008. Klondike Gold Rush National Historical Park. Skagway, Alaska.

Skagway Bird Club. 2010. Birds of Skagway, AK. Skagway Bird Club, Skagway, Alaska.

U.S. Fish and Wildlife Service. 2008. Birds of conservation concern 2008. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia.

U.S. Geological Survey. 2010a. Breeding bird survey data for Skagway route. USGS, Patuxent Wildlife Research Center, North American Breeding Bird Survey. Online. (https://www.pwrc.usgs.gov/BBS/ PublicDataInterface/index.cfm). Accessed 5 April 2010.

U.S. Geological Survey. 2010b. Regional credibility measures. USGS Patuxent Wildlife Research Center. Online. (http://www.mbr-pwrc.usgs.gov/bbs/cred.html). Accessed 16 July 2010.

U.S. Geological Survey. 2010c. Alaska North American breeding bird survey trend results. USGS, Patuxent Wildlife Research Center. Online. (http://www.mbr-pwrc.usgs.gov/cgi-bin/atlasa99.pl?AK%20&2&07). Accessed 16 July 2010.

U.S. Geological Survey. 2010d. Dark-eyed junco. U.S. Geological Survey. Online. (http://www.mbr-pwrc.usgs.gov/id/framlst/i5670id.html). Accessed 20 July 2010.

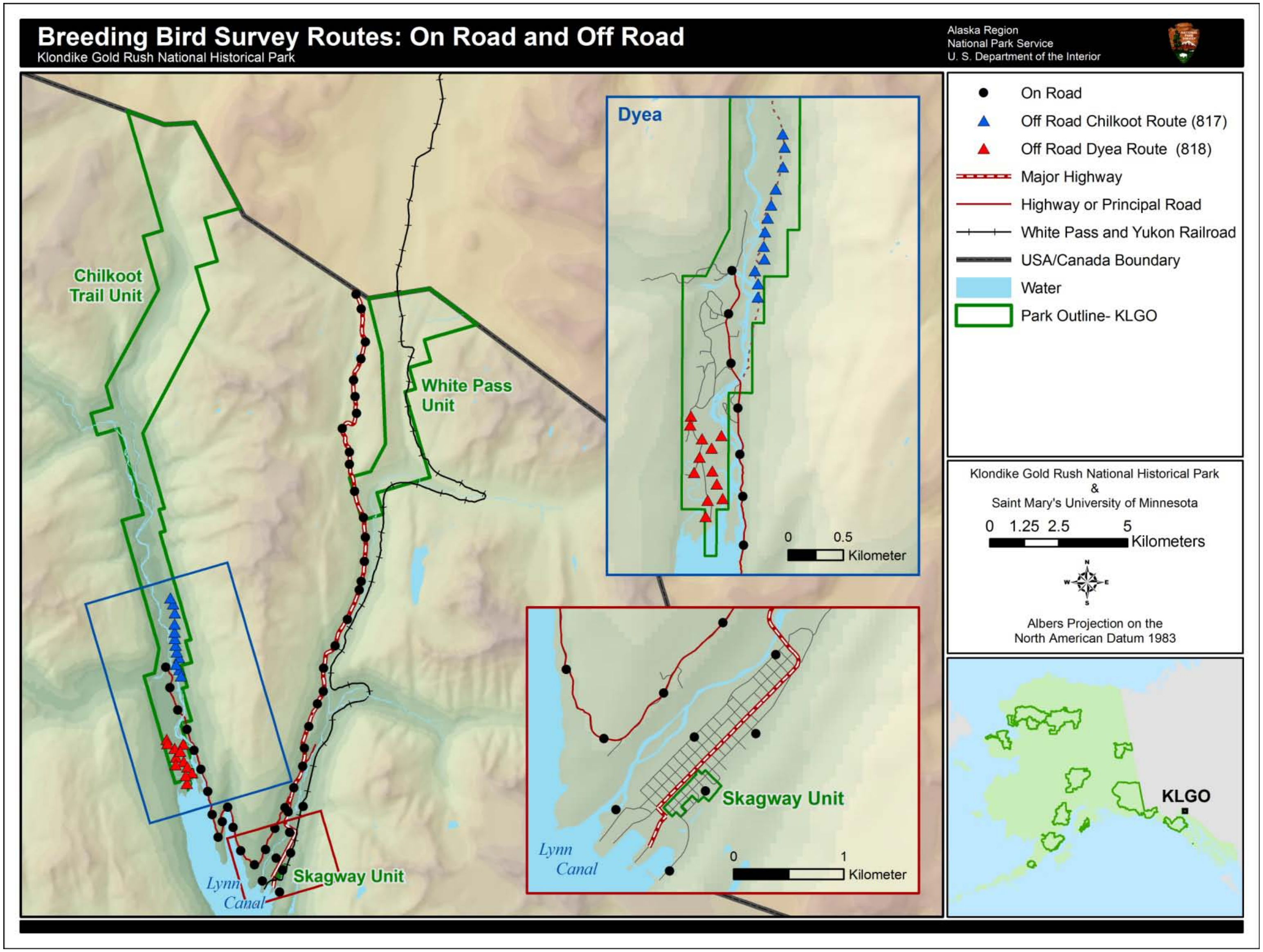
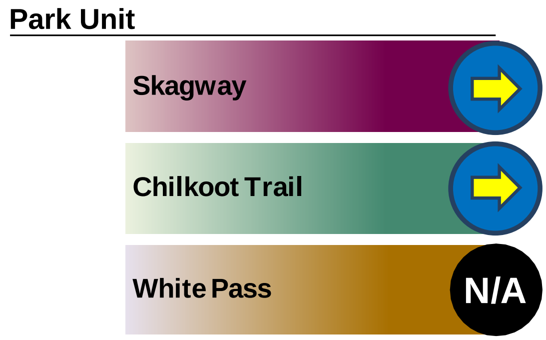


Plate 4. Breeding bird survey routes: On road and off road (NPS 2009a, 2009b, 2009c).

4.6 Coastal Birds

Measures
Number of Species
Diversity



Background
Coastal birds contribute to the overall biological diversity of KLGO and are sensitive indicators of ecosystem change (Hahr and Trapp 2004). KLGO is located within the Northern Pacific Rainforest Bird Conservation Region (BCR) but also borders the Northwestern Interior Forest BCR. Being part of this transition area between regions results in diverse avifauna, including breeding, migrating, and wintering waterbirds (Hahr and Trapp 2004). Large numbers of migratory birds use the area as a stop-over site before flying further north to breeding grounds (Hahr and Trapp 2004). The spring eulachon (*Thaleichthys pacificus)* run, usually in late April and early May, coincides with peak numbers of waterbirds (Hahr and Trapp 2004). Eulachon, which are small, anadromous smelt, are an important prey species for several bird species, including bald eagles (*Haliaeetus leucocephalus*) (Hahr and Trapp 2004).

Reference Condition
A historic reference condition for waterbirds is not available because waterbird surveys have only been conducted in a consistent manner since 2003. An expected bird species list has been compiled by the Skagway Bird Club (2010) and represents the best reference for the number of expected species. The list is compiled from observations made by the Skagway Bird Club, Alaska Breeding Bird Survey data, and the Coastal Waterbird Survey data. Seventy-nine waterbird species are expected in the park. A complete list of expected waterbirds and their scientific names is provided as Appendix D.

Data
A waterbird survey has occurred in KLGO every year since 2003. There are eight survey units, which are sampled weekly in the spring and bi-weekly in the fall (Plate 5). Each unit is surveyed until all waterbirds have been counted (KLGO 2009b). Sampling is scheduled around the timing of the tide, and periods of high wind or heavy precipitation are avoided. Occasionally census unit

one is not surveyed due to cruise ship interference. At each census unit, the number, age, composition (sex), breeding status, and any noteworthy behavioral observations are recorded for each species (KLGO 2009b). There is variability in the actual number of surveys per year and units surveyed during each census (Figure 16 and Figure 17).

All results are recorded in a Microsoft Access database (KLGO 2009a). Data were analyzed using Microsoft Excel and the Biodiversity Calculator (Danoff-Burg and Xu 2005) to report condition of waterbirds. The waterbird survey database includes raptors and other species that are not classified as waterbirds. All unidentified species were excluded from the analysis. When viewing the results, variations in survey intensity and timing should be considered.

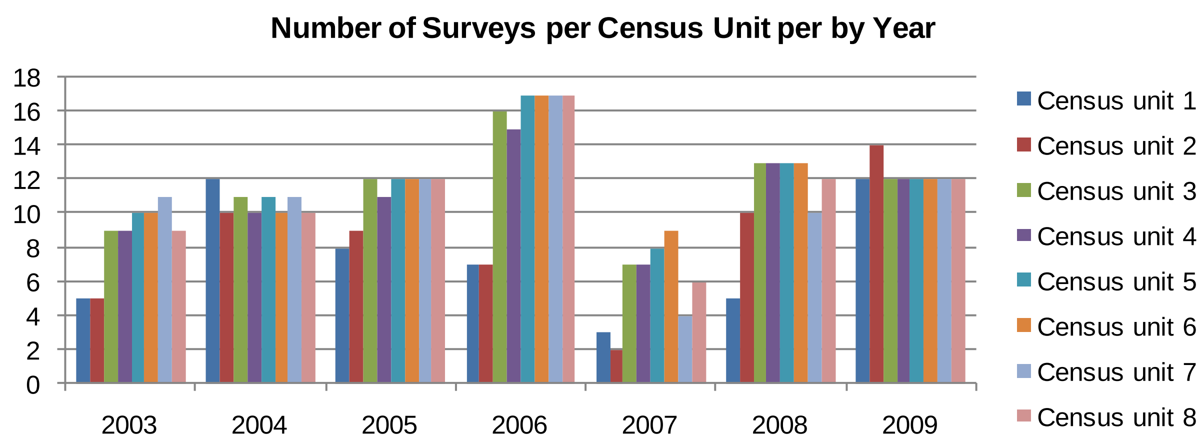


Figure 16. Waterbird survey: Number of surveys per census unit by year (KLGO 2009a).

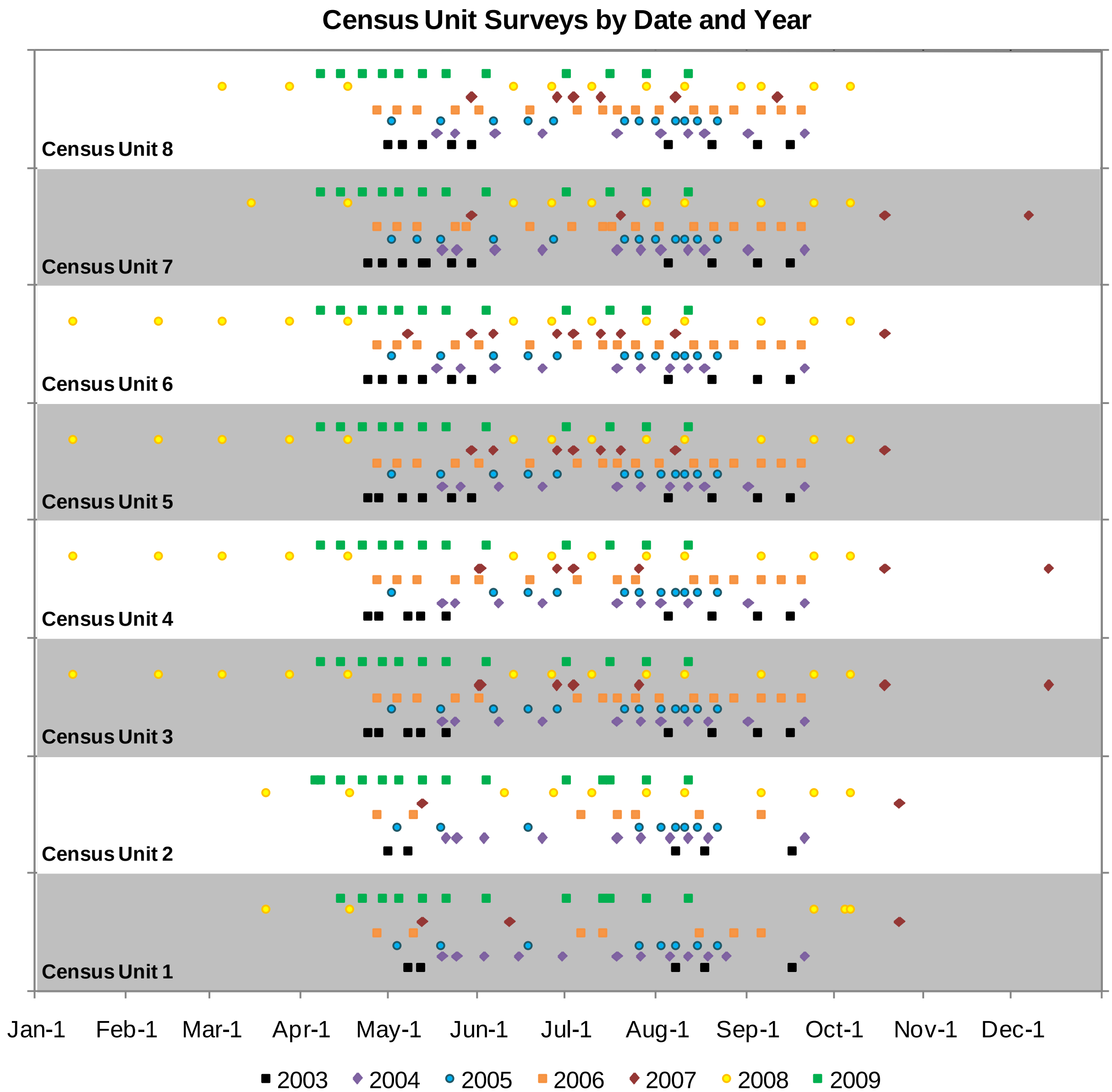


Figure 17. Waterbird survey: Census unit surveys by date and year (KLGO 2009a).

Measures

<u>Percent of Expected Species That are Confirmed</u>
In 2003, a park-wide survey was conducted of waterbirds and breeding landbirds. The goal of the inventory was to document the presence of 90% of the waterbird and breeding landbird species likely to occur in KLGO (Hahr and Trapp 2004). At the time of the report, the expected species list included 174 waterbird and breeding landbird species. Forty waterbird species were observed during the waterbird portion of the inventory. In total, 158 out of the 174 (91%) expected waterbird and breeding landbird species in KLGO were confirmed (Hahr and Trapp 2004). In 2010, an updated expected bird species list was published by the Skagway Bird Club, which

includes 201 species, 79 of which are waterbird species. During the 2009 waterbird surveys, 51 of the 79 expected waterbird species (~65% expected) were recorded.

<u>Number of Species</u>

Species counts for each waterbird survey year were determined (Figure 18). The highest number of waterbird species (51) and all bird species (60) was observed in 2009.

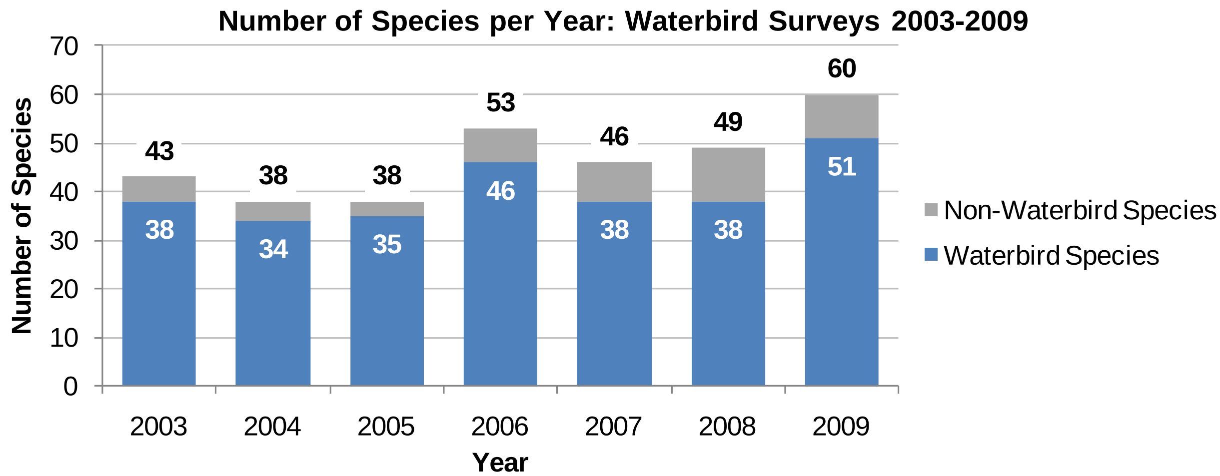


Figure 18. Waterbird survey: Number of waterbird species identified per year (blue with white labels), number of non-waterbird species identified per year (gray), and total number of species identified per year (black labels) (KLGO 2009a).

Sampling effort and timing may have played a significant role in survey results. More surveys were conducted during late April and early May in 2009 compared to any other year. This is the time of year when peak numbers of waterbirds have been noted migrating through KLGO (Hahr and Trapp 2004). Surveys also began earlier in 2009 than every other year except 2008. 2006 reported the second highest number of species. In this year, census units three through eight were surveyed more than any other year. The fewest species were observed in 2004 and 2005. There were few surveys during these two years during the late April to early May migration period, and surveys in 2004 started later than every other year.

<u>Diversity</u>

The Simpson diversity index was calculated for each year of waterbird survey data (Figure 19 left). Considered one of the most meaningful and robust diversity measures available, the Simpson diversity index (D) represents the probability of any two individuals drawn randomly from a community belonging to the same species (Magurran 2004). As D increases, diversity decreases; this is why the index is often reported as 1/D. The value of 1/D will increase as the community becomes more even.

The most abundant species in a community strongly influences the Simpson index. As an alternative measure of diversity for comparison, the Q statistic was also calculated (Figure 19 right). The Q statistic is calculated from the interquartile slope of the cumulative species abundance curve, and therefore is not biased by the very abundant or very rare species in the community. A higher value indicates a more diverse assemblage.

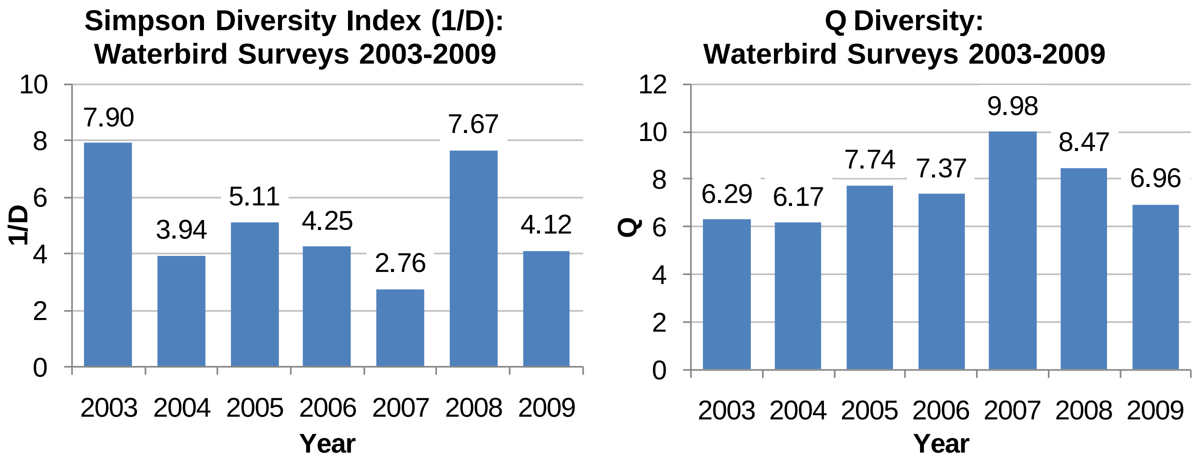


Figure 19. Waterbird survey: Simpson diversity index (left) and Q diversity (right) per year (KLGO 2009a). These results only include waterbird species.

The results of the two diversity measures are very different. In 2007, the lowest Simpson index (1/D) was reported and the highest Q statistic. The highest Simpson index score was reported in 2003. The difference in outcomes between the two measures suggests that abundant species in the community have influenced the Simpson scores. This is not necessarily a weakness, as the score is designed to emphasize dominance in a community. However, migratory birds are common in KLGO, and a flock of a thousand birds observed on one day could greatly impact the result.

To further explore diversity, the Simpson evenness measure was calculated for each census year (Figure 20). Evenness is calculated by dividing the reciprocal of D by the number of species in the sample (Magurran 2004):

$$\text{Simpson Evenness } (E_{1/D}) = \frac{(1/D)}{\text{the number of species in the sample}}$$

The value of Simpson evenness will range from zero to one, with one having a completely even distribution of individuals among species. As the value of the measure moves closer to zero, there is a less equal distribution of individuals per species in the sample. The measure is not sensitive to species richness (Magurran 2004).

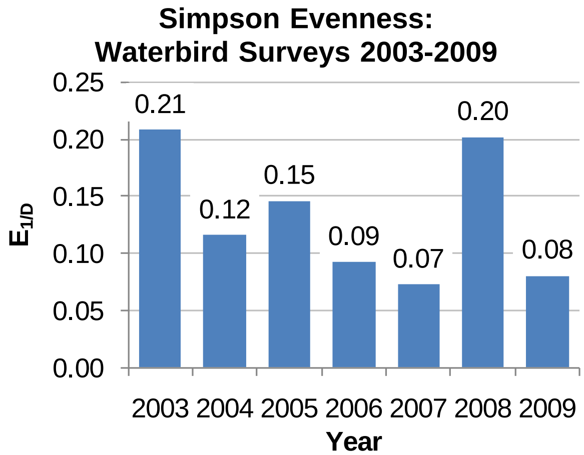
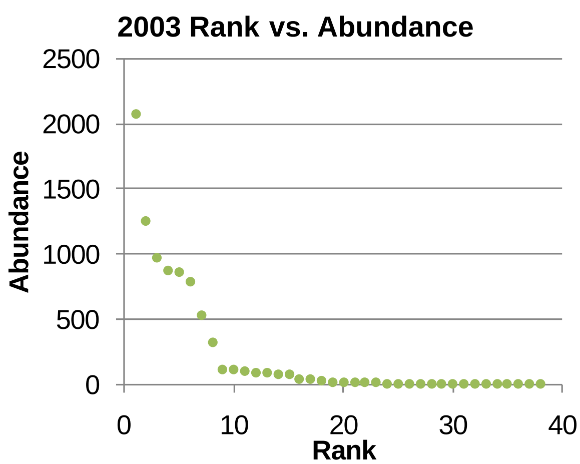


Figure 20. Waterbird survey: Simpson measure of evenness per year (KLGO 2009a). These results include only waterbird species.

The results of the Simpson evenness measure followed the same pattern as the Simpson diversity index. Years with greater evenness were also years of greater Simpson diversity. Although 13 more waterbird species were identified in 2009 than in 2003, the distribution of species in 2003 was more even, which resulted in the greater Simpson diversity and evenness scores (Figure 21). If the four most abundant species were removed from the 2009 dataset, the value of Simpson diversity and evenness would be greater than every other year ($1/D = 18.1118$, $E_{1/D} = 0.39$).



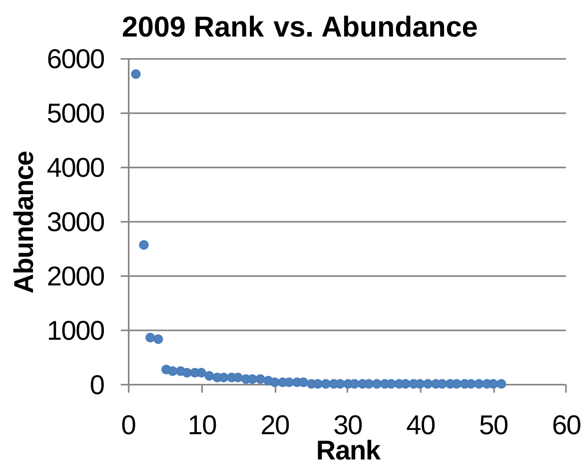


Figure 21. Waterbird survey: Rank versus abundance for 2003 (left) and 2009 (right) (KLGO 2009a).

Census Unit Comparisons

An investigation was conducted to compare results by census unit. Appendix E includes a table indicating which bird species have been observed in each census unit. Sixteen species were observed in only one of the eight units. No species unique to census units 3, 4, or 5 were observed.

To compare waterbird density in each unit, the number of waterbirds recorded in each census unit was totaled and divided by the total number of surveys. The average number of birds per survey per unit was then divided by the number of square kilometers in the census unit (NPS 2009b). Census units seven and eight reported the highest average number of waterbirds per survey per square kilometer (Figure 22).

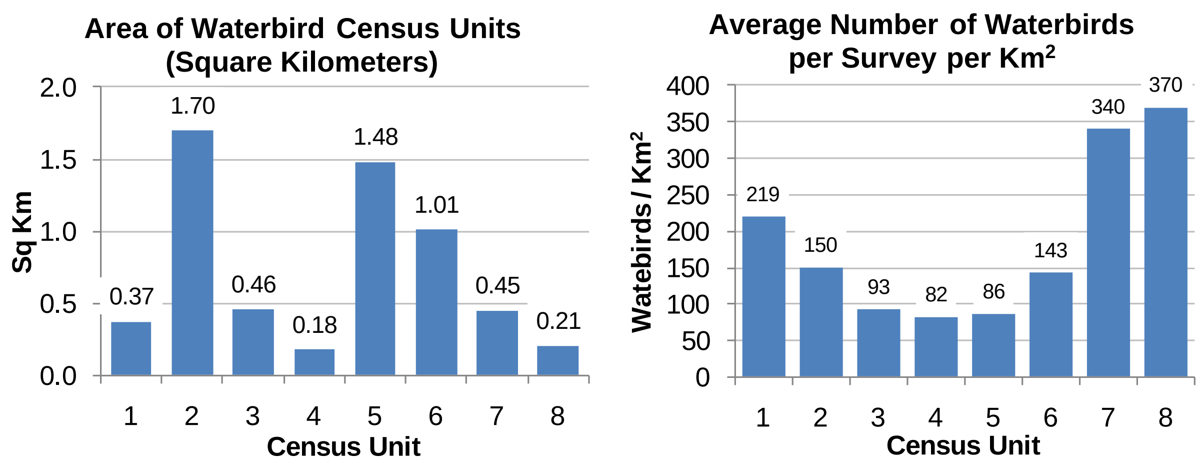


Figure 22. Waterbird survey: Area of each census unit (km^2) (left) and average number of waterbirds per survey per square kilometer by census unit (right) (NPS 2009b, KLGO 2009a).

The shape of the census unit may influence the number and diversity of birds observed as many species nest and feed along shore. Census unit eight, despite encompassing the second smallest amount of area, has the greatest amount of shoreline (Figure 23). Shoreline habitat is also important to species occupancy. Length of shoreline habitat (meters) by census unit was estimated using habitat classes delinated by the ShoreZone Program (NPS 2009a). Census unit eight was not include in the ShoreZone mapping but follows the Taiya River. The boundary of the unit was used to determine shoreline length. The second highest density of waterbirds was observed in census unit seven. Although not a large area, the census unit has the second greatest amount of shoreline and all shoreline is estuarine habitat.

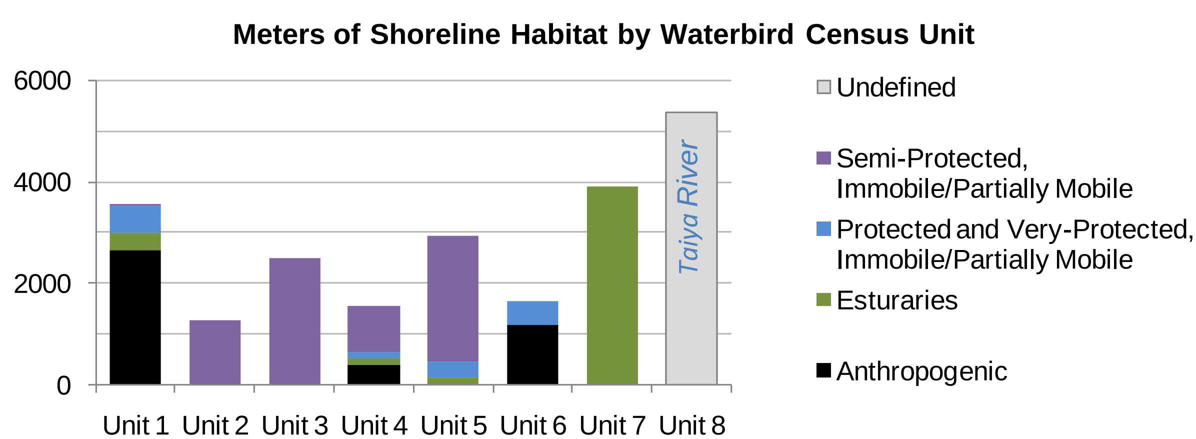


Figure 23. Meters of shoreline habitat by type and waterbird census unit (NPS 2009a, 2009b).

The average number of species, Simpson diversity, Q diversity statistic, and Simpson evenness were also calculated for each census unit (Figure 24 and Figure 25). Each statistic was calculated for each census unit each year and then averaged. These results only include waterbird species and were not normalized to the size of the unit.

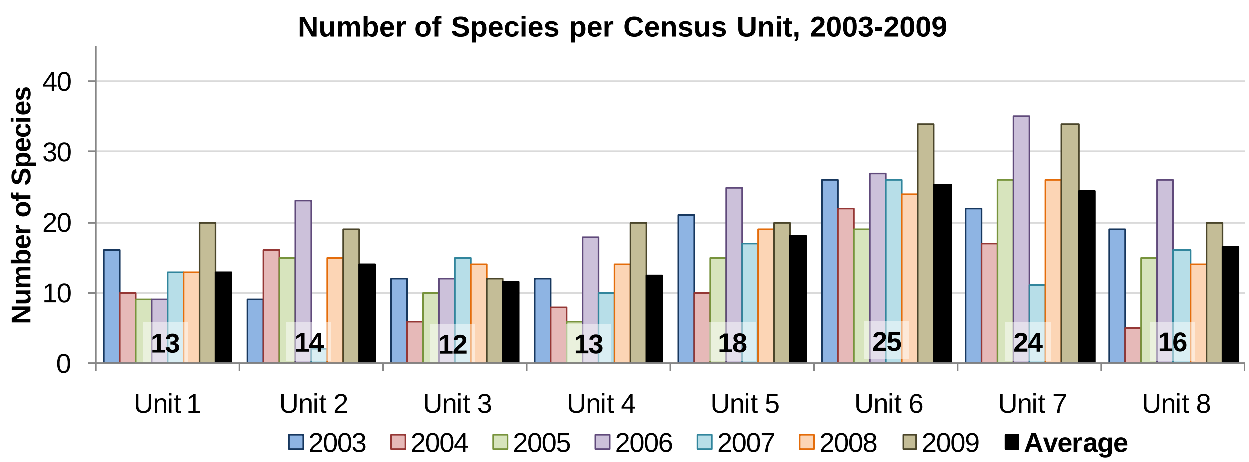


Figure 24. Waterbird surveys: Number of species by census unit: 2003-2009 (KLGO 2009a). The black bar and numeric labels represent the average of years 2003-2009. Only waterbird species are included in these results. These results were not normalized to the size of the unit.

Significant variability was observed between years. On average the highest number of species is reported in unit six and the lowest number is observed in unit three. Unit six is twice the size of unit three, which might explain part of the difference in diversity. Other studies of species diversity have found that the number of species observed increases as the area surveyed increases (Cam et al. 2002). Unit seven, however, is approximately the same size as unit three, and on average twice the number of species were found in unit seven than unit three. Diversity and evenness results also varied by year. This variability, combined with differences in sampling intensity, limit the conclusions that can be made when comparing census units.

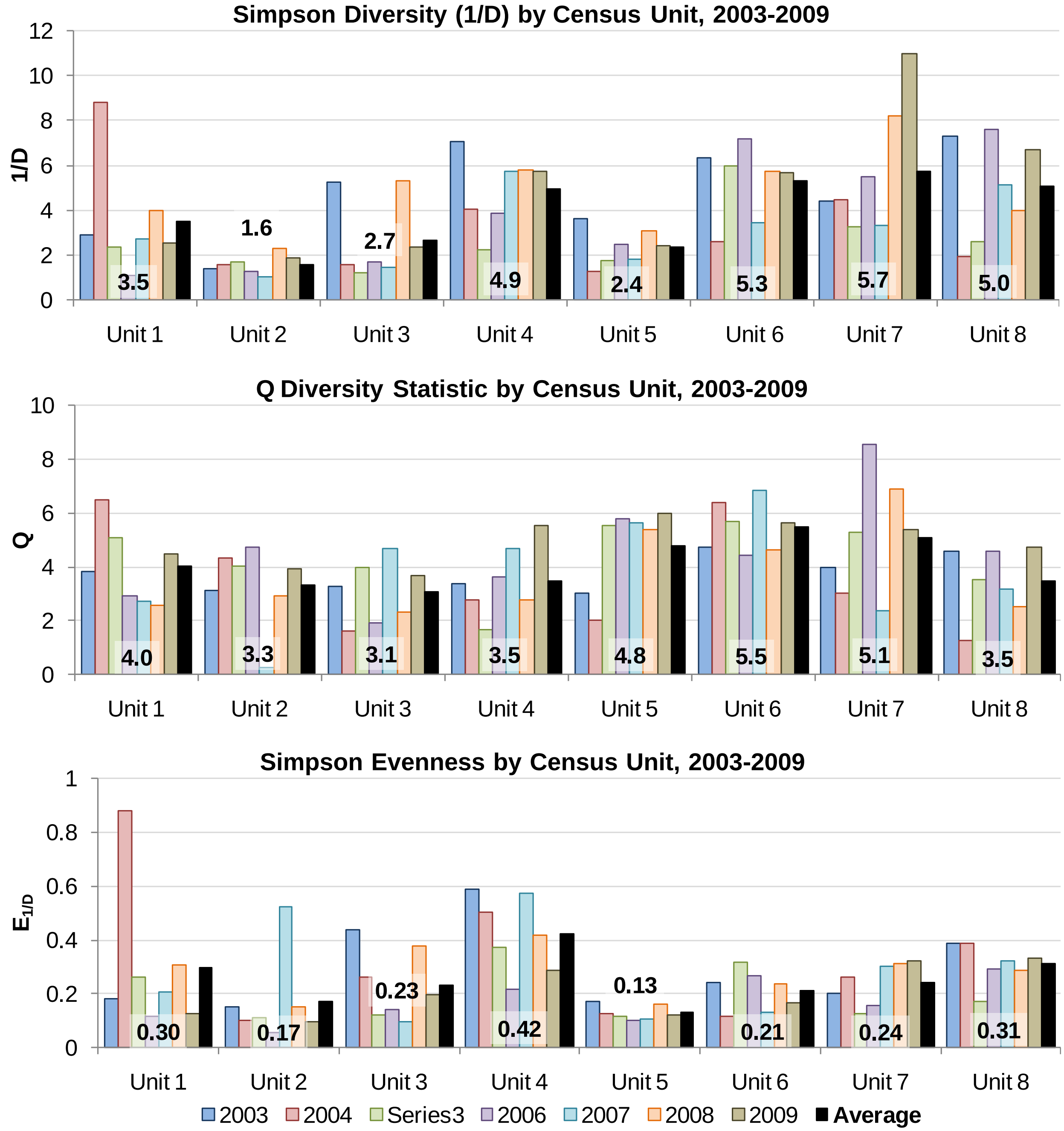


Figure 25. Waterbird surveys: Simpson diversity index, Q diversity statistic, and Simpson evenness by census unit: 2003 to 2009 (KLGO 2009a). The black bar and numeric labels represent the average of years 2003 to 2009. Only waterbird species are included in these results. These results were not normalized to the size of the unit.

Seasonal Comparisons

Number of species, number of birds, Simpson diversity, Q diversity, and Simpson evenness were calculated by survey date to investigate change during the year (Figure 26, Figure 27). There were relatively few surveys during which all census units were surveyed in one day. To increase the number of data points, data were included if all eight census units were surveyed once within a period of four days. The data from the four days were combined and assigned a date within the four day range.

There is substantial variability in the results, but there appears to be a higher number of bird species in the spring compared to later in the summer and fall, which likely reflects migration patterns. This is consistent with previous observations of peak waterbird species numbers during the spring eulachon run, although it should be noted that the eulachon run does not occur every year (Hahr and Trapp 2004). The trend is reflected in the Simpson and Q diversity indices, which were higher in the spring. Simpson evenness shows less correlation with date than species richness or diversity. If there is a trend present, it is that evenness increases during the year. This may reflect the presence of more migratory flocks early in the year, which would cause the population to be less evenly distributed among species.

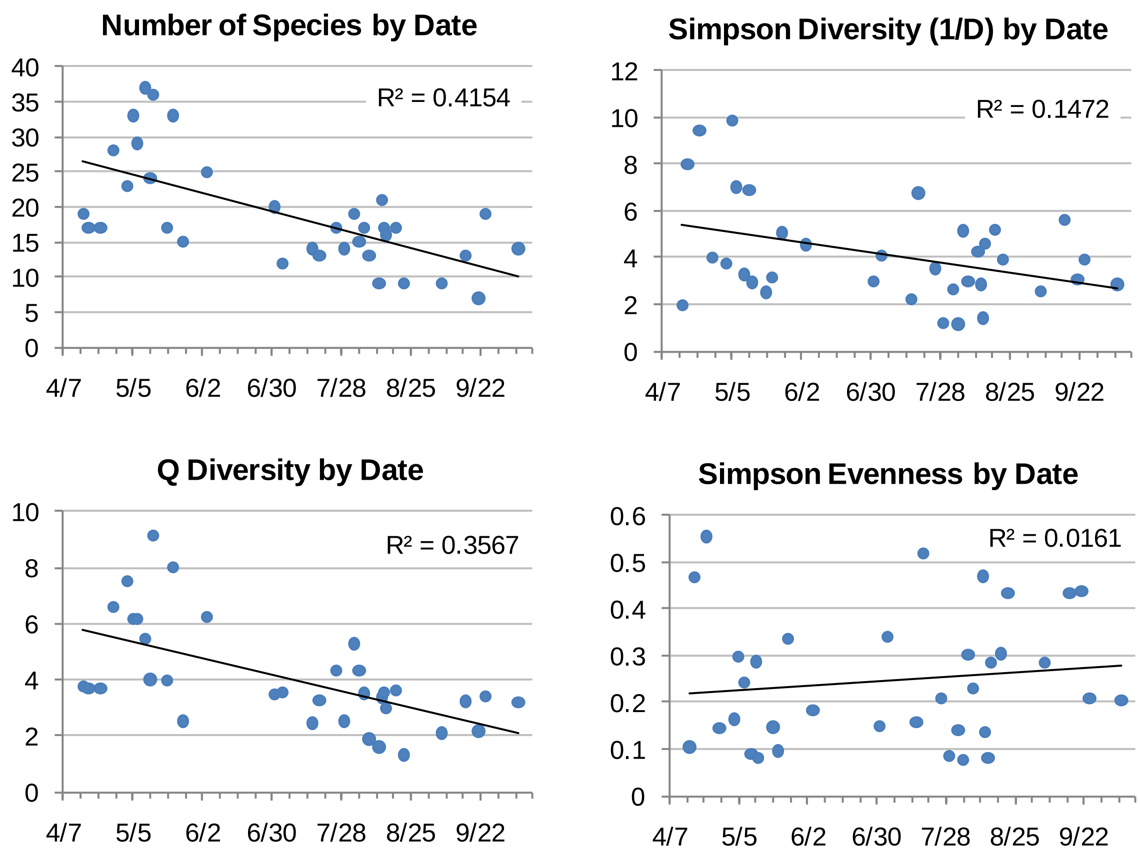


Figure 26. Waterbird surveys: Number of species, Simpson diversity (1/D), Q diversity, and Simpson evenness by date (KLGO 2009a). Data include years 2003 to 2009. These results include all bird species recorded during the surveys, not only waterbird species.

The number of birds appears to increase in the spring and fall, which would correspond to times of migration (Figure 27). These results emphasize the importance of multiple survey dates throughout the year. Appendix F includes charts depicting which dates from 2003 to 2009 each bird species has been observed in KLGO. The earliest observation of each bird species varies throughout the year, which further reinforces the importance of multiple surveys at various times during the year.

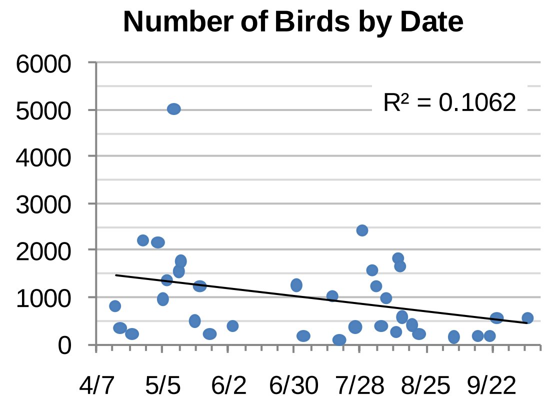


Figure 27. Waterbird surveys: Number of birds by date (KLGO 2009a). Data include years 2003 to 2009.

<u>Species of Concern</u>

Audubon Alaska publishes a list of species of concern, which indicates species that are vulnerable or declining and deserving of special conservation attention (Kirchhoff and Padula 2010). The number of each species of concern recorded during each year of the coastal waterbird survey was determined (Table 11). Most species do not have enough records to determine a recent trend; however, the highest numbers of marbled murrelet (*Brachyramphus marmoratus)* and wandering tattler (*Tringa incana*) were recorded in 2009. Although not yet detected in KLGO, the winter range of the yellow-billed loon includes the Taiya Inlet. The yellow-billed loon is considered a candidate species under the Endangered Species Act (USFWS 2009). A listing as threatened or endangered is considered warranted by the Federal Register, but the listing has been precluded by other priority species (USFWS 2009).

Photo 13. Marbled murrelet. Photo courtesy of USFWS (2010).

Photo 14. Wandering tattler. Photo by Dominic Sherony (2007).

Table 11. Waterbird surveys: Number of species of concern recorded each year (KLGO 2009a, Kirchhoff and Padula 2010).

Species	2003	2004	2005	2006	2007	2008	2009	Total
Dunlin* *(Calidris alpina)*	4	-	-	-	-	-	-	4
Lesser Yellowlegs* *(Tringa flavipes)*	7	2	10	81	12	10	14	136
Marbled Murrelet* *(Brachyramphus marmoratus)*	1,257	1,453	1,607	521	203	1,221	5,703	11,965
Red-throated Loon* *(Gavia stellata)*	-	7	9	16	12	20	17	81
Rusty Blackbird* *(Euphagus carolinus)*	-	-	-	6	-	4	-	10
Solitary Sandpiper* *(Tringa solitaria)*	-	1	-	-	-	-	26	27
Whimbrel* *(Numenius phaeopus)*	-	-	-	-	-	-	1	1
Black Scoter *(Melanitta nigra)*	-	-	-	2	1	-	-	3
Canada Goose *(Branta canadensis)*	-	-	-	7	-	-	2	9
Greater White-fronted Goose *(Anser albifrons)*	-	-	-	109	-	-	46	155
Hudsonian Godwit *(Limosa haemastica)*	-	-	-	56	-	-	1	57
Surfbird *(Aphriza virgata)*	-	-	-	-	-	-	2	2
Wandering Tattler *(Tringa incana)*	5	6	-	7	7	2	9	36

*also listed on the USFWS Region 7 (Alaska Region) Birds of Conservation Concern 2008 List (USFWS 2008)

Also of concern in KLGO is highly pathogenic avian influenza (HPAI H5N1). The Alaska Natural Heritage Program has identified 36 species as probable carriers of HPAI H5N1 (Feierabend and Schirokauer 2009 citing Gotthardt pers. comm. 2008). No cases of HPAI H5N1 have been reported in KLGO, but the following possible carriers identified by the Natural Heritage Program have been sighted in KLGO (Feierabend and Schirokauer 2009). This list includes both confirmed and unconfirmed sightings that may or may not have been part of a waterbird survey.

- Yellow-Billed Loon *(Gavia adamsii)*
- Glaucous-Winged Gull *(Larus glaucescens)*
- Dunlin *(Calidris alpina)*
- Glaucous Gull *(Larus hyperboreus)*
- Northern Pintail *(Anas acuta)*
- Gyrfalcon *(Falco rusticolus)*
- Blackpoll Warbler *(Dendroica striata)*
- Lesser Sandhill Crane (*Grus canadensis canadensis)*
- Bar-Tailed Godwit (*Limosa lapponica*)
- Lesser Snow Goose (*Chen caerulescens caerulescens)*
- Pectoral Sandpiper (*Calidris melanotos)*
- Olive-Sided Flycatcher *(Contopus cooperi)*
- Tundra Swan *(Cygnus columbianus)*
- Rusty Blackbird *(Euphagus carolinus)*
- Long-Tailed Duck *(Clangula hyemalis)*
- Long-Billed Dowitcher *(Limnodromus scolopaceus)*

Stressors
Birds are sensitive indicators of ecosystem change. Several species are susceptible to oil spills, contaminants, climate change, over harvest, and habitat loss (Stenhouse and Senner 2005). The marbled murrelet, for example, is vulnerable to loss of old-growth forest breeding habitat (Stenhouse and Senner 2005). Migratory bird species in KLGO are also affected by events occurring elsewhere in their annual range. For example, the greater-white-fronted goose (*Anser albifrons elgasi*) faces harvest concerns in western states, and the wandering tattler and dunlin (*Calidris alpina*) are vulnerable to winter habitat loss (Stenhouse and Senner 2005). Some species, such as the Red-throated loon (*Gavia stellata*) are vulnerable to bycatch by fisheries (Stenhouse and Senner 2005).

Avian influenza has not been detected in KLGO, but it is a potential stressor. The sampling protocol for Asian H5N1 avian influenza in migratory birds for Alaska can be found in Alaska Interagency HPAI Bird Surveillance Working Group (2006). A summary of HPAI H5N1 surveys in KLGO is found in Feierabend and Schirokauer (2009).

Reporting Zones
The waterbird survey occurs between the Skagway and Chilkoot Trail reporting zones, and therefore the results are applied to each. Part of the survey area near Dyea is in the park boundary (Chilkoot Trail reporting zone).

Condition
Over the past four years more species have been documented during the coastal waterbird surveys than during the first waterbird inventory in 2003. This may be at least partially due to adjustments in survey timing and effort. Change in bird diversity and evenness over time is difficult to determine given variations in survey intensity and timing. The Q diversity statistic, which is not biased by the most abundant or least abundant species, appears fairly consistent since 2003 and, if anything, has increased in recent years. Condition of waterbirds in KLGO is considered good because of the high numbers of species observed in recent years. More study is required to determine if changes in diversity and evenness scores are significant or represent natural variability between years.

Data Needs
More data regarding the breeding success, phenology, and population age structure of waterbirds in KLGO would better inform the statement of condition (Hahr and Trapp 2004). This is especially important for species of concern. Collaborating with other agencies that collect waterbird data may also provide better estimates of regional bird populations and diversity.

A significant weakness in the analysis of the waterbird survey database is the omission of species detectability information. The analysis assumes all species had an equal chance of being detected during every survey and in every survey unit. Several published articles have concluded this is an unfounded assumption (McCallum 2005, Farmer and Durbian 2006). Several factors can affect the detectability of a species: the behavior of the species; the vegetative cover of the survey area; the actual percent of survey area visible from the observer's position; the length of stay for migratory birds; and observer bias (McCallum 2005, Farmer and Durbian 2006).

Determining species detectability was not possible given the existing waterbird data and limitations of the NRCA project. Future data collection or changes to survey protocol could provide data allowing for estimation of species detectability. One method for estimating dectabililty is the double-observer method (McCallum 2005). With this method, a second observer records all birds missed by the primary observer. The two observers can alternate between primary and secondary observer in order to estimate detectability for each observer. This addresses only observer bias, however, and not differences in bird behavior affecting detectability.

Literature Cited

Alaska Interagency HPAI Bird Surveillance Working Group. 2006. Sampling protocol for highly pathogenic Asian H5N1 avian influenza in migratory birds in Alaska. Interagency planning report, Anchorage, Alaska.

Cam, E., J. D. Nichols, J. E. Hines, J. R. Sauer, R. Alpizar-Jara, and C. H. Flather. 2002. Disentangling sampling and ecological explanations underlying species-area relationships. Ecology 83(4):1118-1130.

Danoff-Burg, J. A., and Xu C. 2005. Biodiversity calculator. Online. (http://www.columbia.edu/itc/cerc/danoff-burg/MBD_Links.html). Accessed 13 June 2010.

Farmer, A. and F. Durbian. 2006. Estimating shorebird numbers at migration stopover sites. The Condor 108:792-807.

Feierabend, D., and D. Schirokauer. 2009. 2009 bird surveys summary: Breeding bird survey, off road breeding bird surveys, waterbird surveys, and eagle nest monitoring. Klondike Gold Rush National Historical Park. Skagway, Alaska.

Hahr, M., and T. W. Trapp. 2004. Waterbird and breeding landbird inventories in Klondike Gold Rush National Historical Park. SE Alaska Inventory and Monitoring Network, National Park Service, Alaska Region. Inventory and Monitoring Program Final Report, Klondike Gold Rush National Historical Park, Skagway, Alaska.

Kirchhoff, M., and V. Padula. 2010. The Audubon Alaska WatchList 2010. Audubon Alaska, Anchorage, Alaska.

Klondike Gold Rush National Historical Park. 2009a. Coastal_Bird_Survey_Data. Database. National Park Service, Inventory and Monitoring Program, Alaska.

Klondike Gold Rush National Historical Park. 2009b. Waterbird monitoring protocol for Klondike Gold Rush National Historical Park, Skagway, Alaska: Standard operating procedure (SOP) #3 conducting the waterbird survey transect. Version 1.00. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Magurran, A. E. 2004. Measuring biological diversity. Blackwell Publishing, Malden, Massachusetts, USA.

McCallum, D. A. 2005. A conceptual guide to detection probability for point counts and other count-based survey methods. Gen. Tech. Rep. PSW-GTR-191. U.S. Department of Agriculture, Forest Service, Washington, D.C.

National Park Service. 2009a. ShoreZone coastal habitat unit mapping (lines) Sep 08-SEAN WRST. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009b. KLGO waterbird survey units. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009c. KLGO waterbird survey points. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Sherony, D. 2007. Wandering tattler. Image. Online. (http://www.flickr.com/photos/9765210@N03/2587703264/). Accessed 21 November 2010. Creative Commons Attribution-Share Alike 2.0 Generic license.

Skagway Bird Club. 2010. Birds of Skagway, AK. Skagway Bird Club, Skagway, Alaska.

Stenhouse, I. J. and S.E. Senner. 2005. Alaska WatchList 2005. Audubon Alaska. Online. (http://ak.audubon.org/files/Audubon%20Alaska/documents/WatchList2005.pdf). Accessed 30 November 2009.

U.S. Fish and Wildlife Service. 2008. Birds of conservation concern 2008. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia.

U.S. Fish and Wildlife Service. 2009. Yellow-billed loon. Online. (http://alaska.fws.gov/fisheries/endangered/yellow_billed_loon.htm). Accessed 10 November 2010.

U.S. Fish and Wildlife Service. 2010. New Carissa oil spill marbled murrelet photo library. Online. (http://www.fws.gov/oregonfwo/Contaminants/Spills/NewCarissa/MarbledMurrelet/PhotoPage.asp). Accessed 21 November 2010.

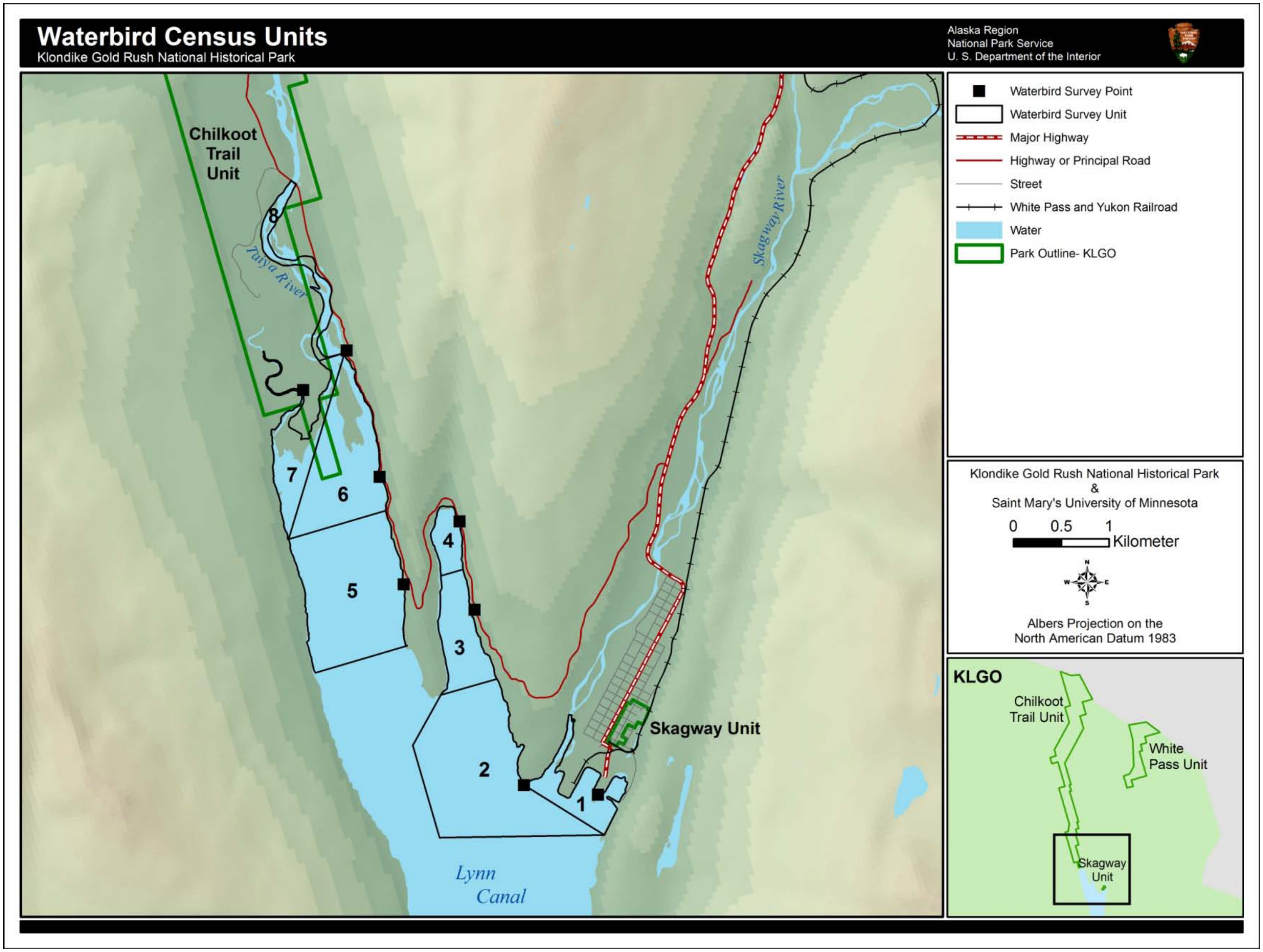
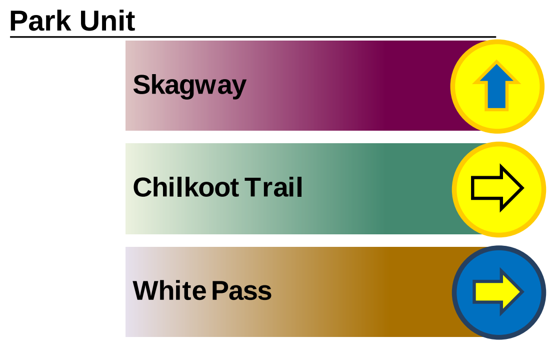


Plate 5. Waterbird survey points and census units (NPS 2009b, 2009c).

4.7 Bears

Measures

Number of Bear-human Incidents
Number of Bears Moved as a Nuisance
Number of Bear-human Incidents Where Bears Obtain Human Food
Bear Population and Distribution



Background

Both grizzly bears (*Ursus arctos*) and black bears (*Ursus americanus*) live in and near KLGO. While little quantitative data are available regarding the number of bears or their distribution in the area, their presence is an important issue for management (ADF&G 2007, 2008). KLGO experiences high visitor use, and bear-human conflict can be dangerous for both bears and people (Rudisill 2010). A recent study of bear-human interaction on the Chilkoot Trail reported an average of 28.7 reports of bear-human interaction each year on the U.S. portion of the trail (MacDougall 2009). When data from the Canadian portion of the Chilkoot Trail are included, the first few miles of the trail were found to have the second highest level of bear-human interaction of all trail segments (MacDougall 2009). Interactions with humans, including bears obtaining human food, can alter the animal’s natural behavior. Park staff work hard to educate visitors about bear safety, what to do if they see a bear, and current bear warnings. Visitors are encouraged to report bear sightings

Photo 15. Brown bear (Photo by Dave Schirokauer).

(Rudisill 2010).

There is an important distinction between bear-human interactions and bear-human incidents. A bear-human interaction is any activity and its effects involving bears and humans. This includes sightings, where a human sees a bear but the bear is apparently unaware of the human's presence, and encounters, where the bear and human are aware of each other's presence, but the bear does not approach the human in an aggressive manner (MacDougall 2009). During many encounters, the bear will walk or run away. A bear-human incident occurs when a bear approaches the observers in any manner other than curious (or unknowingly) without aggression. MacDougall (2009) also used the term 'incident' to describe cases where bears damaged property with or without people present.

Reference Condition

The reference condition for number of bear-human incidents, number of bears moved as a nuisance, and number of bear incidents where bears get human food is no occurences. There is insufficient information to determine a reference condition for bear population and distribution in or near KLGO at this time.

Data

In 2008, a study of bear-human interaction along the Chilkoot Trail was conducted using bear-human interaction data from 2002 to 2008 (MacDougall 2009). The study included both the U.S. and Canadian portions of the trail. Spatial analysis determined where most interactions occurred, and a temporal analysis determined what time of year most interactions were reported. Both interactions on trail segments and interactions in or near designated campsites were analyzed. Visitor use was accounted for by calculating rates of bear-human interaction relative to visitor levels. Detailed statistics reported by location, time of year, type of interaction, and bear species are available in MacDougall (2009).

Measures

Number of Bear-human Incidents

Three of the 201 bear-human interactions reported along the KLGO portion of the Chilkoot Trail were considered bear-human incidents, two involving a black bear and one involving a grizzly bear (MacDougall 2009). There were 16 incidents reported along the Canadian portion of the Chilkoot Trail during the same time period. Incidents per capita appear to be increasing from 2002 to 2008 when both the U.S. and Canadian portions of the trail were included in the analysis, but the majority of incidents occurred on the Canadian side of the trail (MacDougall 2009).

Number of Bears Moved as a Nuisance

There were no reports in MacDougall (2009) of bears moved as a nuisance along the Chilkoot Trail. Management directed the destruction of a black bear approaching hikers in 2007, but the bear was never found (MacDougall 2009). Schirokauer (2008) reports that during 2007 bear activity increased in Skagway. During the summer of 2008, bears continued to be a nuisance, but reports were not as numerous as the previous year. An ordinance passed in Skagway requiring residents to use bear-proof garbage containers and an investment in bear-resistant dumpster lids may have contributed to the decline in bear reports. In July of 2009 an adult female black bear was killed in the Skagway area by municipal police, and her glacier phased bear cub was relocated (Dischner 2009). Both bears were considered public safety risks after making multiple appearances in town.

Photo 16. Bear prints at Dyea

Number of Bear-human Incidents Where Bears Obtain Human Food

From 2002 to 2008, one incident occurred along the Chilkoot Trail where a black bear obtained a ‘non-natural’ attractant during an encounter at Sheep Camp (MacDougall 2009). This incident occurred on 17 August 2007 when a black bear entered Sheep Camp, wandered into the tent area, and appeared to eat food from a tent platform despite a group of 18 people yelling at it (MacDougall 2009).

Schirokauer (2008) also reports an incident of a female black bear and her three cubs-of-the-year obtaining food in the group site at the Dyea campground. The food was stored in an unsecured bear-resistant food locker. This family of bears was highly food conditioned and visited dumpsters in Skagway almost every night during the fall of 2008. Police hazed the bears regularly and asked the Alaska Department of Fish and Game to relocate them. This was the same family of which the adult female was killed in 2009 and one of her cubs was relocated.

Bear Population and Distribution

The size of KLGO is smaller than the typical home range of a bear, but bears do pass in and out of the park boundary. No data have been collected in KLGO to monitor the local population and distribution. The Alaska Department of Fish and Game maintains information on the population and distribution of bears throughout Alaska. Information is reported by units referred to as Game Management units (GMUs). KLGO lies within GMU 1D. This unit encompasses an area much larger than the park (Figure 28), so few conclusions about the health of bears in or near KLGO can be drawn from the GMU data. The available information is summarized here to provide some indication of the general health of bears in the region.

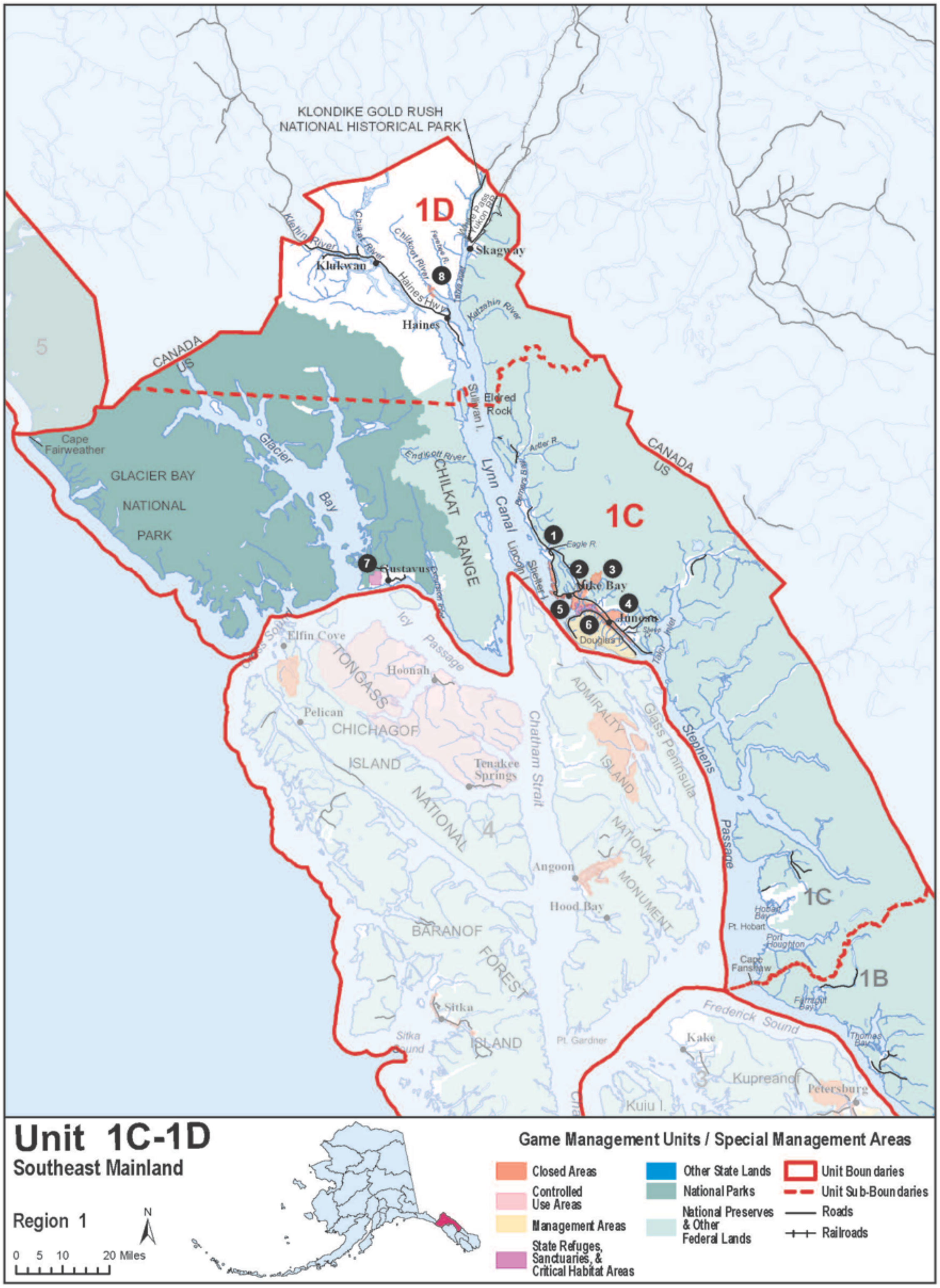


Figure 28. Alaska Department of Fish and Game GMU 1D (© 2010 Alaska Department of Fish Game, used here with permission).

Data collection in GMU 1D is difficult because of the forested terrain and vast, remote areas (ADF&G 2008). No black bear population studies have been conducted in GMU 1D, but black bear densities are thought to be lower in this unit than in other southeast Alaska mainland areas (ADF&G 2008). Estimates of population density from the late 1980s and 1990 range from 1.3 black bears per forested square mile to 3.8 black bears per square mile in GMU 1D. The Alaska Department of Fish and Game concluded it is virtually impossible to have a sense of the true population size in this unit. The population could be high because of productive salmon streams or low because of suppression by brown bears (ADF&G 2008). Black bear distribution information is also scarce, but the Department of Fish and Game reported an increase in the number of bear-human interactions as a result of human population growth (ADF&G 2008).

A relatively high number of black bears harvested in the unit exhibit a cinnamon coat. The glacier (blue) pelage and white-phase (spirit bear) have also been observed in the GMU 1D (ADF&G 2008, KLGO D. Schirokauer pers. comm. 7 June 2010). The white-phase of the black bear was observed in the Skagway area, and a white-phased sub-adult was harvested just outside Skagway in 2008 (KLGO D. Schirokauer pers. comm. 7 June 2010).

Even less information is available for the brown bear than the black bear. The Alaska Department of Fish and Game summarized the brown bear population status for GMU 1 (an area containing GMU 1D but also much of southeast Alaska) from July of 2004 to June of 2006 (ADF&G 2007). Quantitative data were not available, but based on anecdotal reports, staff observations, pilot observations, and sealing records, the population was believed to be stable during the reporting period (ADF&G 2007).

Stressors

The primary stress to bears is the presence of humans. Various factors contribute to the potential for bear-human incidents. Bears often use the Chilkoot Trail for travel because of dense vegetation in the surrounding landscape (MacDougall 2009). The first few miles of the Chilkoot Trail receive high numbers of day-hikers, and this section of the trail also happens to be near the Taiya River and its salmon. Lack of bear-proof food and garbage containers had been a problem, but significant investments in recent years have greatly improved the situation along the trail and in the municipality of Skagway. All food and garbage containers along the Chilkoot Trail are now bear proof (KLGO D. Schirokauer pers. comm. 25 August 2010).

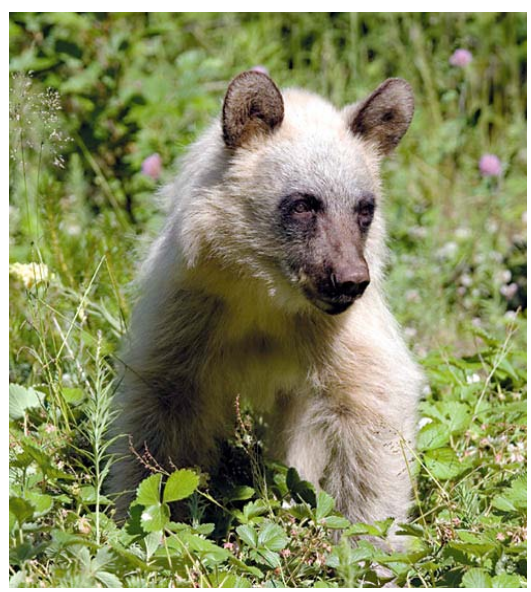


Photo 17. Spirit bear (Photo by Andrew Cremata. Used with permission).

Reporting Zones

The MacDougall report addresses only the Chilkoot Trail reporting zone. A combination of anecdotes and local news stories provide information for the Skagway area, which although encompassing a larger area, is reported as the Skagway reporting zone. The Alaska Department of Fish and Game information encompasses a very large area extending far beyond the park boundaries. All reporting zones fall within the same GMU.

Condition

Insufficient information exists to make condition statements for KLGO based on bear population and distribution. Condition for this report, therefore, is based on measures of bear-human interaction. Reports of nuisance bears were still frequent in Skagway during 2008 but showed improvement compared to 2007. The municipality has recently made a significant effort to bear-proof garbage containers and educate citizens.

Three bear-human incidents were reported along the Chilkoot Trail between 2002 and 2008, and there have also been at least two reports of bears obtaining human food. Although this represents less than three percent of the 201 bear-human interactions reported during the same time period, it is still cause for concern. No trend in the Chilkoot Trail park unit was reported in MacDougall (2009), likely because of the relatively few incidents reported over multiple years. Nonetheless, there is no indication that incidents are increasing or declining. The White Pass reporting zone is considered good with a stable trend. Few hikers visit the White Pass park unit, and there are no known reported bear-human incidents (KLGO D. Schirokauer pers. comm. 25 August 2010).

Data Needs

Population and distribution data for bears in or near KLGO are needed to fully describe the condition of bears in the park. Park staff may want to track the number of bears that are relocated or killed in the area as either a nuisance or as a defense of life and property, because these bears impact the park’s overall bear population.

Literature Cited

Alaska Department of Fish and Game. 2007. Brown bear management report of survey-inventory activities 1 July 2004 - 30 June 2006. P. Harper, editor. Juneau, Alaska.

Alaska Department of Fish and Game. 2008. Black bear management report of survey-inventory activities 1 July 2004 - 30 June 2007. P. Harper, editor. Juneau, Alaska.

Alaska Department of Fish and Game. 2010. Unit 1C-1D. Map. Online. (http://wildlife.alaska.gov/gis/maps/gmus/CurrentSimple/gif/1cd.gif). Accessed 22 November 2010.

Dischner, M. 2009. Dead sow, public safety, color considered in decision to move glacier bear to Katzehein area. Skagway News. Online. (http://www.skagwaynews.com/072409SNtopstories.html). Accessed 22 June 2010.

MacDougall, S. 2009. Bear-human interactions along the Chilkoot Trail. Red Deer College, Red Deer, Alberta. Prepared for Chilkoot Trail National Historic Site, Whitehorse, Yukon.

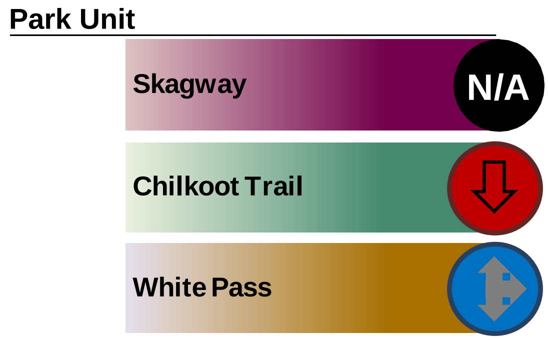
Rudisill, J. 2010. Bear-human interaction guidelines. Updated 2010. Final draft. Chilkoot Trail National Historic Site of Canada.

Schirokauer, D. 2008. Natural resources program summary report FY2008. Klondike Gold Rush National Historical Park. Skagway, Alaska.

4.8 Western Toads

Measures

Distribution (Percent of core sites occupied by breeding toads)
Abundance
Reproduction (Percent of sites where toads are successfully recruited)
Presence and Distribution of Chytrid Fungus
Presence / Absence of Other Amphibian Species Park-wide



Background

Amphibians play an important role in ecosystems, participating in nutrient cycling, insect control, and providing prey for predator species (KLGO 2009). Due to their dependence on aquatic habitats, amphibians are also important indicators of ecosystem health (Anderson 2004b). Two amphibian species have been found in KLGO: the western toad (*Bufo boreas*) and the Columbia spotted frog (*Rana luteiventris*).

The western toad has become the focus of monitoring efforts in recent years for various reasons. First, it is relatively more abundant than the Columbia spotted frog, which has only been found at a few locations in the White Pass Unit. In addition, local anecdotal reports suggest a decline in western toad population over the last several decades, which parallels precipitous declines in large portions of their range as well as declines in the overall global amphibian population (Carstensen et al. 2003, Fairchild 2008, Welz 2008, KLGO 2009). The USFWS considers western toads to be a species of concern, and the National Heritage Network and The Nature Conservancy classify the species as rare and uncommon in Alaska (KLGO 2009, USFWS 2010). A lack of regional knowledge regarding western toad distribution, population, and habitat range also

Photo 18. Western toad (Wetherbee 2009).

prompted recent monitoring efforts (Wetherbee 2009b).

The full extent of western toad distribution extends south from Alaska through western portions of Canada and the United States (Fairchild 2008). Western toads, which are also known as boreal toads, have been found in KLGO at elevations up to 870 meters; however, most are found below 305 meters, which might be partially explained by likelihood of detection (Carstensen et al. 2003, Fairchild 2008, Welz 2008). Toads gather in shallow breeding ponds in the spring and later move to upland wetland sites. In winter they hibernate in terrestrial forests (KLGO 2009).

Reference Condition

Determining a reference condition for western toads is difficult for two reasons. First, monitoring of western toads in KLGO did not occur prior to 2001, so a historic reference point does not exist. There are, however, anecdotal reports of greater western toad abundance around Dyea and Skagway in the past than is observed now. Second, survey intensity and locations monitored each year have evolved since monitoring began. This presents a challenge when comparing survey statistics over the last ten years. In addition, the number and use of breeding ponds may fluctuate naturally from year to year (KLGO 2009). The establishment of a standard protocol in recent years will allow for trends to be determined in the future, and measures of reproductive success observed in recent years will become a baseline for future condition assessments. Due to its known threat to amphibian species, any presence of the chytrid fungus (*Batrochytrium dendrobatitis*) in the park is cause for concern.

Data

From 2001 to 2003, an opportunistic amphibian inventory was conducted in southeast Alaska parks through the I&M Program (Anderson 2004b). The goal was to collect baseline information about amphibians and to confirm 90% presence/absence of expected amphibian species. Field staff were asked to document opportunistic observations of amphibians while conducting their normal duties. Twenty-two observations of western toads totaling 334 individuals (likely includes recounts) occurred in KLGO or within 20km of the park boundary, and several western toad breeding sites were discovered in the Dyea Flats area (Anderson 2004b) (Plate 6). Throughout the summer of 2002, many tadpoles, toadlets, and subadults were noted by staff in the Dyea Flats area (Anderson 2004b). Western toads were also observed along the Chilkoot Trail across the border in Canada (Anderson 2004b).

Following the opportunistic survey, formal monitoring of amphibians in KLGO began in 2004 (Wetherbee 2009b). The western toad is the primary focus of the monitoring efforts due to its relative abundance (Wetherbee 2009a). The current detailed monitoring protocol is available in Wetherbee (2009a). This protocol was not in place prior to 2009 but was developed using information from previous monitoring efforts. Monitoring includes routine visual encounter surveys, individual adult and juvenile toad measurements, and chytrid fungus testing (Wetherbee 2009a). Breeding phenology, egg mass locations, predation, and habitat information is also collected (KLGO 2009). Given the changes in amphibian survey intensity and the monitoring of site locations prior to 2009, a brief summary of each year’s monitoring effort is included below to provide context. Results are discussed in the appropriate measures sections, and detailed results can be found in the annual amphibian monitoring reports (Payne 2004, 2005, 2006, Fairchild 2008, Welz 2008, and Wetherbee 2009b).

2004

In 2004, data collection focused on determining the distribution of amphibians in the park, including a survey and characterization of wetland habitat (Wetherbee 2009b) Wetlands were evaluated for habitat suitability and as potential long-term monitoring sites. Basic phenology data and amphibian sightings were also recorded (Payne 2004). All surveys occurred within the Taiya watershed; however, sightings by park staff and visitors elsewhere in or near the park were also documented and mapped.

2005

In 2005, thirty-nine wetland sites were identified using 2003 LIDAR imagery and the National Wetland Inventory GIS layer (Wetherbee 2009b). Between 21 April and 18 August, 121 surveys were conducted at these wetland sites. Some of these sites were previously surveyed in 2004. In addition to habitat suitability and phenology data, fifteen adult toads were captured and tagged, and ten chytrid fungal swabs were collected (Payne 2005). Some opportunistic observations were also documented.

2006

In 2006, eighty surveys were conducted of 28 wetland sites (Payne 2006). Twelve toads were captured and tagged. Following the detection of chytrid fungus in 2005, 38 samples were collected to monitor the distribution of chytrid fungus. Phenology and habitat data were once again collected. Data collection methods and documentation changed from previous years to conform to the USGS Amphibian Research and Monitoring Initiative (ARMI) protocol (Payne 2006).

2007

Due to low recapture rates in previous years, mark-recapture data were no longer considered beneficial, and no additional western toads were tagged. USGS ARMI reclassified Dyea from an apex monitoring site to a mid-level monitoring site, which documents trends in site occupancy (Adams et al. 2008). Survey site selection was also modified from previous years in an effort to explore new sites while continuing to monitor sites with previously documented breeding activity and locations determined to be potential breeding sites (Fairchild 2008). In 2007, nineteen previously identified wetlands and 35 new pond sites were surveyed (Fairchild 2008). Twenty of the 35 new sites were located in the White Pass Unit, and the remaining sites were in the Taiya watershed. A total of 156 surveys were conducted, and 26 samples were obtained to test for chytrid fungus. A Microsoft Access database was developed to store survey data (Fairchild 2008).

Photo 19. Swabbing for chytrid fungus (NPS Photo by Kevin Payne).

2008

The monitoring site selection method used in 2007 was further developed in 2008 with the establishment of a rotating panel survey of remote areas. Sites with documented breeding activity in previous years (core sites) and locations determined to be likely breeding sites (non-core sites) are surveyed every year. These are referred to as 'intensive sites' and are monitored multiple times each year (Welz 2008). Additional wetlands in the park are divided into four ‘panels’ with planned monitoring of one panel each year on a rotating schedule (Figure 29). These are referred to as ‘extensive sites’ and are surveyed once per season (Welz 2008). A total of 156 surveys were completed of one new and fifteen previously identified wetlands in the Taiya watershed. Seven previously identified lakes and 156 new lake sites in the White Pass Unit were also surveyed (Welz 2008). Funding limitations in 2008 did not allow for chytrid fungus sampling. Sampling is planned for every other year, pending availability of funding (Schirokauer 2008).

2009

In 2009, the stratified survey method was formalized. Routine amphibian surveys were conducted between 14 April and 19 August at eight western toad core breeding sites in Dyea and three non-core sites at Lost Lake and West Creek (Plate 7). All thirteen extensive sites in panel three along the Chilkoot Trail corridor were also surveyed (Wetherbee 2009b) (Figure 29).

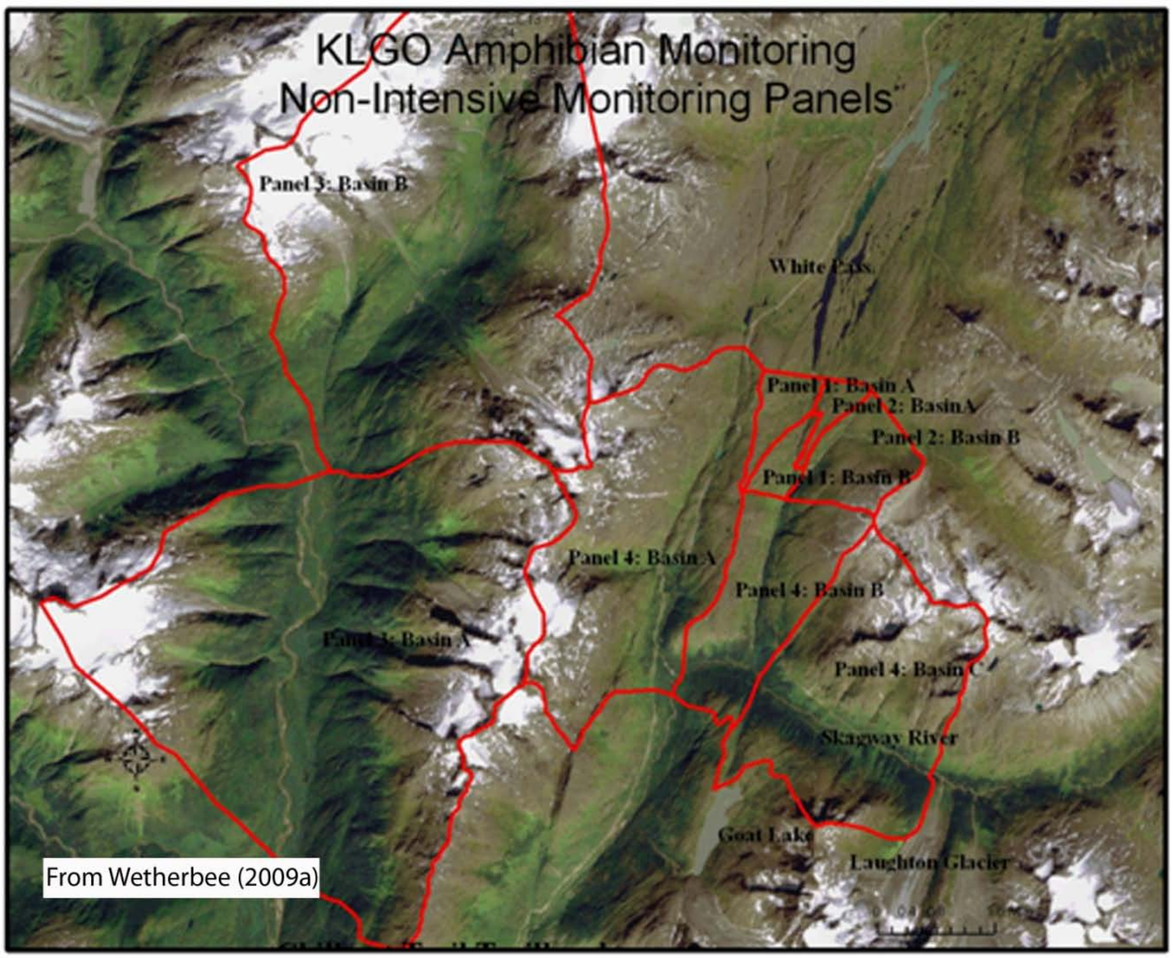


Figure 29. KLGO amphibian extensive monitoring panels (From Wetherbee 2009a).

Other Data

The University of Alaska Museum of the North contains historic amphibian specimens from KLGO and other Alaskan parks. These specimens could provide information pertaining to genetics, phenology, and biodiversity studies (Anderson 2004a). Iris Holmes, a graduate student from Cornell University, is conducting western toad genetics research in southeast Alaska, including sites in KLGO (Wetherbee 2009b). Preliminary results indicate genetically distinct populations from the Chilkat River valley, Chilkoot River valley, and the Taiya River corridor (Wetherbee 2009a).

Measures

Distribution (Percent of core sites occupied by breeding toads)
As of 2009, eight wetlands, all of which are located in the Taiya River watershed, are considered core monitoring sites (Plate 7). Presence of western toads in each core site is summarized by life stage and year in Table 12. Due to ongoing protocol development prior to 2009, survey effort at sites varied from year to year. Breeding site occupation appears to have declined since 2004 (Wetherbee 2009b). Five sites where breeding activity had been heavy in the previous five years lacked any breeding activity in 2009 (Wetherbee 2009b).

No core monitoring sites are located in the White Pass Unit, but the unit has been surveyed and will be surveyed in the future as part of the rotating panel component of the protocol. A western toad was confirmed in the unit in 2004 after a railroad employee reported a sighting (Payne 2004). This site was revisited each year from 2005 to 2008, but no toads were detected. Surveys of 20 additional sites in 2007 and 163 lakes in 2008 resulted in no additional western toad sightings (Welz 2008).

Table 12. Presence of western toad life stages at core monitoring sites: 2004-2009 (Welz 2008, Wetherbee 2009b). Sites included are those considered core sites as of 2009 (Wetherbee 2009b). NS indicates site was not surveyed.

		Core Site							
Year	Life Stage	DY2	DY3	DY13	DY14	TR01	DY33	WC02	WC04
2004	Amplexing pairs or egg masses					NS		NS	NS
	tadpoles		X		X	NS	X	NS	NS
	metamorphs		X			NS		NS	NS
	juveniles			X	X	NS		NS	NS
	adults					NS	X	NS	NS
2005	Amplexing pairs or egg masses		X		X		X		NS
	tadpoles		X		X	X	X	X	NS
	metamorphs			X		X		X	NS
	juveniles	X	X						NS
	adults					X		X	NS
2006	Amplexing pairs or egg masses		X		X	X	X	X	NS
	tadpoles		X		X	X	X	X	NS
	metamorphs		X		X			X	NS
	juveniles	X	X	X	X			X	NS
	adults		X			X	X	X	NS
2007	Amplexing pairs or egg masses		X		X	X			NS
	tadpoles		X		X	X		X	NS
	metamorphs				X	X			NS
	juveniles							X	NS
	adults	X	X		X	X		X	NS
2008	Amplexing pairs or egg masses				X	X			
	tadpoles			X	X	X			X
	metamorphs				X	X			X
	juveniles			X					
	adults				X	X			
2009	Amplexing pairs or egg masses		X		X	X			X
	tadpoles (larvae)				X	X			X
	metamorphs			X	X				
	juveniles	X							X
	adults				X	X		X	

Abundance

Comparing abundance of western toads over the last six years is complicated by the variability in survey effort and monitoring sites. Early mark-recapture efforts to estimate population size were unsuccessful. Now that a monitoring protocol has been established, future condition assessments could consider using abundance of western toads at core sites as a measure of condition.

Reproduction (Percent of sites where toads are successfully recruited)
A successful breeding cycle is defined as one in which eggs, laid in the spring, hatch and the toads reach maturity and migrate to their upland winter sites (Wetherbee 2009b). In 2009, a successful breeding cycle occurred at only two sites (DY13 and DY14). In previous years, monitoring efforts were not as focused on determining recruitment; however, metamorphs were usually sighted at two or three of the core sites each year. The number of sites with tadpoles appears to have decreased since 2005. Tadpoles were observed at five of the core sites in 2005 and 2006, four in 2007 and 2008, and three in 2009.

Presence and Distribution of Chytrid Fungus
The presence of chytrid fungus (*Batrochytrium dendrobatitis*) in KLGO was confirmed in 2005 by swab samples obtained from western toads (Wetherbee 2009b). This was the first confirmed case of chytrid fungus in Alaska (Payne 2006). Further tests in 2006 and 2007 were conducted to learn of the extent and distribution of the fungus in the park. Results are summarized below by location and life stage (Table 13). Chytrid fungus testing did not occur in 2008, but in 2009, seven swab samples were collected from three adult and four juvenile western toads. The results were not available at the time of this report.

Table 13. Summary of chytrid fungus sampling and results: 2005-2007 (Adapted from Fairchild 2008).

Site	Species	Adults Positive/Tested	Juveniles Positive/Tested	Metamorphs Positive/Tested
Dyea 3	Western Toad	-	3-5/10	-
TR 1	Western Toad	5/10	-	0/3
WC 2	Western Toad	0/1	1-6/8	-
Dyea 14	Western Toad	-	-	0/2
Dyea 19	Western Toad	-	1/10	-
WC 3	Western Toad	-	0/2	-
Dyea 2	Western Toad	1/1	8/10	-
WP02	Columbia Spotted Frog	0/1	-	-

Presence / Absence of Other Amphibian Species Park-wide
During the 2001-2003 opportunistic surveys, only western toads were reported in KLGO. In 2007, one Columbia spotted frog was found in the White Pass Unit about four kilometers from the Canadian border (Fairchild 2008). This species is commonly found in Canada but was new to KLGO (Fairchild 2008). Deep permanent ponds, which the frogs need for winter hibernation, are available in areas of the White Pass Unit near Canada (Fairchild 2008). Breeding activity was not noted at the time of observation (Fairchild 2008). A much greater survey effort in the White Pass Unit in 2008 (164 lake sites) resulted in a total of four records of the Columbia spotted frog from three occupied lakes (Welz 2008).

Two unconfirmed sightings of salamanders have been reported in the park. One sighting occurred in the Canyon City area in 1976, and the other was from Saintly Hill in 2001 near the start of the Chilkoot Trail (Fairchild 2008). The distribution range of the wood frog (*Rana sylvatica*) includes KLGO, but the species has never been documented in the park (Welz 2008). No amphibians besides western toads were noted in 2009 (Wetherbee 2009b).

Photo 20. Columbia spotted frog.

Stressors
Chytrid fungus is considered one of the main factors contributing to loss of amphibian diversity worldwide and has been found in KLGO (Wetherbee 2009b). The fungus is thought to spread quickly through infected organisms, contaminated water, or an unknown host, and death can occur soon after infection (Wetherbee 2009b). Chytrid fungus can survive in lake water for seven weeks without amphibian presence, but if allowed to dry for more than three hours, it will die (Payne 2006). An ecological niche model for the fungus predicts that, if established, the fungus will be able to persist in much of coastal southeast Alaska (Payne 2006).

Amphibians are also sensitive to UV radiation, water contamination, water temperature, and water availability (KLGO 2009). Relatively permanent water is required for successful breeding (KLGO 2009). Climate is one driver of water availability. Flood events, which do occur along the Taiya River, can disrupt breeding ponds (Welz 2008, Wetherbee 2009b). Drying of wetlands is also thought to potentially stress the toad population, and isostatic rebound may be contributing to the problem (Anderson 2004a). As land rises, abundance of groundwater mediated aquatic habitat declines. Habitat may additionally be stressed by human disturbance, as wetland sites in the Chilkoot Trail area are near high recreational use areas (Welz 2008).

Reporting Zones
During the 2001 through 2003 opportunistic survey, most records of western toads came from the Chilkoot Trail Unit, but there was at least one observation of a western toad in or near the White Pass Unit (Anderson 2004b). One toad was also recorded on a street in downtown Skagway (Anderson 2004b). Monitoring since 2003 has focused on the Chilkoot Trail Unit, which contains all core sites monitored for breeding. Sites in the White Pass Unit were monitored in 2008, and future monitoring of the White Pass Unit will occur on a rotating schedule.

Condition
Western toads are of significant concern in the Chilkoot Trail reporting zone for multiple reasons. Breeding site occupancy and success rates appear to have declined since monitoring began in 2004, and concern exists regarding how many toads survive to reach maturity. Chytrid fungus, a well documented threat to amphibian species, has been confirmed in this unit. In

addition to chytrid fungus, other stressors, including periodic flooding, drying of wetlands, and human disturbance of habitat, are also present in this unit. Anecdotal reports echo concern about a perceived decline in the abundance of western toads. This local concern is consistent with regional anecdotal reports of dramatic declines in western toad populations from Ketchikan to Haines, Alaska (Carstensen et al. 2003).

Few amphibians have been observed in the White Pass Unit despite repeated surveys of many sites. This does not mean that condition is poor but rather may reflect the amount of suitable habitat or challenges of detection. Chytrid fungus has not been recorded in this unit, although results are only available for one specimen. Based on the limited data and the fact that stressors are less prevalent than in the Chilkoot Trail Unit, condition is considered good in the White Pass Unit. Insufficient information exists to determine a trend. Despite a recorded sighting of a western toad on a Skagway sidewalk, the Skagway Unit reporting zone is considered not applicable for this indicator. Skagway is an urban park unit and not managed for western toad habitat. It should be noted that prior to the construction of the Skagway airport, the site was a wetland and western toads were abundant (B. Kalin pers. comm. 2010).

Data Needs
Ongoing monitoring of amphibians in KLGO is needed to accurately determine condition and trend. Long-term data are especially important for western toads because natural fluctuation in breeding pond use, metapopulation dynamics, and abundance is possible. Additional recommendations for future monitoring can be found in Wetherbee (2009b).

Literature Cited

Adams, M. J., C. A. Pearl, S. Galvan, B. McCreary, N. Chelgren, R. Klaver, and D. Pilliod. 2008. Pacific northwest region 2008 annual report. United States Geological Survey Forest and Rangeland Ecosystem Science Center Amphibian Research and Monitoring Initiative. Corvallis, Oregon.

Anderson, B. 2004a. Glacier toads and frozen frogs: Alaska's surprising amphibian diversity. Alaska Park Science 3(2):11-15.

Anderson, B. C. 2004b. An opportunistic amphibian inventory in Alaska's National Parks 2001-2003: Final report. Alaska Region Inventory & Monitoring Program, Anchorage, Alaska.

Carstensen, R., M. Willson, and R. Armstrong. 2003. Habitat use of amphibians in northern southeast Alaska. Report to the Alaska Department of Fish and Game. Discovery Southeast. Juneau, Alaska.

Fairchild, L. L. 2008. Amphibian productivity monitoring, Chytrid fungal sampling, and habitat assessment in Klondike Gold Rush National Historical Park. Final Report. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Klondike Gold Rush National Historical Park. 2009. Amphibian monitoring. Klondike Gold Rush National Historical Park, Skagway, Alaska.

National Park Service. 2009a. Alaska parks amphibian inventory 2003 version. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 2009b. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Payne, K. J. 2004. Amphibian monitoring and habitat assessment in Klondike Gold Rush National Historical Park. Final Report. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Payne, K. J. 2005. Amphibian productivity monitoring and habitat assessment in Klondike Gold Rush National Historical Park. Final Report. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Payne, K. J. 2006. Amphibian productivity monitoring, Chytrid fungal sampling, and habitat assessment in Klondike Gold Rush National Historical Park. Final Report. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Schirokauer, D. 2008. Natural resources program summary report FY2008. Klondike Gold Rush National Historical Park. Skagway, Alaska.

U.S. Fish and Wildlife Service. 2010. Species profile for western toad (*Bufo boreas*). Online. (http://ecos.fws.gov/ speciesProfile/profile/speciesProfile.action?spcode=D03T). Accessed 1 July 2010.

Welz, J. P. 2008. Amphibian productivity monitoring and habitat assessment in Klondike Gold Rush National Historical Park. Final Report. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Wetherbee, H. 2009a. Amphibian monitoring protocol. Version 1.0. Klondike Gold Rush National Historical Park. Skagway, Alaska.

Wetherbee, H. 2009b. 2009 Amphibian monitoring report. Klondike Gold Rush National Historical Park. Natural Resource Management Program. Skagway, Alaska.

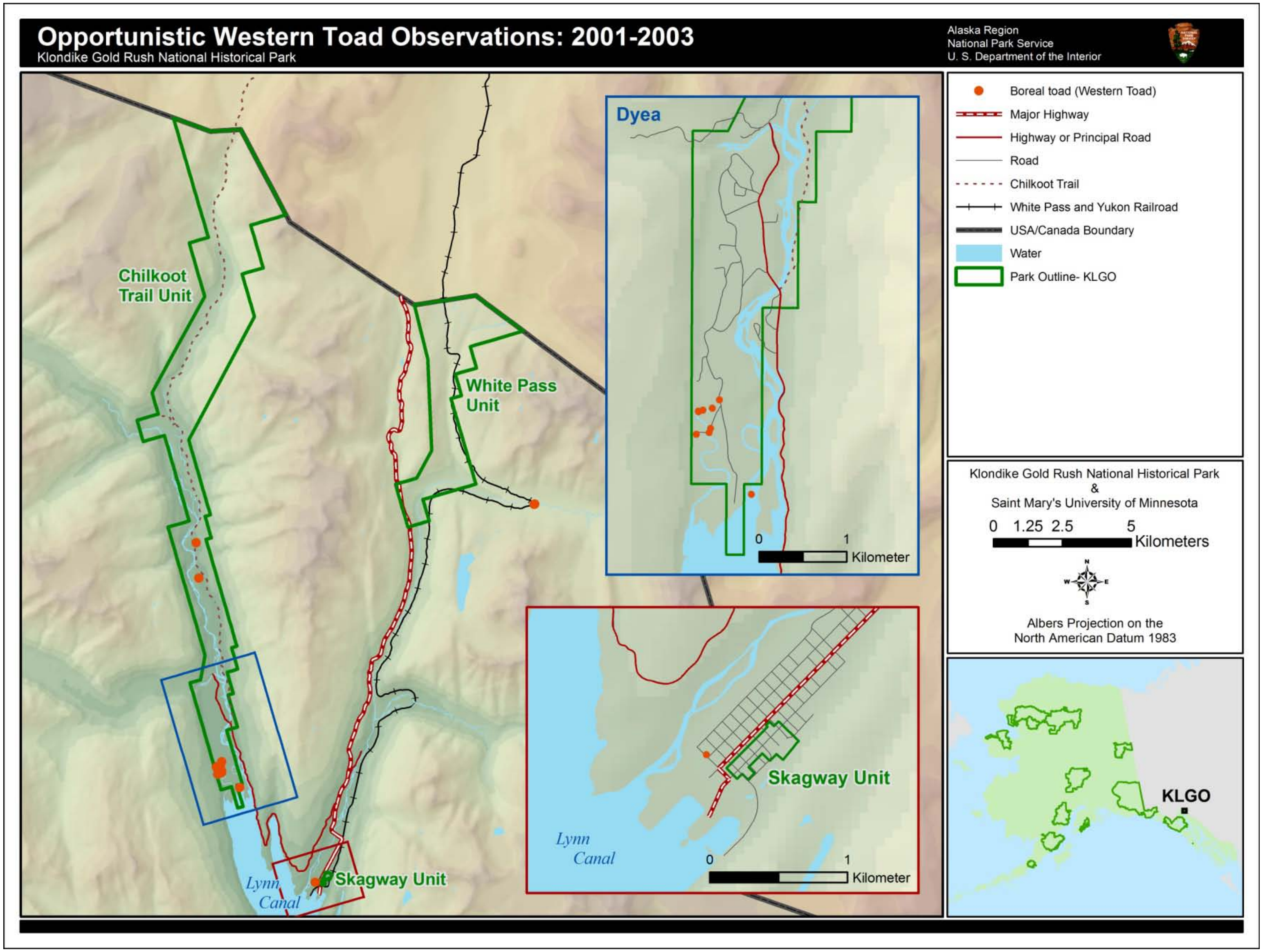


Plate 6. Opportunistic western toad observations: 2001-2003 (NPS 2009a).

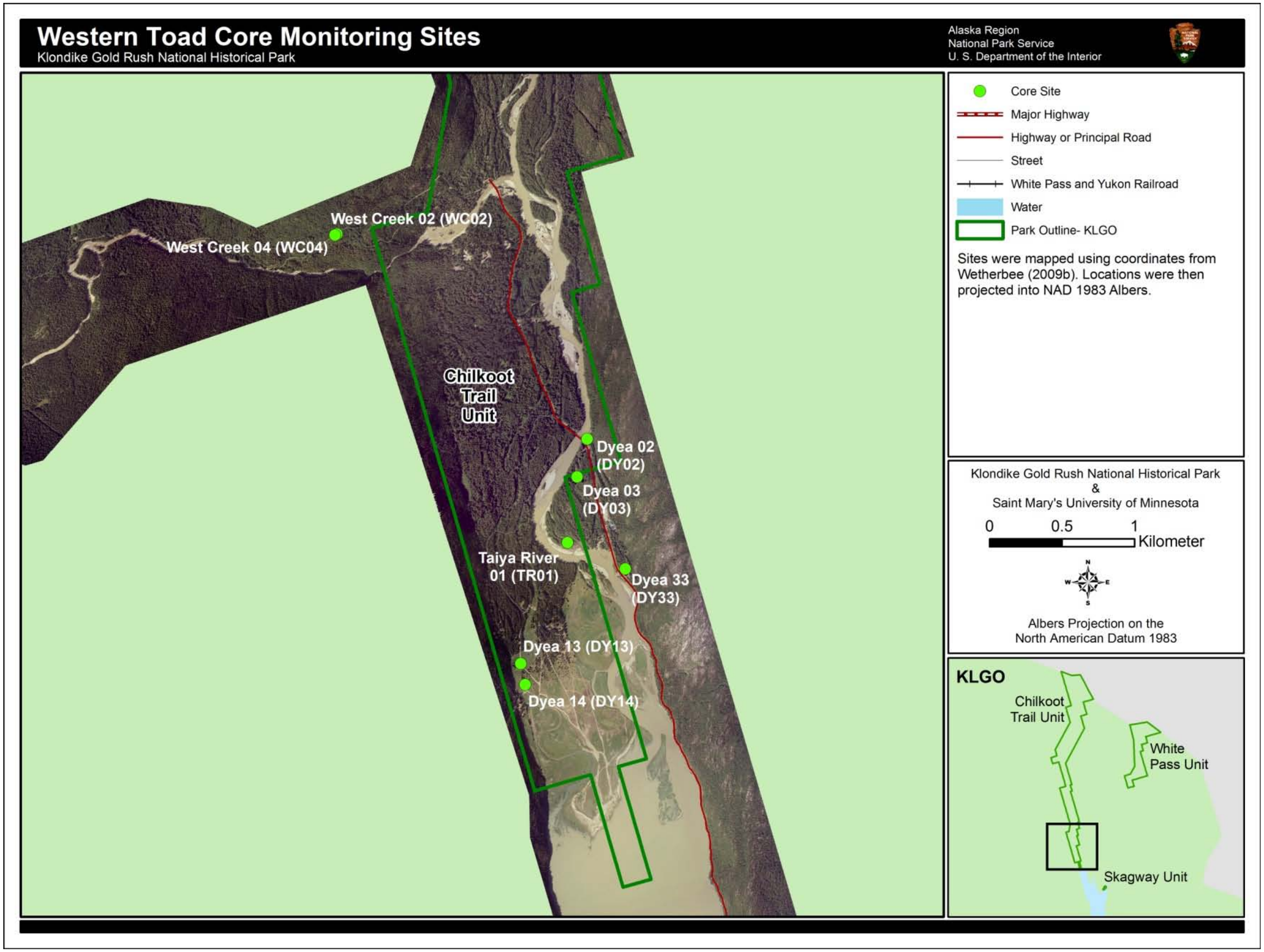
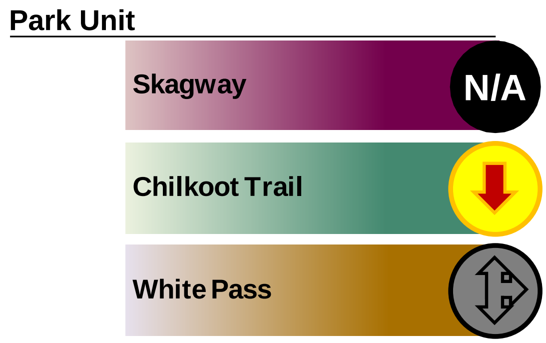


Plate 7. Western toad core monitoring sites (Wetherbee 2009b, NPS 2009b).

4.9 Wetlands

Measures
Area of Wetland Types



Background
Wetlands in KLGO provide many ecological benefits, including habitat for several fish, wildlife, and plant species (USFWS 2010). Wetlands also help regulate water supply by recharging ground water and retaining and slowly releasing flood waters and snow melt (USFWS 2010). Nutrient cycling and water purification are additional ecological services provided by wetlands. The National Park Service is directed by executive order to "provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands (Exec. Order 11990)."

Reference Condition
Wetland communities are driven by many ecosystem processes including hydrology and vegetative succession; therefore, a historic point in time or threshold value is not applicable as a reference condition. Despite this recognition of the dynamic nature of wetlands, monitoring wetlands is critical for understanding changes to habitat, water quality, and local hydrology. KLGO lacks historic data, so quantifying change in wetlands at this time is not possible; however, a greater extent of historic wetlands in Dyea has been reported anecdotally by park staff (KLGO D. Schirokauer pers. comm. 7 December 2009).

Data
Three primary sources of recent wetland data exist for KLGO: the National Wetland Inventory (NPS 2009), a wetland inventory conducted in 2000 (Bosworth 2000), and a GIS data layer of wetlands provided by the park (Schirokauer 2009).

The National Wetland Inventory is conducted by the U.S. Fish and Wildlife Service, which is the principal Federal agency for providing information regarding the extent and status of wetlands in the United States (USFWS 2010). Wetlands are mapped using high altitude imagery as well as collateral data and field work. Wetland coverage for KLGO was delineated using late 1970's imagery from the Alaska High Altitude Aerial Photography Program.

The 2000 inventory of wetlands included the Dyea area of the lower Taiya River (Bosworth 2000). The goals of the project included locating, mapping, and describing all wetlands in the study area. Potential wetlands identified using aerial photos and topographic maps were visited to determine wetland presence and type. Wetland delineation followed guidelines from the U.S. Army Corps of Engineers (COE) Wetlands Delineation Manual (Environmental Laboratory 1987). The three criteria used were vegetation, hydrology, and soils. Wetlands that did not meet COE methods but did meet NPS wetland management criteria were also delineated. The Cowardin classification for each of these wetlands (Cowardin et al. 1979) was also recorded. Descriptions of all delineated wetlands are included in Bosworth (2000).

The GIS dataset provided by the park is an updated version of the National Wetland Inventory data for the Dyea area. It was last updated by park staff in 2009. All wetlands are attributed using the Cowardin et al. (1979) classification system.

To determine area of each wetland type in KLGO, a composite GIS dataset was created from these three sources. More recent and higher resolution datasets were given priority. The order of priority in the merged dataset was 1) Dyea wetlands (Schirokauer 2009), 2) wetland inventory of the Dyea area by Bosworth (2000), and 3) the National Wetland Inventory (NPS 2009). This composite dataset was used to calculate area by wetland type according to the Cowardin et al. (1979) classification.

Measures

Area of Wetland Types

A variety of wetland types exist in KLGO. A complete list of wetland types with area per park unit is included as Appendix G. Wetlands are summarized here by system and subsystem levels for riverine and estuarine wetlands and by system and class levels for palustrine features (Table 14). Wetlands are also depicted on Plate 8. The only wetland in the Skagway Unit is Pullen Creek, which is not within KLGO's jurisdiction. The Skagway River was not included in any of the three wetland datasets and therefore does not appear in the results for White Pass Unit. The remaining wetlands in the White Pass Unit are all palustrine features. The largest wetland type in the Chilkoot Trail Unit is palustrine forested, most of which occurs along the middle portion of the Chilkoot Trail. Other large wetland types include riverine systems, which represent the Taiya River, and estuarine intertidal systems, which are located in the Dyea area.

Table 14. Area of wetland types by park unit in hectares (Bosworth 2000, NPS 2009, Schirokauer 2009).

Wetland Type	Chilkoot Trail	White Pass	Total
Estuarine Subtidal	5.9		5.9
Estuarine Intertidal	67.1		67.1
Palustrine Aquatic Bed	0.5		0.5
Palustrine Emergent	0.4	0.3	0.7
Palustrine Forested	226.9		226.9
Palustrine Scrub Shrub	27.6	3.3	30.9
Palustrine Unconsolidated Bottom	1.2	4.7	5.9
Palustrine (Mixed Classes)	19.7		19.7
Riverine Tidal	14.4		14.4
Riverine Lower Perennial	2.7		2.7
Riverine Upper Perennial	88.1		88.1
Total:	454.5	8.3	462.9

Stressors

Climate affects the amount of water entering a wetland system through precipitation and the rate of water loss through evapotranspiration. Climate warming trends have been observed in various parts of Alaska, and climate models predict warming trends in the future (Moynahan and Johnson 2008, Scenarios Network for Alaska Planning 2009). Climate models also predict an increase in summer precipitation, but any increase in water availability would likely be more than offset by increased evapotranspiration resulting from warmer temperatures and a longer growing season (Scenarios Network for Alaska Planning 2009).

Climate change can alter the hydrologic phenology (see hydrology section) of the seasonal wetlands that are common in the Dyea area. Earlier spring high-water and early drying of wetlands affects wetland dependent amphibians and can result in the desiccation and death of larval masses. Taiya River hydrology is also important to wetlands along the river, including wetlands in the Dyea area. The Taiya River is heavily influenced by melting snow and ice, which is driven by climate. Proglacial lake outburst flood events are another aspect of local hydrology that can cause sudden dramatic changes to wetlands. Outburst floods can inundate wetland areas with water as well as reroute the course of the river, changing its relationship to adjacent wetlands.

Isostatic rebound is rapidly changing wetlands in the Dyea area. Coastal land is rising following the retreat of glaciers which once covered the area with over a kilometer thick layer of ice (KellerLynn 2009). Larsen et al. (2005) reported that southeast Alaska is experiencing the fastest rate of present-day glacio-isostatic uplift documented anywhere. Estimated rates of uplift within KLGO are 14 to 16 mm per year, suggesting that land has risen approximately 1.6 to 2.1 meters since the gold rush (Larsen et al. 2005, KellerLynn 2009). Other possible contributing factors to uplift are tectonic forces and global glacial isostatic adjustment (KellerLynn 2009). This uplift is decreasing the extent of wetlands in the Dyea area and changing their distribution (Larsen et al. 2005, KellerLynn 2009, KLGO D. Schirokauer pers. comm. 7 December 2009).

Reporting Zones

The Chilkoot Trail Unit contains a greater abundance and variety of wetlands than White Pass. National Wetland Inventory data are available for the entire park, and more detailed wetland data are available for the Dyea area (Bosworth 2000, Schirokauer 2009).

Condition

The dynamic nature of the wetlands in Dyea and lack of historic park-wide data presents a challenge when determining condition. A change in wetlands in the Dyea area, including increased drying and draining, has been noted by park staff (KLGO D. Schirokauer pers. comm. 25 August 2009). This is a concern, because wetlands provide important habitat for many species of flora and fauna. The only dataset available for the White Pass Unit is the National Wetland Inventory. Without a reference condition for White Pass or any anecdotal assessment, there is insufficient information to determine condition or trend. The Skagway Unit does not include any wetlands and is, therefore, not applicable. It should be noted, however, that the area likely contained wetlands prior to the gold rush (KLGO D. Schirokauer pers. comm. 25 August 2010).

Data Needs

To better determine condition, updated high resolution wetland data are needed for the entire park. Wetland delination using historic imagery would be useful for quantifying wetland change over time. This is especially important for the Dyea area, which is experiencing ongoing change due to the dynamic nature of the Taiya River and isostatic rebound.

Literature Cited

Bosworth, K. S. 2000. Wetlands of the Dyea area of the Lower Taiya River Valley. Report and Access Database. Klondike Gold Rush National Historic Park. Skagway, Alaska.

Cowardin, L.M., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

KellerLynn, K. 2009. Geologic resources inventory scoping summary Klondike Gold Rush National Historical Park, Alaska. Draft. National Park Service Geologic Resources Division, Denver, Colorado.

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.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2009. National Wetlands Inventory polygons - KLGO. Anchorage, Alaska. Permanent GIS Dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Protection of Wetlands, Exec. Order No. 11990, 42 Fed. Reg. 26961 (May 24, 1977).

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/downloads/climate-change-summary-reports). Accessed 7 July 2010.

Schirokauer, D. 2009. Dyea wetlands. Shapefile. Klondike Gold Rush National Historical Park, Skagway, Alaska.

U.S. Fish and Wildlife Service. 2010. National wetlands inventory. Online. (http://www.fws.gov/wetlands/). Accessed 12 July 2010.

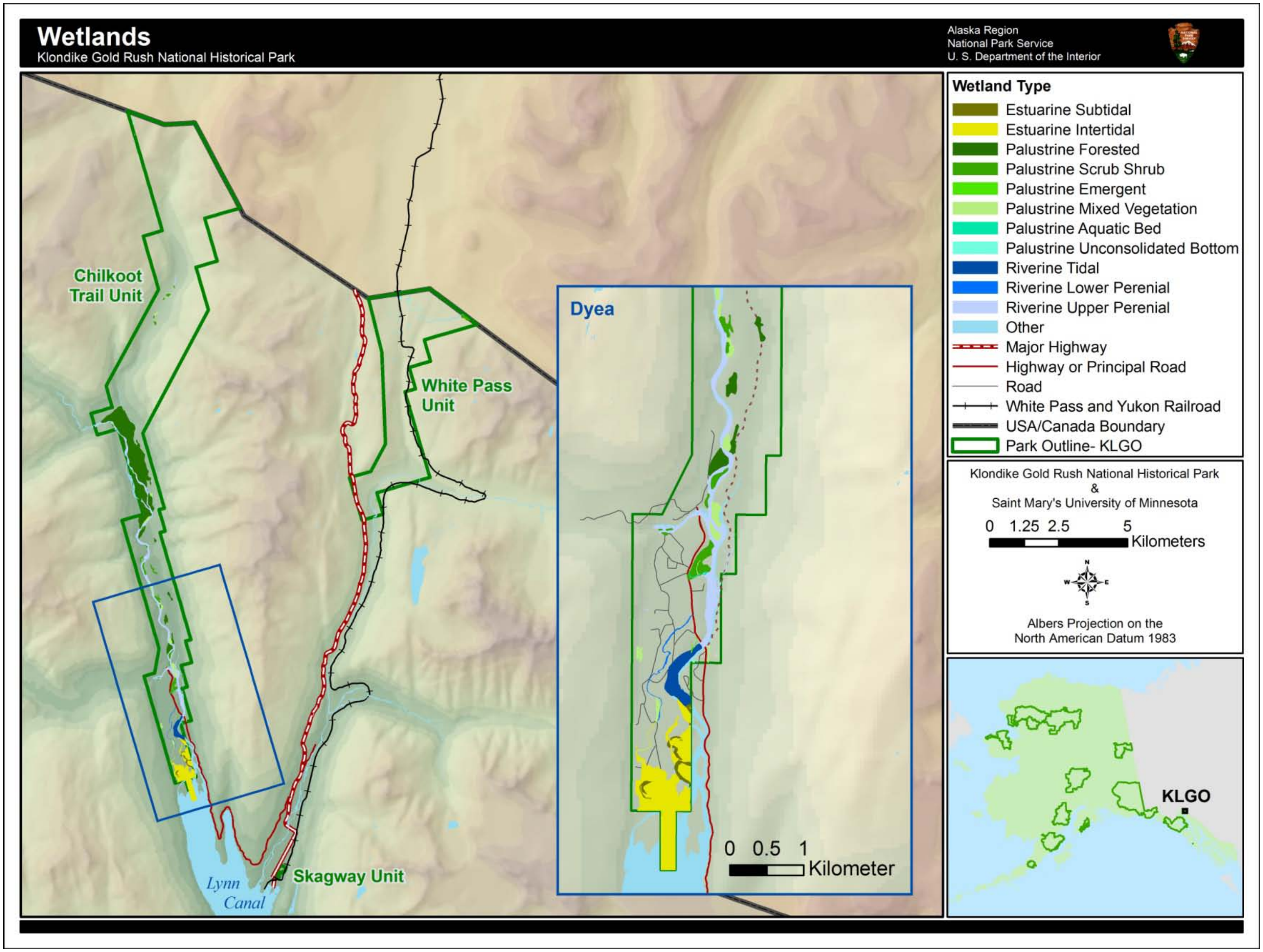
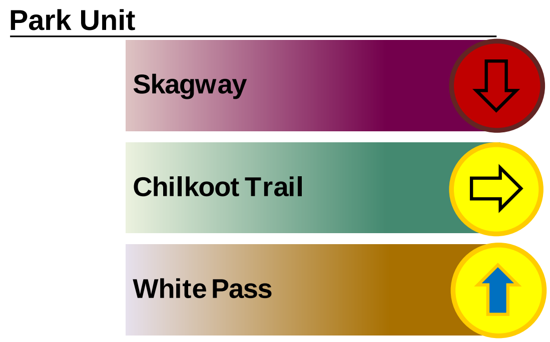


Plate 8. Wetland types in KLGO (Bosworth 2000, NPS 2009, Schirokauer 2009).

4.10 Air Quality

Measures
Particulates
Lichen Contaminants
Sulfur and Nitrogen Oxides
Visibility



Background
Many people assume air quality in southeast Alaska to be relatively pristine; however, KLGO air quality faces threats from local sources such as cruise ships, boat traffic, diesel fired generators, and wood smoke, as well as global sources of air pollution carried by international transport pathways (Moynahan and Johnson 2008). Air quality in all national parks is protected under both the 1916 Organic Act and the Clean Air Act (MacCluskie and Oakley 2005, NPS 2006). KLGO is a designated Class II airshed under the Clean Air Act. It is not subject to the strict regulations and monitoring required of a Class I airshed; however, national ambient air quality standards must be met within the park. Visibility and atmospheric deposition are two key air quality indicators identified by the National Park Service (NPS 2009a). Visibility affects the ability of visitors to see and appreciate their natural surroundings (NPS 2009a). Acidification and fertilization of soil and surface water resulting from deposition affects terrestrial and marine ecosystem health (NPS 2009a, Moynahan and Johnson 2008). KLGO has chosen to report on two air quality indicators in addition to visibility and deposition: particulates and lichen contaminants.

In addition to contributing to haze and reducing visibility by absorbing and scattering light, particulate matter can also be directly harmful to humans as small particulates can enter the lungs and cause health problems (EPA 2009). Particulate matter is measured by its diameter. Particles less than 2.5 micrometers are referred to as fine particles, and sources include motor vehicles, power plants, wood burning, forest fires, and some industrial processes. Coarse particles are those greater than 2.5 micrometers but less than 10 micrometers (EPA 2009). Dust on roads and other particles resulting from crushing or grinding processes are examples of course particles (EPA 2009).

Lichens can grow on trees, on the ground, and even on bare rock, and are sensitive to air pollution because they absorb nutrients directly from their surroundings (Conti and Cecchetti 2001). Lichens can indicate air quality in two ways. Some lichens are especially sensitive to certain types of air pollution, and their presence or absence in a location can be indicative of air quality and the deposition of airborne contaminants. Other lichens bioaccumulate and / or integrate chemical elements from atmospheric sources. Measuring chemical concentrations in lichen tissue can provide insight into air quality before air quality deteriorates to the point where lichens die or there are changes in lichen species composition (Furbish et al. 2000). Using lichens and lichen community composition as indicators of air pollution has a long history in Europe dating back to Erasmus Darwin, Charles Darwin's grandfather (Nimis et al. 2002).

Reference Condition

Little historic air quality data exists for KLGO. According to Hood et al. (2006), based on limited water quality data, wet and dry chemical deposition did not appear to affect water quality in the mid-1980s. Recent air quality data from KLGO have been compared to a variety of regulatory standards, regional baselines, and thresholds. These references are not specific to the condition in KLGO, but provide some context for interpreting measurements of air quality.

Particulate data collected in Skagway in 2004 and 2005 were compared to state and federal air quality standards. The annual state and federal standard for particulates is 15 $\mu g/m^3$. The daily state and federal ambient air quality standard in place during the study was 65 $\mu g/m^3$. This standard was lowered to 35 $\mu g/m^3$ in 2006 (EPA 2010).

Lichen measurements in Furbish et al. (2000) were compared to baseline data from the Tongass National Forest and thresholds determined using a dataset from the Pacific Northwest. One hundred and twenty-three permanent air quality biomonitoring plots have been installed and maintained in the Tongass National Forest since 1989 (Geiser et al. 2010, KLGO D. Schirokauer pers. comm. 31 August 2010). Baseline sites are considered clean, and sites subject to obvious anthropogenic air pollution are excluded from baseline data (Furbish et al. 2000). A dataset from the Pacific Northwest, including southeast Alaska, encompassing 1200 sites in 11 National Forests has been used to determine 97.5 quantile levels for each chemical per lichen species (Furbish et al. 2000). These levels are considered to be air pollution indication thresholds.

The National Park Service Air Resources Division recommends the following values for determining air quality condition (Table 15). These standards take into account the current national ambient air quality standards. Data are not available at this time to calculate the applicable measures for KLGO.

Table 15. National Park Service Air Resources Division air quality index values (NPS 2009a).

Condition	Ozone concentration[1]	Wet Deposition of N or S (kg/ha/yr)	Current Group 50 – Estimated Group 50 Natural (dv)
Significant Concern	≥ 76 ppb	> 3	> 8
Moderate	61-75 ppb	1-3	2-8
Good	≤ 60 ppb	< 1	< 2

[1] "Ozone concentration" represents the 4th-highest daily maximum 8-hour average concentration averaged over five years.

Data

Particulates

During 2004 and the first quarter of 2005, the Alaska Department of Environmental Conservation, the City of Skagway, and the Skagway Traditional Council monitored particulate matter at two sites in Skagway. One site, operated by the Traditional Council staff, was located behind the Police Station near First Avenue and State Street and contained one fine particulate matter ($PM_{2.5}$) sampler. Samples were collected from February through September of 2004. The second site, operated by Skagway public works staff, contained two $PM_{2.5}$ samplers and was located at the skating rink adjacent to the Recreation Center near 11th Avenue and Main Street (Air Monitoring & Quality Assurance 2007). Measurements at this site occurred every six days during the first half of 2004, and every third day during the second half of 2004 and the first quarter of 2005. Results of this study are discussed in the measures section below.

Lichen Contaminants

An ecological reconnaissance study in the early 1990s recommended the consideration of a biomonitoring program for air quality in KLGO using lichens (Furbish et al. 2000). A pilot study was conducted in 1998 and 1999 to provide an overview of the air quality situation (Furbish et al. 2000). Concentrations of several chemicals (nitrogen, sulfur, calcium, magnesium, sodium, aluminum, iron, phosphorus, potassium, boron, manganese, cadmium, chromium, copper, lead, nickel, and zinc) were measured in lichen tissue samples obtained from four sites in and near KLGO: Dewey, Chilkoot, Sturgills, and Dyea (Plate 9) (Furbish et al. 2000).

Three lichen species, *Hypogymnia enteromorpha*, *Hypogymnia inactiva*, and *Platismatia glauca*, were selected due to their local abundance and their use in previous and current air quality monitoring projects conducted by the Tongass National Forest (Furbish et al. 2000). Concentrations were measured in each sample (University of Minnesota – Research Analytical Laboratory), and the results were compared to baseline data from the Tongass National Forest and thresholds determined from a dataset from the Pacific Northwest (Furbish et al. 2000). Comparisons between the Dewey and Chilkoot sites were also conducted to investigate the effect of proximity to Skagway (Furbish et al. 2000).

A follow-up to the 1999 pilot study began in 2008. Lichen tissue was sampled at six sites in KLGO for elemental analysis, including the same four sites used during the 1999 pilot study (Plate 9) (Schirokauer and Geiser 2010). The same three lichen species used as biomonitors by Furbish et al. (2000) were used again in 2008 and 2009.

Sulfur and Nitrogen Oxides

In addition to the lichen tissue sampling, work began in 2008 to measure atmospheric deposition in and around KLGO. Ogawa passive air samplers were deployed in both 2008 and 2009 at four sites to estimate concentrations of nitric acid (HNO_3), nitrogen dioxide (NO_2), nitrogen oxide (NO_x), ammonia (NH_3), and sulfur dioxide (SO_2) (Schirokauer and Geiser 2010). These four sites are collocated with the four sites sampled in the lichen contaminants study from 1998 and 1999 (Plate 9). One additional site was sampled each year in 2008 and 2009.

Beginning in 2008, passive deposition monitors for nitrogen and sulfur ions were deployed at eight sites in KLGO including the four sites from Furbish et al. (2000) (Plate 9) (Schirokauer and

Geiser 2010). Results from the passive deposition samplers are not yet available but will be used to develop models linking deposition rates with lichen tissue concentrations and lichen community structure and diversity (Schirokauer and Geiser 2010).

Analysis of lichen contaminant and deposition data collected in 2008 and 2009 is ongoing, but some initial results are reported in the measures section below.

<u>Visibility</u>
Visibility data collection is in the early stages at KLGO and is relatively informal. There are no IMPROVE (Interagency Monitoring of Protected Visual Environments) monitoring sites near KLGO. Monitoring of visibility using a VisCam system began in 2009. The camera system is installed each spring prior to the arrival of the first cruise ship and records images every fifteen minutes (KLGO 2009a). The image field contains the entire Skagway harbor area from Ore Dock to Railroad Dock. Each image is analyzed qualitatively for cloud cover, emissions, and the number of small and large ships (KLGO 2009b). Analysis of this data was not available at the time of this report.

More formal visibility monitoring data are collected by the Skagway airport. Acquiring this data is recommended for future condition assessment projects; however the data utility may be limited because visibity is not measured beyond 10 miles. Data also exists regarding opacity of stack plumes from cruise ships, and future analysis of this data may be useful for understanding the condition of air quality in KLGO.

<u>Other</u>
The Chilkoot Trail is part of an intercontinental atmospheric transport monitoring project (Hung et al. n.d.). Soil samples were collected along the trail to measure persistent organic pollutants. Results from this study were not available for this report.

Measures

<u>Particulates</u>
A total of one hundred and thirty-seven 24-hour samples were collected at the two particulate monitoring sites in Skagway in 2004 and 2005 (Figure 30). The three highest particulate values were recorded when Skagway was affected by smoke from wildland fires in interior Canada and a barge fire near Haines, Alaska. Samples were obtained from both the City and Traditional Council sites during eight days to allow for inter-site comparison. Seven of the eight samples reported higher concentrations at the Traditional Council site compared to the City site (Air Monitoring & Quality Assurance 2007).

The annual average concentration for the City of Skagway site was 5.9 $\mu g/m^3$, which was below the annual state and federal standard of 15 $\mu g/m^3$. All measurements unaffected by wildland fires were below the 2007 daily ambient air quality standard of 35 $\mu g/m^3$ (Air Monitoring & Quality Assurance 2007). Natural causes for elevated particulate concentrations are not usually considered violations of air quality standards (Air Monitoring & Quality Assurance 2007).

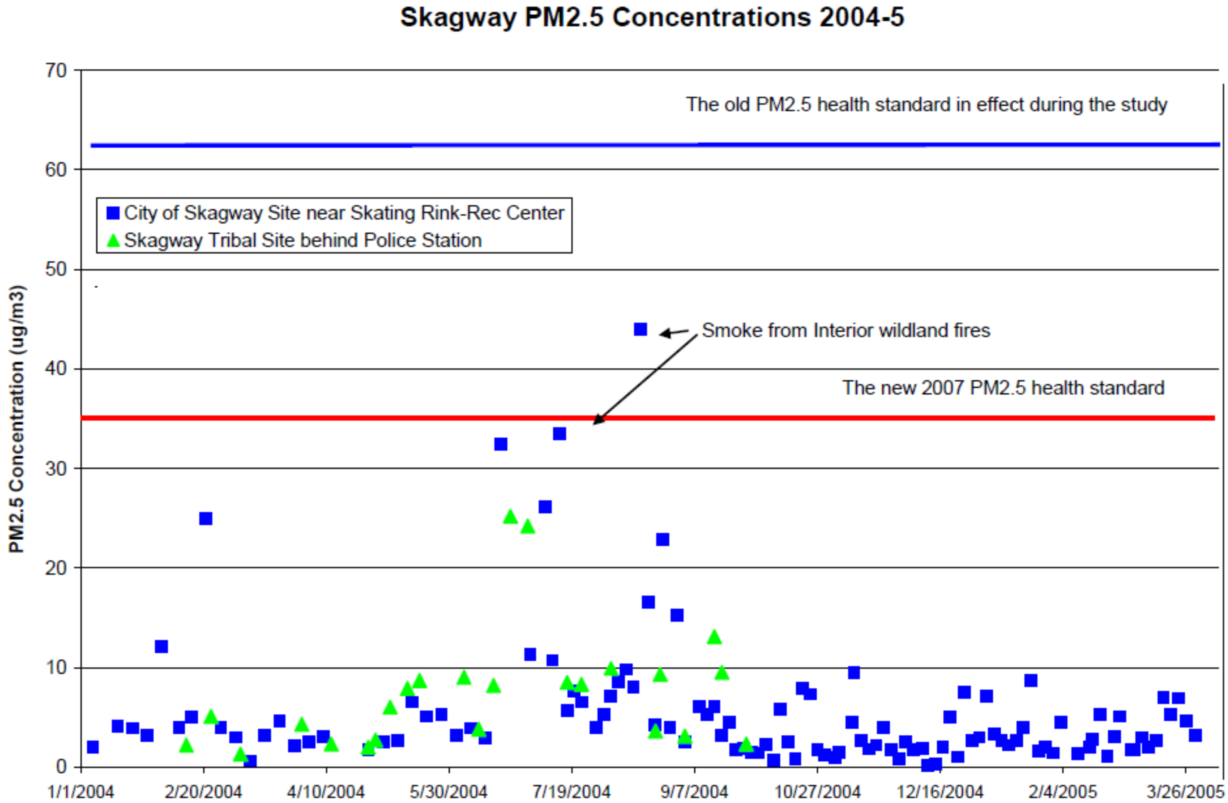


Figure 30. All $PM_{2.5}$ concentrations of samples taken during the study from the City and Traditional Council sites (Figure used with permission from Air Monitoring & Quality Assurance 2007).

Lichen Contaminants

Data collected in 1998 and 1999 at sites in the KLGO area reported higher levels of the heavy metals cadmium, chromium, lead, nickel, and zinc compared to the Tongass National Forest baseline data. Concentrations of sulfur were also significantly higher in the Klondike-Skagway area. All four sites in the Klondike-Skagway area exceeded some of the Pacific Northwest air pollution indication threshold concentrations, but the Dewey site had the highest number of samples exceeding thresholds (Furbish et al. 2000). Repeated exceedence of heavy metals and sulfur thresholds throughout the sites were of particular concern (Furbish et al. 2000).

The Dewey site was located near Skagway and presumably had more exposure to air pollution than the Chilkoot site located in the Taiya valley (Furbish et al. 2000). The Dewey site reported consistently higher levels of cadmium, copper, lead, nickel, and zinc than the Chilkoot site. These elements are usually associated with air pollution. The Chilkoot site reported higher levels of manganese than the Dewey site, possibly indicative of air pollution. Although the difference in proximity to marine waters may result in some variation between the two sites, the results suggest that the site closer to Skagway (Dewey) generally showed more evidence of exposure to air pollution (Furbish et al. 2000).

Data from lichen samples collected in 2008 and 2009 are still undergoing analysis. Initial results from 2008 suggest levels of lead and nickel have decreased since samples were collected in

1998, while nitrogen appears to have increased at all sites over the same period of time (Geiser et al. 2010). Despite the increase in nitrogen, the nitrogen values are still below Tongass National Forest thresholds established by Dillman et al. (2007).

Lead and sulfur remain above the Tongass National Forest thresholds at two sites nearest to Skagway (Geiser et al. 2010). Historically, Skagway harbor was used to transfer mineral ore from open rail cars and trucks to barges. This practice ended in the late 1980s, which may explain why concentrations of lead and nickel have decreased. Possible explanations for the increase in nitrogen include NO_x emissions from increasing cruise ship traffic and increasing contributions of NO_x arriving from northern Alaskan and Canadian wildfires and from trans-Pacific pathways (Geiser et al. 2010). Baseline sites in the Tongass National Forest did not experience a significant increase in nitrogen, suggesting that increases in the Skagway area are more likely a result of local rather than regional or international sources (Geiser et al. 2010). Sulfur declined at all sites except at the site closest to the Skagway docks where it increased and exceeded the Tongass National Forest thresholds.

Sulfur and Nitrogen Oxides

Recent deposition data are still undergoing full analysis, but initial results from the Ogawa samples collected in 2008 demonstrate elevated levels of NO_2, NO_x, and SO_x at sites near Skagway (Schirokauer and Geiser 2010). Further results are expected in the near future.

Visibility

Analysis of VisCam data was not available at the time of publication, but anecdotal reports of visible haze and impaired views are documented in several reports (Furbish et al. 2000, Schirokauer et al. 2008, Geiser et al. 2010).

Stressors

The year-round population of Skagway is approximately 700, but about 750,000 additional people visit the city and KLGO every summer (Furbish et al. 2000). The facilities and services needed to support the tourism, transportation, and city of Skagway produce compounds which are released into the air (Furbish et al. 2000). Cruise ship, car, bus, shuttle, large truck, ferry, barge, small boat, small plane, railway, and helicopter traffic, as well as incinerator use increase substantially during the tourist season (Furbish et al. 2000). The Municipal Waste Incinerator emits approximately 32 pounds of NO_x per hour each day (Graw and Faure 2010). Skagway residents have expressed concerns about emissions from the White Pass Railroad, cruise ships, and re-entrained road dust (Air Monitoring & Quality Assurance 2007). The Alaska Department of Environmental Conservation has also identified wood smoke impacts as a potential issue for Skagway in the late 1990s (Air Monitoring & Quality Assurance 2007).

Photo 21. Incinerator emissions**.**

The largest contributing source of NO_x and SO_2 emissions are cruise ships (Graw and Faure 2010). Graw and Faure (2010) analyzed emissions from cruise ships, buses, trains, and the incinerator during the 2008 tourist season, and found cruise ships were responsible for 73% of the NO_x emissions and 99% of the SO_2 emissions (Figure 31). Skagway is the 16th busiest cruise ship port in the world during the tourist season. During the season, up to six large cruise ships dock each day (Schirokauer et al. 2008). These cruise ships operate diesel or bunker fuel generators while in port because Skagway cannot provide sufficient dockside electricity (Schirokauer et al. 2008, Geiser et al. 2010). The exhaust from larger cruise ships contains nitrogen oxides and sulfur dioxide and is usually visible to the naked eye (Furbish et al. 2000). Visible haze is not uncommon in the KLGO area (Schirokauer et al. 2008).

Photo 22. Cruise ship emissions.

Trains, mostly diesel engine locomotives, have been in use in the KLGO area for the last century. Trains transported mineral ores from the Yukon to the waterfront from 1902 to 1982 (most activity was from the 1960s to 1982). The mineral ores transported through Skagway by train contained lead, zinc, and other heavy metals. Prior to 1989, when a covered conveyor loading system was installed, mineral particles were exposed to wind while being transported and loaded onto barges (Furbish et al. 2000). These particles could still be present in the ecosystem and may be redistributed by air during dry, windy periods (Furbish et al. 2000). The railroad was also used during World War II to transport materials for the Alaska Highway project in the Yukon (Furbish et al. 2000).

Photo 23. Train in the White Pass Unit approaching the White Pass Summit.

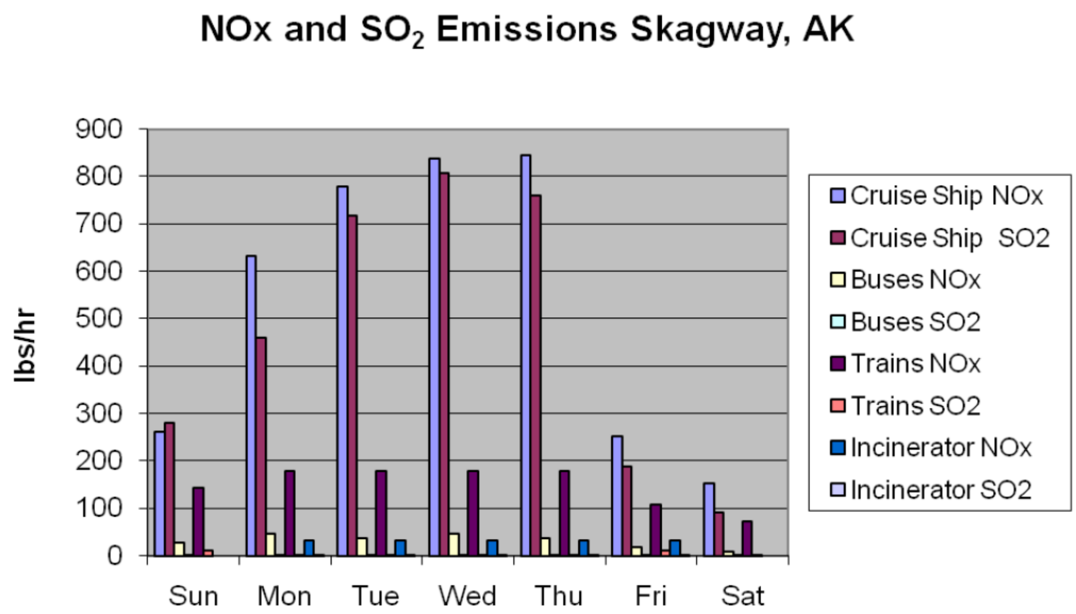


Figure 31. Daily NOx and SO_2 emissions in Skagway, Alaska. Figure from Graw and Faure (2010) used here with permission.

Passengers and freight have also been moved by train from Skagway to the interior (Furbish et al. 2000), and tourism is now the only component of diesel train traffic (Schirokauer et al. 2008). Up to 12 trains traverse the White Pass Unit per day, and each train includes two or three locomotives (Graw and Faure 2010). From Monday through Thursday, these trains emit approximately 180 lbs of NO_x per hour of operation (Graw and Faure 2010). The White Pass Yukon Railroad is actively upgrading their diesel locomotive with much more efficient and cleaner engines. The newly retrofitted engines emit about 1/3 less NO_x (KLGO D. Schirokauer pers. comm. 1 September 2010). Twice per week steam locomotives traverse the unit, which emit approximately 12 pounds of SO_2 per hour (Graw and Faure 2010).

Skagway is known for windy conditions (Furbish et al. 2000). Although wind can disperse air pollution, wind can also stir up dust and contribute to particulate pollution (Furbish et al. 2000). Temperature inversions, which are not uncommon during summer mornings in Skagway, and the relatively low levels of precipitation for the region, are other natural stressors to air quality (Furbish et al. 2000).

Local sources of air pollution are not the only stressors of KLGO's air quality. Particulates, nitrogen oxides, and other pollutants can arrive in KLGO from regional forest fires and international industrial emissions. Recent studies suggest long-range atmospheric transport of chemicals contributes to ecosystem contamination in Alaska, including in the southeast region (Hood et al. 2006, Landers et al. 2008).

Reporting Zones

All four sites in the Furbish et al. (2000) lichen contaminant study showed signs of air pollution, but Dewey, the site closest to Skagway, reported the highest occurrence and concentrations of pollutants in lichen tissue (Furbish et al. 2000). The Dewey and Sturgills sites are closest to the

Skagway reporting zone. The Dyea and Chilkoot sites are in or near the Chilkoot Trail reporting zone. Additional sites added in 2008 and 2009 are in or near the Skagway reporting zone and the Chilkoot Trail reporting zone. There has been no active monitoring of air quality in the White Pass reporting zone, but the White Pass Yukon Railroad is a known source of air pollution.

Condition

The Alaska Department of Environmental Conservation concluded in their particulate study that ambient air quality in Skagway was generally good; however, the data also suggest that, although meeting state and federal standards, particulates, NO_x, and SO_2 are elevated above background levels during the months the park receives high visitor use (Air Monitoring & Quality Assurance 2007, Shirokauer and Geiser 2010). There are also several anecdotal reports of visible haze and concern about particulate matter in KLGO. Lichen samples obtained in 1998 and 1999 revealed that several chemical concentrations in lichens in the Klondike-Skagway area exceeded regional baseline values and USDA-Forest Service Pacific Northwest thresholds, including heavy metals and sulfur (Furbish et al. 2000). Although initial results from 2008 suggest levels of lead and nickel have improved since 1998, concentrations are still above baseline values and the Pacific Northwest thresholds near Skagway. Nitrogen and sulfur concentrations in lichens appear to have increased at the sampling site nearest Skagway, resulting in a declining condition trend for this reporting zone.

Although recent lichen measurements in the Chilkoot Trail reporting zone do not exceed the clean-site thresholds established by Dillman et al. (2007), air quality condition remains a concern. Values reported in or near this reporting zone often exceed those reported at other sites in the region, and the proximity of the site to population and tourism stressors in Skagway increases the risk of air pollution (Geiser et al. 2010). Sulfur, nickel, and lead levels appear to have improved in the Chilkoot Trail reporting zone; however, nitrogen levels have increased. A stable trend has been assigned for Chilkoot Trail to reflect both the improving and declining trends. This is not meant to imply that the trends offset one another. They are separate trends with different drivers. None of the air quality sample sites are located in the White Pass reporting zone, but the train activity is a known and quantifiable source of air pollution, which is cause for concern. The recent improvements to the diesel train engines contribute to assigning the White Pass reporting zone an improving trend.

Data Needs

Repeated air quality sampling every five to ten years is necessary because of rapidly increasing tourism, low levels of industrial development, and slow population growth around KLGO (Schirokauer et al. 2008). Air quality monitoring is now part of the SEAN I&M Program, and data have been collected in 2008 and 2009. This information needs to be fully analyzed when the lab results become available.

In addition to the deposition and lichen monitoring conducted as part of the SEAN I&M Program, an airshed model is under development (Schirokauer et al. 2008). This model will assist the park in quantifying nitrogen and sulfur impacts from transportation sources and Skagway's municipal incinerator (Schirokauer and Geiser 2010). Part of the model development includes a survey of cruise ship line operations while docked in Skagway, from which emission inventories were completed (Graw and Faure 2010). An initial trial has been completed, and a final report is expected in the winter of 2010 (Schirokauer and Geiser 2010).

Literature Cited

Air Monitoring & Quality Assurance. 2007. Skagway air monitoring study of airborne fine particulate matter during 2004-5: Final report. Alaska Department of Environmental Conservation, Juneau, Alaska.

Conti, M. E., and G. Cecchetti. 2001. Biological monitoring: Lichens as bioindicators of air pollution assessment - a review. Environmental Pollution 114:471-492.

Dillman, K., L. Geiser, and G. Brenner. 2007. Air quality bio-monitoring with lichens: The Tongass National Forest. U.S. Forest Service. Online. (http://gis.nacse.org/lichenair/?page=reports#R10). Accessed 30 March 2010.

Environmental Protection Agency. 2009. Air quality index: A guide to air quality and your health. EPA-456/F-09-002. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Outreach and Information Division. Research Triangle Park, North Carolina.

Environmental Protection Agency. 2010. Particulate matter: PM standards. Online. (http://www.epa.gov/air/particlepollution/standards.html). Accessed 17 November 2010.

Furbish, C. E., L. Geiser, and C. Rector. 2000. Lichen-air quality pilot study for Klondike Gold Rush National Historical Park and the city of Skagway, Alaska. Klondike Gold Rush National Historical Park Natural Resources Management Program, Skagway, Alaska.

Geiser, L., D. Schirokauer, A. Bytnerowicz, K. Dillman, and M. Fenn. 2010. Effects of cruise ship emissions on terrestrial vegetation in Southeast Alaska. Prepared for publication in Alaska Park Science.

Graw, R. and Faure, A. 2010. Air pollution inventory for 2008 tourism season Klondike Gold Rush Naitonal Heritage Park Skagway, Alaska. Alaska Department of Environmental Conservation Division of Water Cruise Ship Program, Juneau, Alaska.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Hung, H., A. Steffen, A. Cole, Y. F. Li, J. Ma, A. Dastoor, Y. Su, S. Sverko, T. Hamer, N. Ren, and others. n.d. The international polar year (IPY) project of intercontinental atmospheric transport of anthropogenic pollutants to the arctic (INCATPA).

Klondike Gold Rush National Historical Park. 2009a. VisCam protocol for Klondike Gold Rush National Historical Park, Skagway, Alaska: Standard operating procedure (SOP) #1: Installation, management, and uninstallation. Version 1.00. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Klondike Gold Rush National Historical Park. 2009b. VisCam protocol for Klondike Gold Rush National Historical Park, Skagway, Alaska: Standard operating procedure (SOP) #2: Data management. Version 1.00. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Klondike Gold Rush National Historical Park. 2010. KLGO air quality monitoring stations. GIS Shapefile. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Landers, D. H., S. L. Simonich, D. A. Jaffe, L. H. Geiser, D. H. Campbell, A. R. Schwindt, C. B. Schreck, M. L. Kent, W. D. Hafner, H. E. Taylor, and others. 2008. The fate, transport, and ecological impacts of airborne contaminants in western national parks (USA). U.S. Environmental Protection Agency, Office of Research and Development, NHEERL, Western Ecology Division, Corvallis, Oregon, USA. EPA/600/R-07/138.

MacCluskie, M., and K. Oakley. 2005. Central Alaska network vital signs monitoring plan. Central Alaska Network. Fairbanks, Alaska.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2006. Management policies 2006. ISBN 0-16-076874-8. U.S. Department of the Interior. National Park Service, Washington, D.C., USA.

National Park Service. 2009a. Air quality in national parks: 2008 annual performance & progress report. National Park Service. Natural Resource Report NPS/NRPC/ARD/NRR-2009/151.Natural Resource Program Center. Denver, Colorado.

National Park Service. 2009b. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Nimis, P. L., editor, C. Scheidegger, editor, and P. A. Wolseley, editor. 2002. Monitoring with lichens: monitoring lichens. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Schirokauer, D., and L. Geiser. 2010. Monitoring air quality in the Southeast Alaska Network: linking ambient and depositional pollutants with ecological effects: Assessment of conditions, trends, and refinement of passive sampling and lichen bio-monitoring protocols. 2009 Progress Report. Alaska.

Schirokauer, D., L. Geiser, E. Porter, and B. Moynahan. 2008. Monitoring air quality in the Southeast Alaska Network: linking ambient and depositional pollutants with ecological effects. Klondike Gold Rush National Historical Park, Skagway, Alaska, USA and U.S. Forest Service, Pacific Northwest Region Air Resource Management Program, Corvalis, Oregon, USA.

U.S. Forest Service. 2010. National lichens & air quality database and clearinghouse. Online. (http://gis.nacse.org/lichenair/). Accessed 28 June 2010.

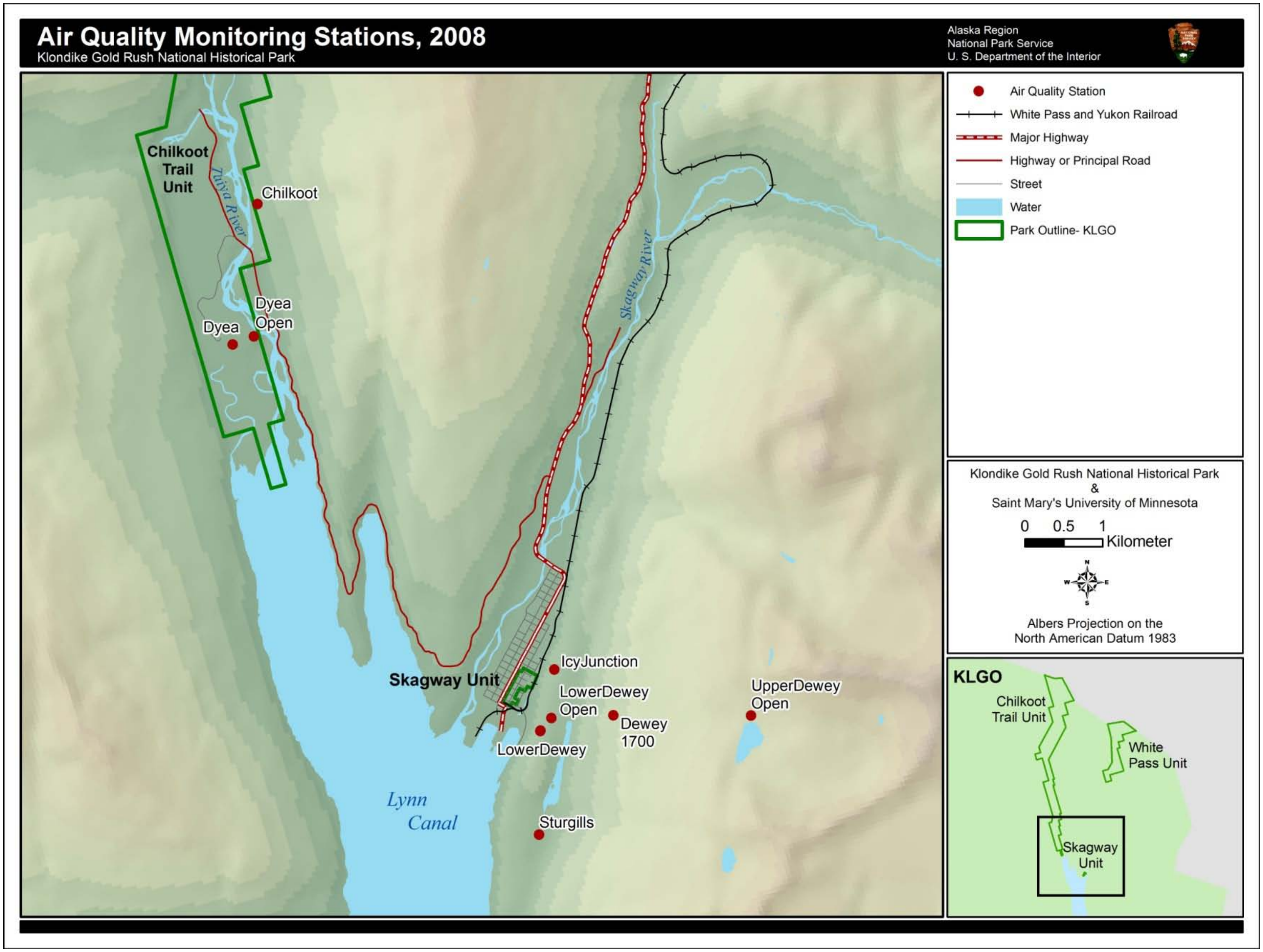
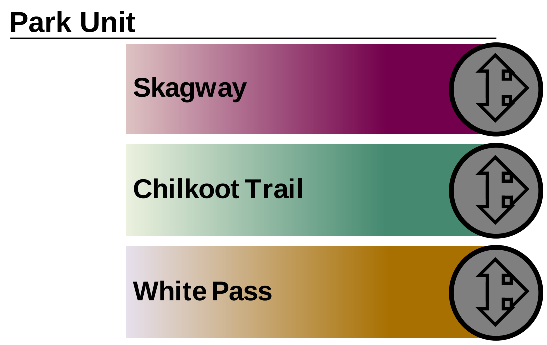


Plate 9. Air quality monitoring stations in KLGO (KLGO 2010, NPS 2009b).

4.11 Soundscape

Measures

Noise Free Interval
Percent Time of Audible Extrinsic Sound
Percent Time of dB Levels of Extrinsic Sound Exceeding Threshold (Percent Exceedance (L_x))



Background

Soundscape is an extremely important attribute of KLGO (Moynahan and Johnson 2008). Natural sounds are a component of biological and physical resources. Some species use sound to attract mates or to detect and avoid predators or other sources of danger (NPS 2006). Wind across the landscape and flowing water are examples of natural sounds related to the physical environment (NPS 2006). In addition to biological significance, soundscape is also important to human perception and enjoyment of the park.

Natural resources within parks must be preserved and/or restored according the National Park Service Organic Act (NPS 2010). This includes the acoustic environment, which is composed of various natural, cultural, and historic acoustic resources (NPS 2010). Parks such as KLGO, which contain historic or cultural resources, are directed to "replicate to the greatest extent possible an acoustic environment that is appropriate for the resource (NPS 2010)."

Reference Condition

The natural ambient sound level is the baseline for park management (NPS 2010). According to Director's Order #47, natural ambient sound level is defined as the natural soundscape of the park. Sounds which are part of the cultural and historic soundscape are also part of the reference condition for KLGO (NPS 2010, McCusker and Cahill 2009). Due to the different historical and cultural sounds in each park unit, the reference condition is defined individually for each unit. Schirokauer and Gurcke (2008) provide descriptions of natural sounds as well as the cultural and historic sounds of the park, which are quoted here:

Natural sounds:
Weather: The Skagway unit of the park is famous for persistent high winds. On most summer afternoons wind is the dominant natural sound and in winter you [*sic*] can be heard without interruption for days on end. The name "Skagway" is a Tlingit word meaning windy or area with white capped waves. A day in Skagway without the sound of wind is rare and because of the narrow valley and the many buildings, the wind seems to whip around from all directions. The wind will push trees about occasionally toppling them and will often rattle buildings. Wind speeds are generally much lower in the Dyea area and along the Chilkoot trail. Rain and snowfall are also common in the area during winter. Rain, snowfall and wind interacting with natural features including trees, ponds, and meadows are common sounds. During break-up (the time of year when the solid ice layer in the river bed breaks up and begins to move) the sounds of ice chunks hitting each other occurs.

Wildlife: Although ungulates are not as common as in other areas of Alaska (ungulate populations are low due to limited habitat), occasionally the sounds of coyotes howling and bears interacting with each other can be heard. Songbirds are abundant in [*sic*] over 40 species are commonly detected by their songs during annual breeding bird surveys. Bald eagles are abundant here and the sound of them flying overhead is commonly heard. Amphibians utilize some of the park's wetlands but are only rarely heard and usually only by researchers studying them. Mountain goats are heard and [*sic*] some of the more remote high elevation portions of the park. Other ungulates are extremely rare but on occasion the sounds of caribou hooves have been detected. Bats our [*sic*] common during the summer and can occasionally be heard by the unaided ear. For the past two years the park has been conducting bat surveys using Anabat ultrasonic recording devices.

Cultural and historic sounds:
Trains: The construction and operation of the White Pass and Yukon Route railway was one of the most significant accomplishments of the gold rush. The railroad continues to operate today, mostly in the summer time. The sounds of two different steam engines and their whistles can still be heard on summer weekends and at other times during the week. One of the trains dates to 1900, very near the gold rush period while the other steam train dates to 1947 but the locomotive’s sound would certainly have been similar. The sound of passenger cars and other rolling stock running on tracks would probably be very similar to the gold rush period sounds. Because of the heavy summer tourist traffic, the number of trains (now mostly diesel) operating now is probably greater than during the gold rush. During the gold rush, the trains and rolling stock were probably lighter and shorter, and there was a mixture of passenger, freight, and work trains. The trains also ran year round. Today the railroad runs almost only passenger trains and an occasional work train and they run almost only during the summer.

Sled dogs: Sled dogs were present in moderate numbers during the gold rush and are notoriously noisy at times. Currently, a commercial kennel operates during the summer just outside the park boundary and provides summertime sled dog rides to tourists. About 400 dogs live in a small area and can be heard barking and howling on a regular basis. To the park visitor the sound of these dogs is a point source which is quite different from how dogs would have sounded during the gold rush because they would have been spread out across the town site and on the trail; yet in some ways it can be considered an intrinsic sound. During the gold rush the sounds of sled dogs were probably masked by other anthropogenic sounds. Today, sled dog sounds are the dominant anthropogenic sounds in Dyea. In Skagway, the occasional non-sled dog will bark at people walking by, a common occurrence now and during the gold rush.

Horses: The sounds of the horseback rides in Dyea and horse and buggy rides in Skagway, (both offered today) may have been similar to the sounds of horse and buggies during the gold rush. In Skagway, however, the horses would have walked over dirt roads while today the roads are paved. In addition, the sounds of horses and wagons would have been more common throughout the park, on the Chilkoot and White Pass trails up to and past the US-Canadian border.

People walking and talking: The streets of Skagway were crowded during the gold rush, as they are now during the summer and human voices remain a significant part of the soundscape. Today, people walking on the wooden boardwalks of down town Skagway creates a very similar sound as during the gold rush, however, today people walk on the paved streets of Skagway whereas during the gold rush, they walked on the dirt and muddy streets of town. During the winter, the population of Skagway shrinks to 500 or so and any human voice you hear is usually drowned out by the wind. Today, many more languages are spoken on the streets of Skagway then during the gold rush. In Dyea, the sounds of people talking are much less than during the gold rush.

Ships: A very small percentage of the ships visiting Skagway today may have whistles / horns that sound similar to the ships that brought the Stampeders to Skagway and Dyea.

Construction sounds: During the first couple of years of Skagway and Dyeas' existence, there would have been a great deal of construction sounds heard in both valleys. Wharfs were being built which means the sound of steam pile drivers. Railroad construction involved building grade, laying track, and blasting rock up the valley. In the Chilkoot Valley, the construction and operation of three aerial tramways with their stationary steam engines and gasoline engines would have been heard. One, two, and three story wooden buildings were being built all over town in both communities with the sound of hammers against nails heard everywhere. Although you may hear the occasional construction sounds today, the intensity of the gold rush construction period will probably never be matched.

Animals: During the gold rush, the horses in Skagway were trotting on dirt roads whereas today they are generally trotting on pavement so the quality of sound would have been different. In Dyea, however, they are still trotting on dirt. Also, because there were a lot more horses during the gold rush (possibly as many 3-6,000), pulling a lot more wagons, and the types of wagons were much more diverse (from small carts to very large freight wagons); the level of sound coming from the horses and wagons would have been higher and more diverse.

Most of the domestic animal sounds you hear today would have been the same except during the gold rush there was probably a lot more of them and the variety would have been greater. During the gold rush you would have had to add the sounds of cows, oxen, mules, donkeys, sheep, goats, chickens, to the sounds dogs, cats and horses make today and because there were a lot more people year round there were a lot more domesticated animals during the gold rush. Also, many of these animals were working animals, not just pets so that may have affected the sound. There were also some domesticated wildlife about - reindeer, elk, moose, and bears that were used as pets or in some cases beasts of burden so their sounds would have been part of the mix.

Music: Walking down Broadway during the gold rush period you probably heard music coming out of many of the buildings (saloons - theaters) during all hours of the day and night. Today you might be able to hear music as well but the songs and character of the music would have been different - no hip hop or electronic music then - no I-pods, radios, stereos, tape decks, CDs, or televisions then - but there would have been bands, instrumental music, singing, plays, etc. (Schirokauer and Gurcke 2008)

Data

In the fall of 2008 Dave Schirokauer and Karl Gurcke responded to a survey of natural soundscapes in parks distributed by Lelaina Marin from the NPS Natural Sounds Program (Schirokauer and Gurcke 2008). The responses provide a descriptive assessment of acoustic resources and stressors present in the KLGO soundscape. Some sound data were collected at the Moore House in Skagway during the spring of 2009 (KLGO D. Schirokauer pers. comm. 22 March 2010). The data remain in raw form and have not yet been analyzed. In the absence of analyzed quantitative soundscape data, the descriptive information provided in the survey responses by Schirokauer and Gurcke is included in this discussion.

Measures

The NPS Natural Sounds Program differentiates between intrinsic and extrinsic sound (NPS 2010). Intrinsic sounds are those that belong to the park based on its nature, the park unit purposes, values, and enabling legislation. They can include cultural and historic sounds. Extrinsic sounds are non-essential to the park unit. The natural ambient sound level is an estimate of the acoustic environment in the absence of extrinsic sounds and is used as a baseline for park management (NPS 2010).

Federal law prohibits or regulates some forms of audio disturbances (2.12 CFR 36). Additional acoustic standards are created for individual parks (KLGO D. Schirokauer pers. comm. 22 March 2010). For example, Denali National Park and Preserve's backcountry management plan sets limits on: percent of each hour motorized sounds are audible, number of times per day motorized sounds are noticeable above the natural ambient sound level, and maximum motorized sound levels (Hults 2004).

Possible measures for assessing soundscape condition include: noise free interval, percent time of audible extrinsic sound, existing ambient sound level, and percent exceedence of natural ambient sound level (Lx) (Withers 2006, Miller 2008). Percent exceedence measures the sound level exceeded during x percent of the sampling period and is reported in decibels (Withers 2006). Wildland soundscapes are unlikely to be affected by non-natural noise more than 50% or in most cases 90% of the time and, as a result, L_{50} and L_{90} are sometimes used to determine natural sound levels (Withers 2006). Final measures of soundscape will be determined when a monitoring plan is established.

Photo 24. Passenger trains in Skagway run through the White Pass Unit several time per day during the summer season.

Stressors

The National Park Service Natural Sounds Program defines noise as “sound that is negatively evaluated (undesired) or extraneous to an environment (NPS 2010).” Schirokauer and Gurcke (2008) identify sources of noise which adversely affect the park’s acoustic environment:

> Today's Skagway is a very noisy place. On a busy day six cruise ships are docked and unload about 10,000 people. There are [*sic*] at least as many people here during the height of the gold rush but some of the activities they are engaged in [are] quite different.
>
> Trains: The most popular attraction in Skagway is the White Pass and Yukon Railway. Today the vast majority of the train trips or [*sic*] run by diesel electric engines most commonly three in series. On a busy day there are 14 roundtrips [and] at times trains can be heard every few minutes heading north to the summit or coming back from the summit. The sound of a diesel electric engine’s horn is disruptive and at times annoying; however, its use is required for safety. The sounds of the diesel electric engines are also not part of the intrinsic soundscape of the park.
>
> Aircraft: On clear busy summer days the sounds of aircraft can be heard almost continuously (taking off, flying overhead, and landing). At least 12 small commercial aircraft flights arrive and depart daily. Seven helicopters are stationed in Skagway during the summer providing almost continuous flight-seeing operations. None of these sounds would have been heard during the gold rush.
>
> Cruise ships: Idling cruise ships can generally not be heard but their whistles / horns can be heard intermittently throughout the day and especially on arrival and when leaving town.
>
> Tour buses: The sounds of diesel buses are heard throughout the day. However, most disruptive to the intrinsic soundscape are the "historic coach tours" of Skagway. These small historic looking buses have a loud “aa-ruu-ga” horn that the drivers like to show off. These horns were not probably present during the gold rush but will be the topic of future research.
>
> Other: Hovercraft tours have been proposed for the Skagway River and may occasionally have a detectable impact on the park's acoustic environment. In the past, during dry spring months, the local power company’s hydroelectric generators could not keep up with demand and diesel engines were run. The diesel generators are located adjacent to one of the park's most significant historic buildings, and during May park interpreters

experienced difficulty giving programs at this location due to the generator noise. This may [no] longer be a problem with an additional hydroelectric station now available. (Schirokauer and Gurcke 2008)

Reporting Zones

Soundscape is relevant to all reporting zones. Some of the stressors are more prevalent in the Skagway reporting zone, because of the cruise ships and related tourism.

Condition

Schirokauer and Gurcke (2008) provide good qualitative descriptions of soundscape and changes in soundscape; however, a condition assessment of soundscape as part of the NRCA cannot be completed without quantitative data related to soundscape metrics. Schirokauer and Gurcke reported that, despite common disruptions to the park's intrinsic sounds, most visitors often do not perceive this to be a problem. Visitors, however, have made complaints regarding sled dogs barking in Dyea and helicopter noise from NPS administrative use along the Chilkoot Trail (Schirokauer and Gurcke 2008).

Data Needs

Soundscape monitoring is needed in KLGO to be able to report condition. There is a discussion of available data collection methods in Fristrup et al. (2009).

Literature Cited

Fristrup, K., D. Joyce, and E. Lynch. 2009. Measuring and monitoring soundscapes in the national parks. Park Science 26(3). Online. (http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=344). Accessed 3 March 2010.

Hults, C. 2004. Denali National Park & Preserve soundscape annual report 2004. Center for Resources, Science, and Learning, Denali National Park and Preserve, Alaska.

McCusker, V., and K. Cahill. 2009. Integrating soundscapes into National Park Service planning. Park Science 26(3). Online. (http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=347&Page=1). Accessed 3 March 2010.

Miller, N. P. 2008. US National Parks and management of park soundscapes: A review. Applied Acoustics 69:77-92.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2006. Management policies 2006. ISBN 0-16-076874-8. U.S. Department of the Interior. National Park Service, Washington, D.C., USA.

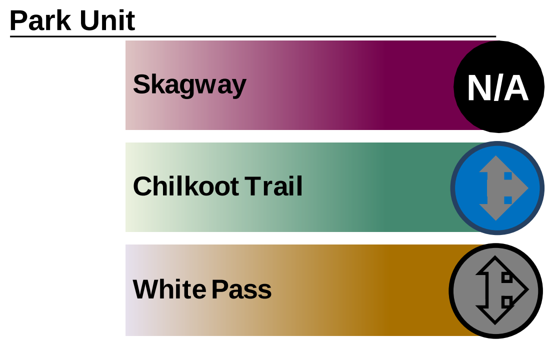
National Park Service. 2010. Explore nature: Natural sounds. Online. (http://www.nature.nps.gov/ naturalsounds/). Accessed 25 January 2010.

Schirokauer, D., and K. Gurcke. 2008. Nationwide survey of acoustical environments in parks – December, 2008. Klondike Gold Rush National Historical Park, Skagway, Alaska, USA.

Withers, J. 2006. Denali National Park & Preserve soundscape draft report 2006. Center for Resources, Science, and Learning, Denali National Park and Preserve, Alaska.

4.12 Dark Night Skies

Measures
V Magnitude



Background
The National Park Service directs each park to preserve, to the greatest extent possible, natural lightscapes (NPS 2006). A lightscape is considered natural if it exists without anthropogenic light sources. Natural cycles of dark and light periods of the day affect the evolution of species and other natural resource processes, including plant phenology (NPS 2006, 2007). Several species require darkness to hunt, hide their location, navigate, or reproduce (NPS 2007). In addition to the ecological importance of dark night skies, park visitors often expect skies free of light pollution and the ability to see stars. In KLGO, anthropogenic light sources diminish the ability of visitors to experience the historic gold rush landscape.

Reference Condition
The reference condition for the Chilkoot Trail and White Pass reporting zones is absence of anthropogenic light, which is in accordance with National Park Service management policies. Each park is to "preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light (NPS 2006)."

Data
No data have been collected in KLGO related to dark night skies.

Measures

<u>V Magnitude</u>
The National Park Service uses a CCD (charged coupled device) digital camera connected to a robotic mount and laptop computer to conduct night sky assessments (NPS 2007). A mosaic image of the entire sky is created by stitching together multiple short exposure images (NPS 2007). The images are filtered using a green filter to approximate human night vision sensitivity, and the data are calibrated using the known brightness of certain stars. The resulting data are

reported in units of V magnitude, which is an astronomical brightness system (NPS 2007). Weather conditions and phases of the moon limit the number of suitable nights for measuring V magnitude (NPS 2007). Night sky assessments have not been completed at KLGO.

Stressors

Light pollution is defined by the National Park Service as primarily "the illumination of the night sky caused by artificial light sources, decreasing the visibility of stars and other natural sky phenomena (NPS 2007)." Light pollution includes glare, use of light or intrusion of light in areas not requiring lighting, and any other disturbance of the natural nighttime landscape (NPS 2007). In addition to human sources of light, airborne particulates can affect night sky brightness (NPS 2007). Many anthropogenic light sources exist in Skagway related to residential use; however, these are outside the jurisdiction of KLGO. If built, a proposed road to Juneau would also impact the park's dark night skies (KLGO D. Schirokauer pers. comm. 3 July 2010).

Reporting Zones

Dark night skies is considered not applicable to the Skagway reporting zone because Skagway is an urban park unit affected by light sources outside of NPS jurisdiction. Insufficient data are available to quantitatively assess condition in the White Pass and Chilkoot Trail reporting zones, but the Chilkoot Trail Unit is thought to be free of anthropogenic light sources (KLGO D. Schirokauer pers. comm. 3 July 2010).

Condition

Due to the lack of data, a quantitative assessment of dark night skies cannot be completed at this time. The Chilkoot Trail Unit is thought to be virtually free from anthropogenic light and is therefore considered in good condition (KLGO D. Schirokauer pers. comm. 3 July 2010). Condition of dark night skies in the White Pass Unit is unknown. Skagway is an urban park unit, and its night skies are greatly influenced by residential and tourism activity outside NPS jurisdiction.

Data Needs

Quantitative dark night skies monitoring is needed in KLGO to be able to report condition.

Literature Cited

National Park Service. 2006. Management policies 2006. ISBN 0-16-076874-8. U.S. Department of the Interior. National Park Service, Washington, D.C., USA.

National Park Service. 2007. Air resources division – natural lightscapes. Online. (http://www.nature.nps.gov/air/lightscapes/). Accessed 25 January 2010.

4.13 Water Quality - Chemistry

Measures
pH
Specific Conductance
Dissolved Oxygen

Park Unit

Skagway N/A

Chilkoot Trail

White Pass

Background
The importance of water quality has been recognized by the national and SEAN I&M Program which designates freshwater water quality as a core vital sign (Moynahan and Johnson 2008). Dissolved oxygen, pH, and specific conductance are three of the core parameters identified by the NPS Water Resources Division and incorporated into the SEAN monitoring plan (Moynahan and Johnson 2008). These three properties of water are important to the organisms dependent on the water supply.

Dissolved oxygen in water is critical for the organisms living in it (USGS 2010a). Fish, zooplankton, and amphibian larvae breathe dissolved oxygen to survive. Several events in the ecosystem can change the amount of dissolved oxygen in a water body, so detecting changes in levels of dissolved oxygen is important for monitoring the health of the larger ecosystem.

The acidity or basicity of water is measured by pH. This measure is an important determinant of water solubility and biological availability of nutrients and other chemicals. Chemicals in water can change its pH; therefore, monitoring pH is useful for detecting natural and anthropogenic changes in water chemistry (USGS 2010a).

Specific conductance measures the ability of water to conduct an electrical current, which is dependent on the amount of dissolved solids in the water. Water with a higher concentration of dissolved solids (such as salty sea water), will have a higher specific conductance than distilled water (USGS 2010a). The amount of dissolved solids is important to organisms ingesting the water. As an indirect measure of dissolved solids (e.g., chloride, nitrate, sulfate, phosphate, calcium, and iron), specific conductance can be an indicator of water pollution. Specific conductance may also be used to detect change in the quantity of glacier runoff, because specific conductance is generally low in glacial melt water (Tockner et al. 2002).

Reference Condition

Some historic readings of pH, specific conductance, and dissolved oxygen exist for KLGO, primarily along the Taiya River. While these data do not necessarily provide a complete picture of historic condition, they may provide some indication of what a natural range of variability would include. These historic measurements are included in the measures section below.

The reference criteria included as Table 16 are not specific to KLGO, but provide some context for interpreting measurements of water quality. The criteria are from the Alaska Department of Environmental Conservation (ADEC) for the growth and propagation of fish, shellfish, other aquatic life, and wildlife (Table 16). These criteria are also referred to in KLGO's coastal watershed condition assessment (Hood et al. 2006). The ADEC does not have criteria for specific conductance. Paustian et al. (1994) concluded specific conductance in KLGO is generally less than 50 µS/cm, because the granite underlying the park results in low amounts of dissolved solutes.

Table 16. Water quality standards for pH and dissolved oxygen from the Alaska Department of Environmental Conservation (2009).

Parameter	Criteria	Source
pH	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH units from natural conditions.	State of Alaska (ADEC 2009)
Dissolved Oxygen	Dissolved Oxygen (D.O.) must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may D.O. be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning. For waters not used by anadromous or resident fish, D.O. must be greater than or equal to 5 mg/l. In no case may D.O. be greater than 17 mg/l or exceed 110% of saturation.	State of Alaska (ADEC 2009)

Data

Monitoring of water chemistry in KLGO has been inconsistent. Available measurements span a variety of years and locations. In 1998, the National Park Service published a collection of water quality data in and around KLGO from six of the EPA national databases: Storage and Retrieval water quality database management system (STORET), River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), Water Gages (GAGES), and Water Impoundments (DAMS). These records include measurements made in 1993 as part of an ecological inventory of KLGO and adjacent national forest lands (Paustian et al. 2004, NPS 1998). The retrieval resulted in over 4,000 observations of various parameters from 70 monitoring sites between 1949 and 1993. Thirteen of the stations included in the report lay within the park boundary. Only those stations residing within the park boundaries are reported as part of this condition assessment. The locations of the measurement sites are depicted on Plate 10, and the results are summarized in the appropriate sections below.

During water year 2004 (October 2003 to September 2004) pH, specific conductance, and dissolved oxygen measurements were made at the Taiya River near Skagway (Meyer et al. 2005). This site was collocated with some measurements obtained in 1969 and during the 1970s. Later in 2007 pH, specific conductance, and dissolved oxygen samples were obtained from the Taiya and Skagway Rivers as part of a study of freshwater contaminant concentrations (Nagorski et al. 2009).

Measures

<u>pH</u>

The measurements of pH obtained at various locations in KLGO are summarized in Table 17. All measurements within the park boundary were within the ADEC standard of 6.5 to 8.5 for the growth and progagation of fish, shellfish, other aquatic life, and wildlife. NPS (1998) summarized all pH measurements obtained both within and near the park. There were 148 total measurements at 58 monitoring stations from 1949 to 1993. The only two stations which reported pH outside of the 2003 ADEC standard of 6.5 to 8.5 were located outside the park boundaries at Skagway. At these two stations there were seven observations of pH below 6.5. The lowest value measured was 6.1 in July 1949 in the Skagway River at Skagway (NPS 1998). Potential causes for these more acidic pH measures were not discussed in the report.

Table 17. pH in KLGO from various studies. Dates and locations are reported as was provided in the original study reports.

Date	Location / Description	Park Unit	pH	Source
25 June 1969 to 27 July 1977[a]	West Creek Near Skagway	Chilkoot Trail	6.8 - 7.7[a]	NPS 1998
25 June 1969 to 28 July 1977[b]	Taiya River near Skagway	Chilkoot Trail	7 – 7.8[b]	NPS 1998
7 September 1979	467667	White Pass	7.4	NPS 1998
7 September 1979	467683	Chilkoot Trail	7.8	NPS 1998
7 September 1979	467682	Chilkoot Trail	7.9	NPS 1998
7 September 1979	467675	Chilkoot Trail	7.5	NPS 1998
7 September 1979	467672	Chilkoot Trail	8	NPS 1998
26 September 1979	467914	Chilkoot Trail	7.9	NPS 1998
27 July 1993	Nelson Creek	Chilkoot Trail	6.9	NPS 1998
27 July 1993	West Branch Taiya River	Chilkoot Trail	7.3	NPS 1998
29 July 1993	Upper Taiya River	Chilkoot Trail	6.8	NPS 1998
30 July 1993	Taiya Tributary	Chilkoot Trail	7.1	NPS 1998
1 August 1993	Skagway River White Pass Fork	White Pass	7.2	NPS 1998
15 December 2003	Taiya River near Skagway	Chilkoot Trail	7.8	Meyer et al. 2005
10 February 2004	Taiya River near Skagway	Chilkoot Trail	7.7	Meyer et al. 2005
6 April 2004	Taiya River near Skagway	Chilkoot Trail	7.7	Meyer et al. 2005
25 June 2004	Taiya River near Skagway	Chilkoot Trail	7.1	Meyer et al. 2005
17 August, 2004	Taiya River near Skagway	Chilkoot Trail	7.0	Meyer et al. 2005
3 July 2007	Taiya River	Chilkoot Trail	6.81	Nagorski et al. 2009
3 July 2007	Skagway River	Outside Park	6.76	Nagorski et al. 2009

[a] There were 13 observations of pH at this location from 25 June 1969 to 27 July 1977. The values ranged from 6.8 to 7.7 with a mean of 7.323 and a standard deviation of 0.255 (NPS 1998). The median of the observations was 7.3.
[b] There were 12 observations of pH at this location from 25 June 1969 to 28 July 1977. The values ranged from 7 to 7.8 with a mean of 7.367 and a standard deviation of 0.219 (NPS 1998). The median of the observations was 7.35.

The only location in KLGO with both historic and recent pH measurements is the USGS station at the Taiya River near Skagway (Figure 32) (USGS 2010b). There are relatively few data points from which to draw conclusions; however, all 2003 to 2004 measurements are within 0.5 pH standard units of the 1969 to 1977 measurements, are greater than 6.5, and are less than 8.5. Of note in this dataset, there does appear to be a seasonal effect on pH measurements. This is consistent with other studies that have shown a relationship between pH and the quantitiy of glacier and snow meltwater (Baraer et al. 2009, Brown et al. 2007, Füreder et al. 2001).

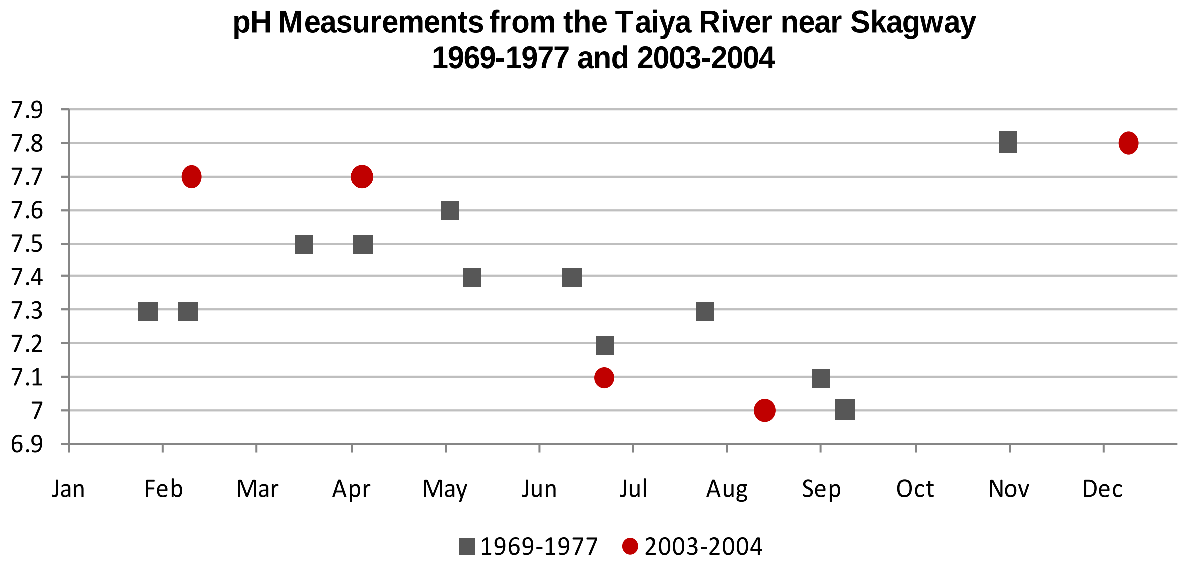


Figure 32. pH measurements from the Taiya River near Skagway: 1969 to 1977 and 2003 to 2004 (USGS 2010b).

Specific Conductance

Measurements of specific conductance in KLGO range from 5 to 127 µS/cm at 25°C (Table 18). Several measures were below 50 µS/cm as Paustian et al. (1994) suggested; however, data from other sources indicate a broader range of values exist in the park (NPS 1998, Meyer et al. 2005).

Table 18. Specific conductance measurements in KLGO from various sources.

Date	Location	Park Unit	Sp Cond (µS/cm @ 25°C)	Study or Source
25 June 1964 to 27 July 1977[a]	West Creek Near Skagway	Chilkoot Trail	17 – 97[a]	NPS 1998
25 June 1969 to 28 July 1977[b]	Taiya River near Skagway	Chilkoot Trail	19 – 114[b]	NPS 1998
7 September 1979	467667	White Pass	42	NPS 1998
7 September 1979	467683	Chilkoot Trail	23	NPS 1998
7 September 1979	467682	Chilkoot Trail	16	NPS 1998
7 September 1979	467675	Chilkoot Trail	29	NPS 1998
7 September 1979	467672	Chilkoot Trail	5	NPS 1998
26 September 1979	467914	Chilkoot Trail	5	NPS 1998
27 July 1993	Nelson Creek	Chilkoot Trail	52	NPS 1998
27 July 1993	West Branch Taiya River	Chilkoot Trail	127	NPS 1998
29 July 1993	Upper Taiya River	Chilkoot Trail	12	NPS 1998
30 July 1993	Taiya Tributary	Chilkoot Trail	33	NPS 1998
1 August 1993	Skagway River White Pass Fork	White Pass	23	NPS 1998
15 December 2003	Taiya River near Skagway	Chilkoot Trail	77	Meyer et al. 2005
10 February 2004	Taiya River near Skagway	Chilkoot Trail	63	Meyer et al. 2005
6 April 2004	Taiya River near Skagway	Chilkoot Trail	79	Meyer et al. 2005
25 June 2004	Taiya River near Skagway	Chilkoot Trail	22	Meyer et al. 2005
17 August 2004	Taiya River near Skagway	Chilkoot Trail	17	Meyer et al. 2005
3 July 2007	Taiya River	Chilkoot Trail	29	Nagorski et al. 2009
3 July 2007	Skagway River	Outside Park	33	Nagorski et al. 2009

[a] There were 18 observations of specific conductance at this location from 25 June 1964 to 27 July 1977. The values ranged from 17 to 97 µS/cm@25°C with a mean of 44.111 and a standard deviation of 20.384 (NPS 1998). The median of the observations was 46 µS/cm@25°C.
[b] There were 12 observations of specific conductance at this location from 25 June 1969 to 28 July 1977. The values ranged from 19 to 114 µS/cm@25°C with a mean of 57.833 and a standard deviation of 29.829 (NPS 1998). The median of the observations was 60 µS/cm@25°C.

The only location in KLGO with both historic and recent specific conductance measurements is the USGS station at the Taiya River near Skagway (Figure 33) (USGS 2010b). There are relatively few data points from which to draw conclusions; however, 2003 and 2004 measurements appear similar to the range of values measured from 1969 to 1977. There does appear to be a seasonal affect on specific conductance measurements. This is similar to the findings of a USGS study in Colorado which found lower specific conductance during times of largest streamflow and is likely due to the influence of glacial melt during the summer months (USGS 2010a, Tockner et al. 2002).

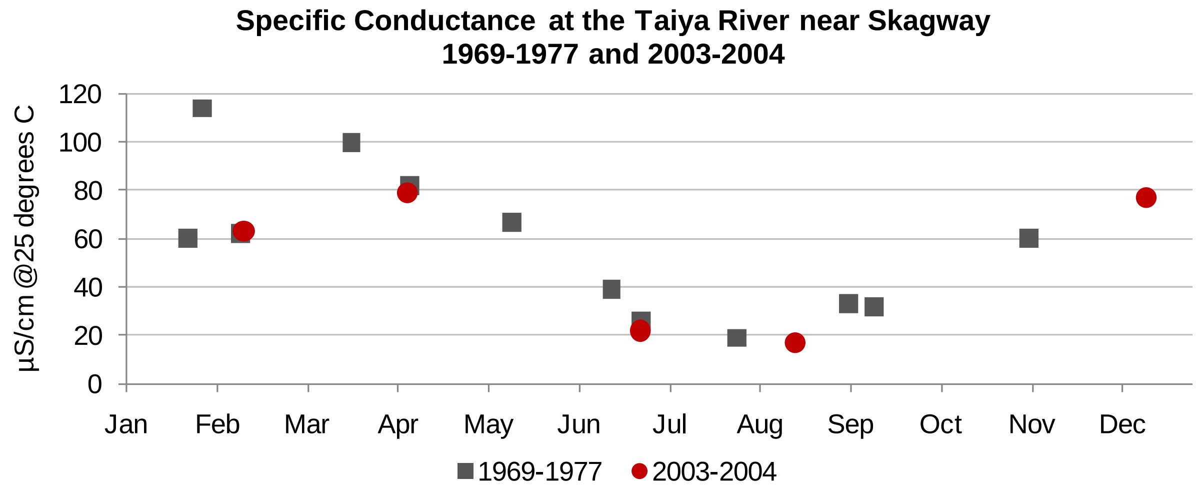


Figure 33. Specific conductance at the Taiya River near Skagway: 1969 to 1977 and 2003 to 2004 (USGS 2010b).

Dissolved Oxygen

The measurements of dissolved oxygen from various locations in KLGO range from 12.6 to 14.8 mg/L (Table 19). All values are greater than 7 mg/L and less than 17 mg/L as required by the ADEC in waters used by anadromous or resident fish (ADEC 2009). Dissolved oxygen saturation never exceeded the ADEC maximum of 110%, but some measurements nearly passed this threshold, including a measure of 108% from the Taiya River and a measure of 110 % from the Skagway River, both in 2007.

Table 19. Dissolved oxygen measurements in KLGO from various studies. Dates and locations are reported in as much detail as was provided in the original study reports.

Date	Location	Park Unit	DO (%)	DO (mg/L)	Study or Source
21 January 1976	West Creek near Skagway	Chilkoot Trail	-	14.8	NPS 1998
22 January 1976	Taiya River near Skagway	Chilkoot Trail	-	12.8	NPS 1998
15 December 2003	Taiya River near Skagway	Chilkoot Trail	100	13.3	Meyer et al. 2005
10 February 2004	Taiya River near Skagway	Chilkoot Trail	90	13.2	Meyer et al. 2005
6 April 2004	Taiya River near Skagway	Chilkoot Trail	100	13.9	Meyer et al. 2005
25 June 2004	Taiya River near Skagway	Chilkoot Trail	98	12.6	Meyer et al. 2005
17 August 2004	Taiya River near Skagway	Chilkoot Trail	104	13.1	Meyer et al. 2005
3 July 2007	Taiya River	Chilkoot Trail	108	14.0	Nagorski et al. 2009
3 July 2007	Skagway River	Outside Park	110	13.4	Nagorski et al. 2009

Stressors

Bryant (2009) reports on potential water quality consequences of global climate change, specifically as they relate to salmonids in southeast Alaska. Summer air temperatures measured at locations in the KLGO region have increased since records began (Hood et al. 2006). According to Bryant (2009), increased air temperatures predicted by general circulation models will change thermal regimes in freshwater ecosystems. Increased temperatures in combination with low stream flow can lead to a rapid depletion of dissolved oxygen when fish are present in high densities (Bryant 2009). Changes in climate can also lead to changes in soil composition and vegetation communities, which can ultimately cause changes in water chemistry (Hood et al. 2006). Climate also influences the quantitiy and timing of snow and glacier melt, which in turn influences water chemistry.

Hood et al. (2006) recognized backcountry toilets as a potential source of pollution in KLGO. Erosion has also been an issue along the Taiya River (Inglis 2002). Organic matter, such as sewage and soil from streambank erosion, is oxygen-demanding and can decrease average dissolved oxygen levels in water.

Reporting Zones
The Skagway reporting zone is not considered applicable for water chemistry because KLGO does not have jurisdiction over Pullen Creek. Measurements obtained from the Taiya River are associated with the Chilkoot Trail reporting zone. A limited number of historic measurements of pH and specific conductance exist for the White Pass reporting zone, but they are not sufficient for reporting current condition. It should be noted that observations from the Skagway River near Skagway might reflect conditions upstream in the White Pass Unit. Measurement sites and reporting zones are depicted on Plate 10.

Condition
The condition of water chemistry in the Chilkoot Trail reporting zone is good with an unknown trend. All values of pH and dissolved oxygen were within the Alaska Department of Environmental Conservation's criteria for aquatic life. Recent values of specific conductance were similar to those measured in the 1970s. Insufficient recent data exist to determine a trend.

Current condition cannot be determined for the White Pass reporting zone. The last measurements of water chemistry in the unit were obtained in 1993. Water chemistry is not considered applicable for the Skagway reporting zone, because Pullen Creek is not within the jurisdiction of KLGO.

Data Needs
Long-term monitoring of pH, specific conductance, and dissolved oxygen are needed throughout the park in order to assess condition and determine trend. Water quality monitoring equipment will be installed during the summer of 2011, and water quality will be monitored as part of the SEAN I&M Program (KLGO D. Schirokauer pers. comm. 22 March 2010, Moynahan and Johnson 2008). The SEAN I&M Program has selected the Taiya River in KLGO for ongoing monitoring. Specific conductance, pH, and dissolved oxygen will be measured every 15 minutes from May to October. These data will allow for future detection of trends, determining adherence to aquatic life and human health criteria, as well as comparison to additional water quality monitoring parameters collected at the Taiya River (Moynahan and Johnson 2008). While greatly improving the available water quality data for the park, these measurements will not provide a direct indication of water quality in the White Pass Unit. Current pH, specific conductance, and dissolved oxygen information for this unit represents a significant data gap.

Literature Cited
Alaska Department of Environmental Conservation. 2009. Water quality standards. 18 AAC 70. Alaska Department of Environmental Conservation, Juneau, Alaska.

Baraer, M., J. M. McKenzie, B. G. Mark, J. Bury, and S. Knox. 2009. Characterizing contributions of glacier melt and groundwater during the dry season in a poorly gauged catchment of the Cordillera Blanca (Peru). Advances in Geosciences 22:41-49.

Brown, L. E., D. M. Hannah, and A. M. Milner. 2007. Vulnerability of alpine stream biodiversity to shrinking glaciers and snowpacks. Global Change Biology 13:958-966.

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

Füreder, L., C. Schütz, M. Wallinger, and R. Burger. 2001. Physio-chemistry and aquatic insects of a glacier-fed and a spring-fed alpine stream. Freshwater Biology (46):1673-1690.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, Colorado.

Inglis, R. 2002. Assessment of bank retreat monitoring data from 1979 to 2002 for the Taiya River at Klondike Gold Rush National Historical Park. USGS Water Resources Division.

Meyer, D. F., H. R. Best, R. H. Host, R. P. Murray, and G. L. Solin. 2005. Water resources data Alaska water year 2004. Water-Data Report AK-04-1. U.S. Geological Survey, Anchorage, Alaska. Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

Nagorski, S., D. Engstrom, J. Hudson, D. Krabbenhoft, J. DeWild, E. Hood, and G. Aiken. 2009. Scale and distribution of global pollutants in Southeast Alaska Network park watersheds. Natural Resource Technical Report NPS/NRWRD/NRTR—2009/XXX, *in press*. National Park Service, Fort Collins, Colorado.

National Park Service. 1998. Baseline water quality data inventory and analysis: Klondike Gold Rush National Historical Park. Technical Report NPS/NRWRD/NRTR-98/160. National Park Service, Water Resources Division, Fort Collins, Colorado, USA.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Tockner, K., F. Malard, U. Uehlinger, and J. V. Ward. 2002. Nutrients and organic matter in a glacial river-floodplain system (Val Roseg, Switzerland). Limnology and Oceanography. 47(1):266-277.

U.S. Geological Survey. 2010a. Common water measurements from USGS water science for schools. U.S. Geological Survey. Information from A Primer on Water Quality by Swanson, H.A., and Baldwin, H.L., U.S. Geological Survey, 1965. Online. (http://ga.water.usgs.gov/edu/ characteristics.html). Accessed 20 April 2010.

U.S. Geological Survey. 2010b. USGS 15056210 Taiya River near Skagway, AK. U.S. Geological Survey National Water Information System. Online. (http://waterdata.usgs.gov/nwis). Accessed 29 April 2010.

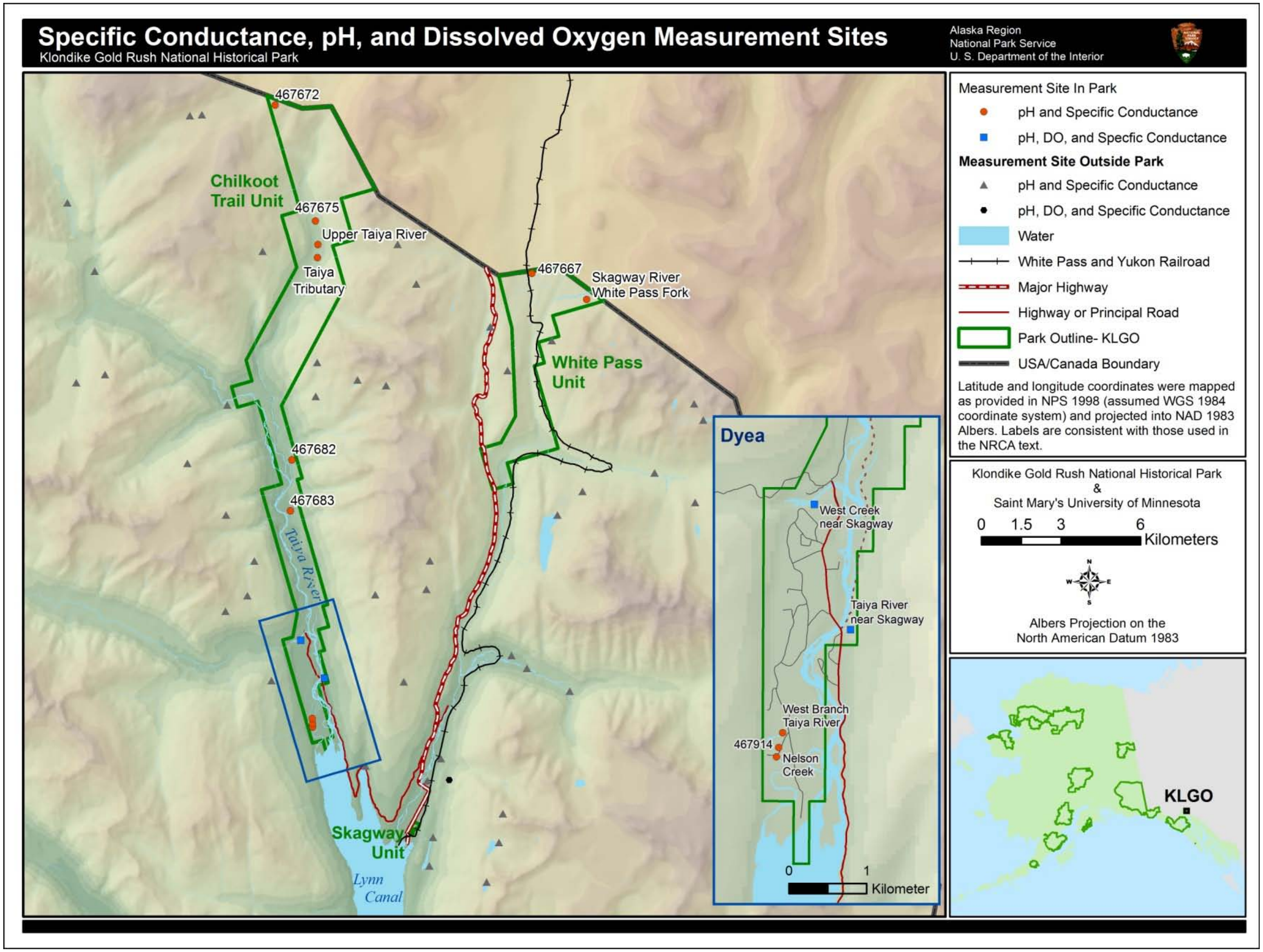
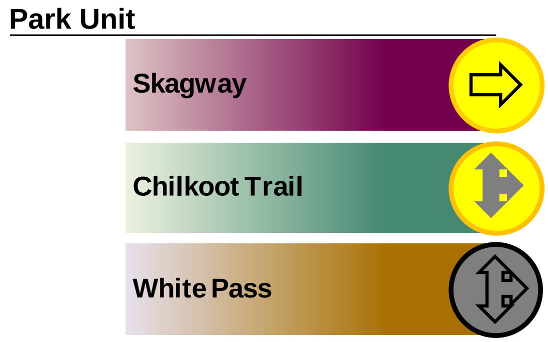


Plate 10. Specific conductance, pH, and dissolved oxygen measurement sites in (red circle and blue square) and near (gray triangle and black circle) KLGO (NPS 1998, NPS 2009).

4.14 Water Quality – Trace Inorganic and Organic Chemicals

Measures
Mercury
Polycyclic Aromatic Hydrocarbons (PAHs)
Persistent Organic Pollutants (POPs)



Background
Pollutants in water can accumulate in food chains and endanger top predators and humans (Tallmon 2009). The importance of water quality has been recognized by the SEAN I&M Program which designated both marine contaminants and freshwater contaminants as vital signs (Moynahan and Johnson 2008). Concentrations of mercury, persistent organic pollutants (POPs), and polycyclic aromatic hydrocarbons (PAHs) have been measured and plans are in place for continued monitoring.

Although mercury is a naturally occurring heavy metal, in high quantities it can cause permanent neurological and developmental damage (Nagorski et al. 2009). Atmospheric mercury levels continue to increase due to anthropogenic emissions (Nagorski et al. 2009). Inorganic mercury becomes highly toxic methylmercury when atmospheric mercury is deposited and is methylated by naturally occurring bacteria (Dastoor and Larocque 2004). Methylmercury bioaccumulates in aquatic food chains (Dastoor and Larocque 2004).

Polycyclic aromatic hydrocarbons are a group of over 100 different chemicals that result from the incomplete burning of organic substances such as coal, oil, gas, wood, and garbage (Agency for Toxic Substances and Disease Registry 1995). Although PAHs often enter the environment naturally from such sources as volcanoes and forest fires, there are many human sources of PAHs including residential wood burning, exhaust from vehicles, and discharge from industrial and waste water treatment plants (Agency for Toxic Substances and Disease Registry 1995). PAHs can be found in air, water, and soil. PAHs in the air can travel great distances before falling as rain or settling to the earth. Certain PAHs have been found to cause tumors in laboratory animals and have been shown to impair reproduction (Agency for Toxic Substances and Disease Registry 1995). Short and long-term exposure to PAHs has also been found to cause harm to an animal's skin, body fluids, and ability to fight disease (Agency for Toxic Substances and Disease Registry 1995).

Persistent organic pollutants are toxic chemicals that are damaging to the health of humans and the environment (EPA 2002). The purpose of many current and historic POPs is to control pests and diseases, improve crop production, and benefit industrial production (EPA 2002). There are also unintentionally produced POPs that are by-products of some industrial processes and combustion (EPA 2002). Persistent organic pollutants are of concern because of adverse health effects, their persistence in the environment, their ability to travel great distance by wind, water, and migratory species, and the ease with which they are absorbed in fatty tissue and accumulate over time (EPA 2002). DDT is a well-known POP that was used as a pesticide on crops and to protect soldiers from insect-borne diseases during World War II (EPA 2002). It was later found to accumulate in humans and wildlife and cause certain bird species, including the bald eagle, to have difficulty producing live offspring (EPA 2002).

Reference Condition

Limited historic water quality measurements are available for KLGO pertaining to mercury, POPs, and PAHs (Hood et al. 2006). Some levels of mercury and PAHs exist naturally; however, this natural baseline level is unknown for KLGO. Since all POPs are from anthropogenic sources, the reference condition for POPs is none. Although the park may lack an adequate reference condition for mercury and PAHs, there are regional and national standards and norms that provide some indication of the condition of KLGO water quality. These standards and norms are not considered the reference condition but are included to provide some context for interpreting water quality results.

The National Oceanic and Atmospheric Administration's (NOAA) National Mussel Watch Program (MWP) has collected data at over 280 sites along the coasts of the United States since 1986 and is the longest continuous contaminant monitoring program in U.S. coastal waters (NOAA 2010). There are five sites in Alaska, including one near KLGO at Nahku Bay (Plate 11). The four additional Alaskan sites (Ketchikan, Port Valdez, Unakwit Inlet, and Cook Inlet) provide some regional context for mercury, POP, and PAH concentrations measured at KLGO. The 2004 and 2005 results for these four sites are included in the the discussion of the measures below. Since 2005 several sites in Alaska have been added and could provide additional data for comparison. The Mussel Watch Program has characterized contaminant levels as low, medium, and high at a regional species level (Kimbrough et al. 2008). These ranges are included in Table 20. Mussel samples were also collected at several sites as part of the SEAN I&M Program, and these sites provide more localized context for KLGO results.

Table 20. Regional species characterizations of low, medium, and high mercury, POP, and PAH concentrations (Kimbrough et al. 2008).

	Mercury	Butyltins	Chlordanes	DDTs	Dieldrins	PAHs	PCBs
Low	0.00-0.17	1-39	0-8	0-112	0-8	63-1187	3-153
Medium	0.18-0.35	40-108	9-20	113-286	9-34	1188-4434	154-478
High	0.36-1.28	109-281	21-49	287-520	35-95	4435-7561	479-1413

Mercury levels referenced in the Nagorski et al. (2009) study include EPA levels of concern for human health, fish tissue standards, national median streambed levels, and mayfly and coho salmon values measured elsewhere in the United States. KLGO mercury results are compared to these references in the mercury section below.

Fifty-three historic measurements of mercury levels exist for one site located near the park. These measurements are reported in a 1998 National Park Service collection of water quality data in and around KLGO from six of the EPA national databases: Storage and Retrieval water quality database management system (STORET), River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), Water Gages (GAGES), and Water Impoundments (DAMS). The only site with mercury data was located at the Skagway River at Skagway. Hood et al. (2006) summarized mercury concentration levels measured at this site from 1978 to 1985 and reported in NPS (1998). Out of 53 samples obtained from 1978 to 1985, one sample, obtained in July of 1979, contained mercury levels greater than or equal to EPA criteria of 2.0 µg/L (Hood et al. 2006, NPS 1998). Hood et al. (2006) thought it likely the sample found to exceed EPA criteria was a result of sampling or analysis contamination error.

Data

As mentioned in the reference condition section above, Nahku Bay near KLGO is a NOAA Mussel Watch Program site. Monitoring at the site began in 1995, and the target species of the program is the blue mussel (*Mytilus edulis)*. Results for mercury, POP, and PAH concentrations are available every two years from 1995 to 2005 and are provided by the U.S. National Oceanic and Atmospheric Administration through its National Status and Trends Program (NOAA 2010).

Two recent studies investigated inorganic and organic chemicals in and near KLGO, as well as the other two parks in the Southeast Alaska Network: Glacier Bay National Park (GLBA) and Sitka National Historic Park (SITK). In July and August of 2007, bay mussel (*Mytilus trossulus*) samples were collected near the Taiya River outlet and at the mouth of the Skagway small boat harbor as part of a baseline assessment of contamination (Tallmon 2009). The mussel samples were analyzed for various chemicals including mercury, PAHs, and POPs.

Mussels were chosen for various reasons, including the ability to compare results to national trends and provide insight into chronic, as well as potentially catastrophic, contamination threats (Tallmon 2009). Mussels are sessile filter feeders that bioaccumulate and bioconcentrate many contaminants (Tallmon 2009). Local long-term data can be derived from sampling because of the relatively long life-span of a mussel (up to 20 years) and the fact that mussels do not migrate long distances (Tallmon 2009). Results for mussel samples are reported as elemental mercury, not methylmercury.

During the same year as the mussel sampling (2007), samples of freshwater stream particulates, bed sediment, water, and juvenile coho salmon (*Oncorhynchus kisutch*) were obtained from the

Taiya and Skagway rivers in order to establish baseline contaminant concentrations and investigate spatial differences in contamination levels (Nagorski et al. 2009). Watersheds in GLBA and SITK were also sampled. All samples were analyzed for mercury. Due to the important differences in the ecological effects of elemental mercury and methlymercury, Nagorski et al. (2009) reports measurements as both total mercury (Hg_T) and methylmercury (meHg) for all samples except coho salmon. It is assumed that most or all of the mecury in juvenile coho salmon is methlymercury (Nagorski et al. 2009). The juvenile coho salmon samples were also analyzed for POPs.

During water year 2004, mercury measurements were obtained from water samples at the Taiya River near Skagway (USGS Site 15056210). These measurements occurred on 6 April and 25 June and included both filtered µg/L and unfiltered recoverable µg/L (Meyer et al. 2005).

A complete report of intertidal and freshwater sample contaminant concentrations is included in Tallmon (2009) and Nagorski et al. (2009). Results are summarized in their applicable subsections below. Site locations for the Mussel Watch Program, the USGS stream gauge, and collections from Tallmon (2009) are depicted on Plate 11. Plate 11 does not include sites from Nagorski et al. (2009), because only generalized locations of the Taiya and Skagway Rivers are provided and not the specific sample sites.

Measures

<u>Mercury</u>

Mercury levels in the Taiya River (USGS Site 15056210) were measured on two days (6 April and 25 June 2004) during water year 2004. Both measures (filtered µg/L and unfiltered recoverable µg/L) were <.02 (Meyer et al. 2005). These values are well below the EPA criteria for freshwater aquatic life (EPA 2010).

Mercury (Hg) levels in mussel samples collected in 2007 were relatively low in all sites in the Southeast Alaska Network compared to sites included in the Mussel Watch Program from other parts of Alaska and the contiguous 48 states (Tallmon 2009). While both sites were considered relatively low, mercury concentration at Skagway Harbor was twice that of Dyea (Table 21).

Table 21. Mercury contaminant levels in mussel samples collected from KLGO reported as µg/g wet tissue (Tallmon 2009).

Sample	Site Description	Hg
1801601	Dyea	0.0070
1801602	Skagway Harbor	0.0140

Mercury concentrations in mussels collected at the Mussel Watch Program site at Nahku Bay near KLGO were low according to the Mussel Watch Program regional species characterization and were within the range of values reported at other sites in Alaska (Figure 34). Although considered to be at a low level, mercury tissue concentrations show an increasing trend since 1995, nearly doubling from 1995 to 2005 (Table 22).

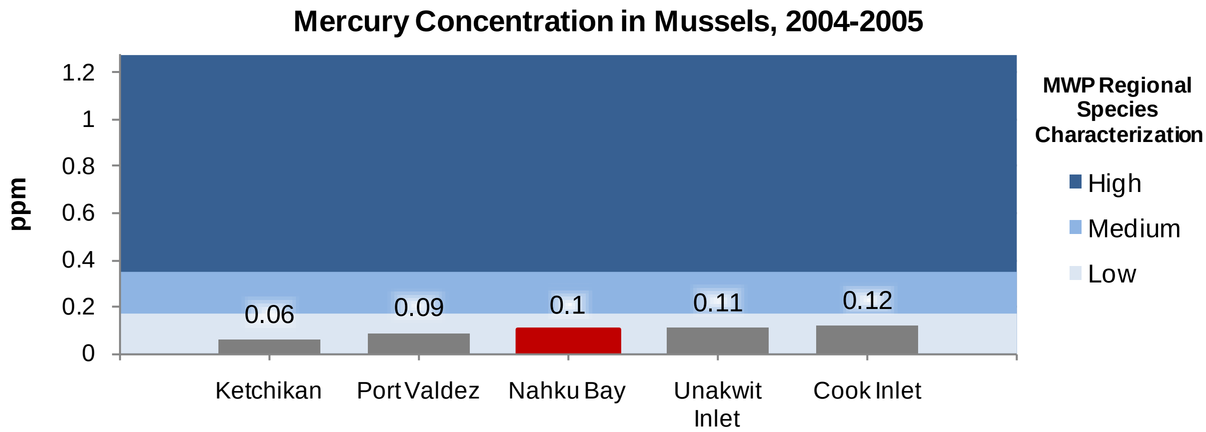


Figure 34. Mercury concentration in mussels (ppm): 2004 and 2005 (Kimbrough et al. 2008).

Table 22. Average tissue concentration of mercury sampled in Mytilus mussel species at the Nahku Bay East Side site as part of the NOAA Mussel Watch Program (NOAA 2010).

Year	1995	1997	1999	2001	2003	2005
Concentration (µg/dry g)	0.056	0.085	0.146	0.045	0.045	0.101

Mercury levels in streamwater, particulates, and bed sediment samples collected in 2007 from the Taiya and Skagway Rivers are within the range of values observed in other SEAN streams (Figure 35). There does not appear to be a consistent difference between results for the Taiya River and Skagway River (Table 23). According to Nagorski et al. (2009), total mercury in streamwater was well below EPA levels of concern for human health and aquatic organisms and streambed mercury levels were well below the national median value (60 ng/g dry weight) and the probable effect levels.

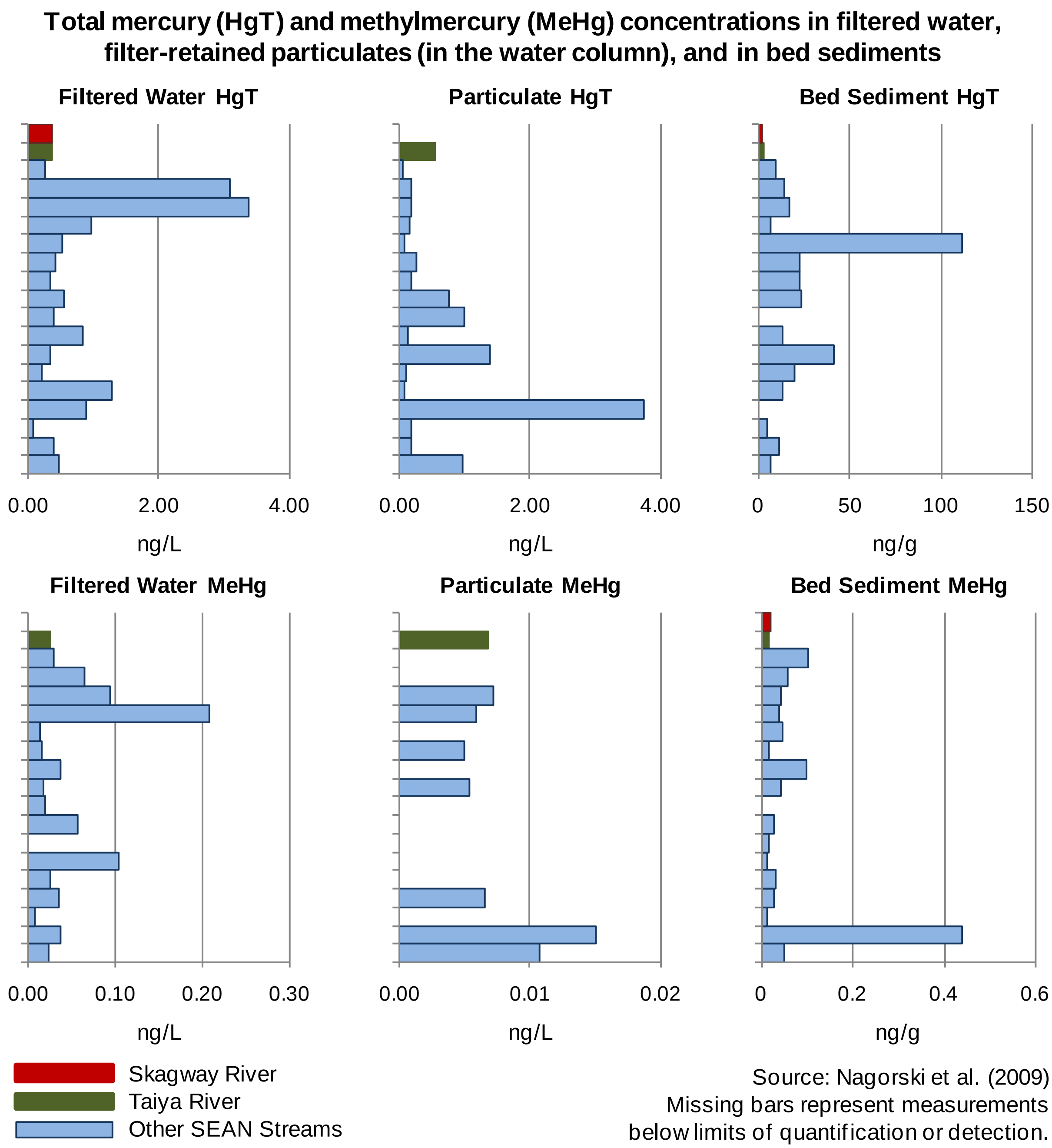


Figure 35. Total mercury (Hg_T) and methylmercury (MeHg) concentrations in filtered water, filter-retained particulates (in the water column), and in bed sediments of the Skagway River (red), Taiya River (green), and other SEAN streams (blue) (Nagorski et al. 2009).

Table 23. Mercury contaminant levels in filtered water, particulates, and bed sediment collected from KLGO (Nagorski et al. 2009).

	Filtered Water		Particulates		Bed sediment	
Stream	Hg_T (ng/L)	MeHg (ng/L)	Hg_T (ng/L)	MeHg (ng/L)	Hg_T (ng/g)	MeHg (ng/g)
Taiya River	0.35	0.02	0.534	<0.01	3.0	0.02
Skagway River	0.37	<0.01	-	0.01	1.7	0.02

Eisler (2000) recommends a limit of of 100 ng/g mercury in fish for the protection of piscivorous birds and mammals that consume fish. Concentrations of mercury in juvenile coho salmon from the Taiya and Skagway Rivers easily met this standard (Table 24). Nagorski et al. (2009) concluded that mercury concentrations in mayflies (Baetidae and Heptageneiidae), and juvenile coho salmon were generally low to midrange when compared to other results reported in the United States (Figure 36). Total mercury and methylmercury concentrations were higher in mayfly samples from the Taiya River compared to the Skagway River (Table 24). Mercury concentrations in juvenile coho salmon were higher in the Skagway River than the Taiya River.

Table 24. Mercury contaminant levels in mayfly samples (Baetidae and Heptageneiidae families) and juvenile (age 0+) coho salmon collected from KLGO and the average and standard deviation of all samples collected in the Southeast Alaska Network (SEAN) (Nagorski et al. 2009).

	Baetidae			Heptageneiidae			Coho
Stream	MeHg (ng/g)	Hg_T (ng/g)	% methyl	MeHg (ng/g)	Hg_T (ng/g)	% methyl	Hg_T (ng/g)
Taiya River	24.5	41.56	59%	28.7	48.2	60%	1.7
Skagway River	10.7	21.5	50%	21.2	36.2	58%	3.1
SEAN Average	18.1	34.4	51%	22.5	45.7	50%	5.9
SEAN STDEV	13.1	15.5	0.2	10.1	15.2	0.2	4.0

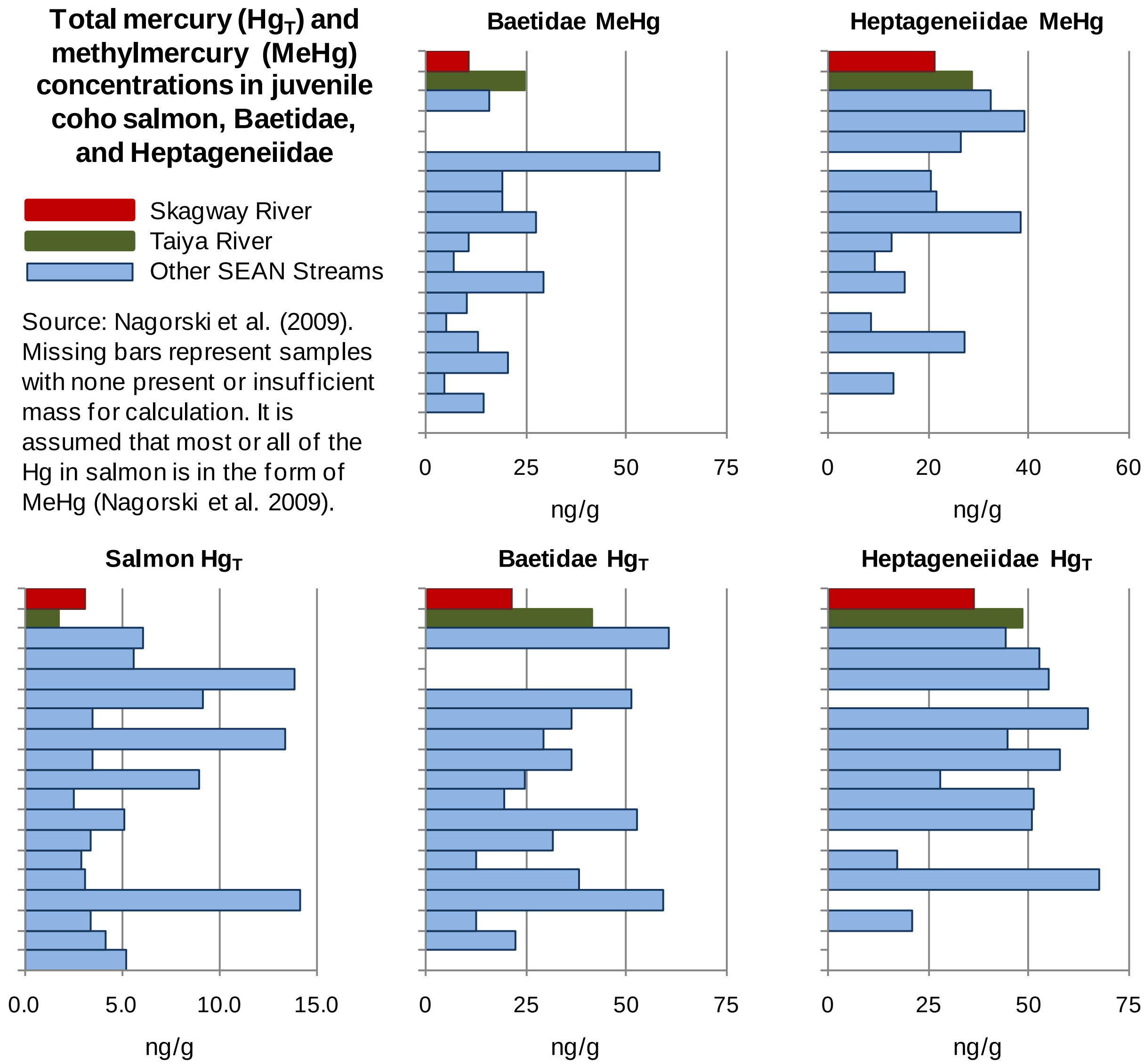


Figure 36. Total mercury (HgT) and methylmercury (MeHg) concentrations in juvenile coho salmon, Baetidae, and Heptageneiidae at the Skagway River (red), Taiya River (green), and other SEAN streams (blue) (Nagorski et al. 2009).

Polycyclic Aromatic Hydrocarbons (PAHs)

The two mussel samples analyzed from the sites in KLGO were found to have detectable TPAH (total PAH) levels, which were believed to be related to the high boat use in the area and the sites' positions at the north end of the Lynn Canal (Table 25). Although the TPAH levels were detectable, they were still low compared to the rest of the sites in the United States referenced in the MWP study (Tallmon 2009).

Table 25. TPAH contamination levels (ng/g) in mussel samples from KLGO (Tallmon 2009).

Sample	Site Description	TPAH
1801601	Dyea	2.69
1801602	Skagway Harbor	42.82

The concentration of PAHs sampled from *Mytilus* sp. as part of the Mussel Watch Program at the Nahku Bay East Side site in 2005 was 316 ppb (Kimbrough et al. 2008). This was higher than three of the other four sites in Alaska, but lower than Port Valdez (Figure 37). All values in Alaska were considered low according to the MWP regional species characterization (Kimbrough et al. 2008).

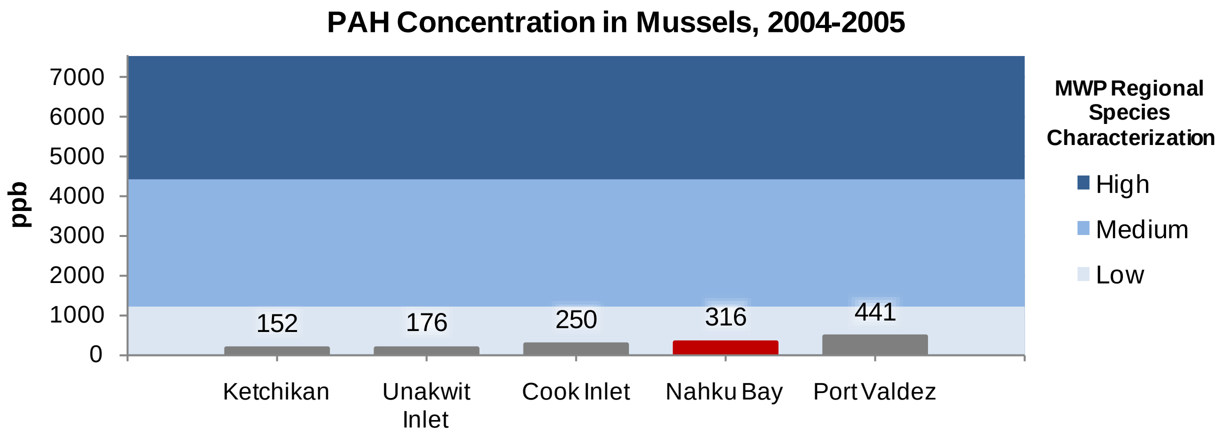


Figure 37. PAH Concentration in mussels at Nahku Bay and other Alaska sites, 2004 and 2005 (Kimbrough et al. 2008).

PAH concentrations were reported differently from 1995 to 2003 than they were in 2005. High molecular weight PAHs and low molecular weight PAHs were totaled separately from 1995 to 2003. The highest total low PAH concentration was reported in 2003. Both total high PAH and total overall PAH appeared to be improving until the reported concentrations increased in 2003 (Table 26).

Table 26. High molecular weight, low molecular weight, and total PAH concentrations in *Mytilus* species at Nahku Bay, 1995 to 2003 (ng/dry g) (NOAA 2010). High and low PAH were not reported separately in 2005.

	1995	1997	1999	2001	2003	2005
Total High PAHs	409.49	135.3	72.15	40.6	100.3	NA
Total Low PAHs	209.9	106.2	123.28	55.5	359.5	NA
Total PAH	619.39	241.5	195.43	96.1	459.8	316

High PAH (high molecular weight) = benanth + chrysene + fluorant + pyrene + benapy + benepy + benzobfl + benzokfl + dibenz + perylene + benzop + indeno
Low PAH (low molecular weight) = biphenyl + dimeth + menap1 + menap2 + naph + trimeth + acenthe + acenthy + anthra + fluorene + mephen1 + phenant

Persistent Organic Pollutants (POPs)

Several categories of persistent organic pollutants were analyzed as part of the intertidal contaminants study: Chlordane (CHLD), dichloro diphenyl trichloroethanes (DDT), hexachlorocyclohexanes (HCH), polychlorinated biphenyls (PCBs), and polybrominated biphenyl ethers (PBDE). PCB, DDT, and CHLD levels in mussel samples collected in the Southeast Alaska Network were in orders of magnitude below the National Academy of Sciences limits for seafood and were relatively low compared to measurements obtained from other sites in the United States (Tallmon 2009). Concentrations of CHLDs and HCHs were below the limits of quantification (LOQ) at both the Dyea and Skagway Harbor sites (Table 27) (Tallmon 2009).

Table 27. POP contamination levels (ng/g) in mussel samples from KLGO (Tallmon 2009). LOQ= Limit of quantification.

Sample	Site Description	∑CHLD	∑DDT	∑HCH	∑PCB	∑PBDE
1801601	Dyea	< LOQ	0.11	< LOQ	1.6	< LOQ
1801602	Skagway Harbor	< LOQ	0.22	< LOQ	2.1	0.42

POP concentrations measured near KLGO (Nahku Bay) as part of the Mussel Watch Program were also considered low according to the MWP regional species characterization (Kimbrough et al. 2008). Concentrations of chlordanes, DDTs, and dieldrins were, however, the highest among the five Alaskan sites (Figure 38) (Kimbrough et al. 2008).

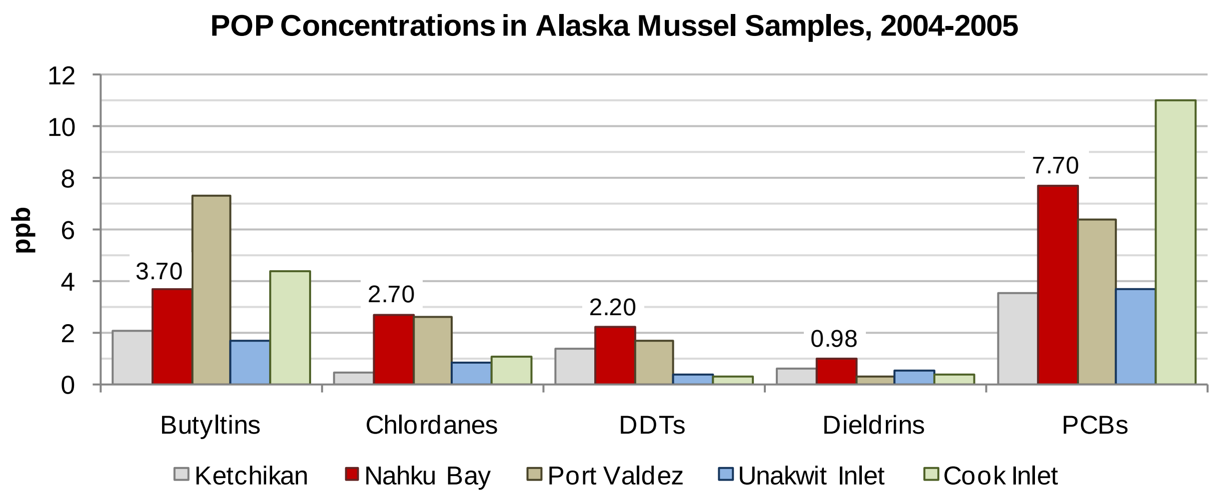


Figure 38. POP concentrations in mussels at Nahku Bay and other Alaska sites (ppb), 2004 and 2005 (Kimbrough et al. 2008).

Concentrations of DDTs and PCBs measured in mussels at Nahku Bay in 2005 were at the lowest levels since monitoring began at the site in 1995 (Table 28, Figure 39). Values of butyltins, chlordanes, and dieldrins observed in 2005 were within the range of values reported between 1995 and 2003. All POP concentrations observed from 1995 to 2005 were considered low according to the Mussel Watch Program regional species characterizations (Table 20).

Table 28. POP concentrations in Mytilus species at Nahku Bay, 1995 to 2005 (ng/dry g) (NOAA 2010).

POP	1995	1997	1999	2001	2003	2005
Butyltins	5.35	27	2.78	19.78	5.36	3.73
Chlordanes	6.065	1.66	0.965	1.941	1.655	2.73
DDTs	5.748	3.3	3.542	3.275	9.755	2.2
Dieldrins	0	0.98	0.881	0.849	1.067	0.98
PCBs	10.916	13.81	16.147	10.068	9.091	7.71

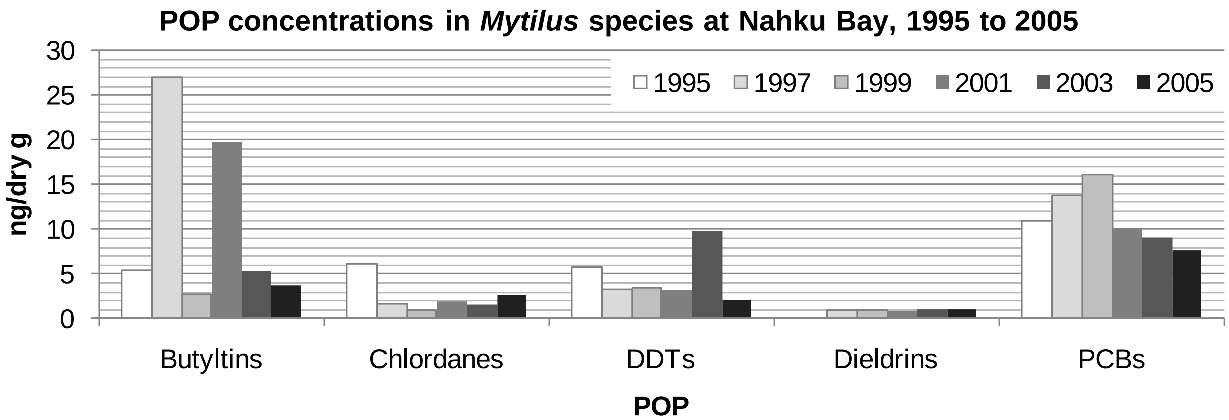


Figure 39. POP concentrations in Mytilus species at Nahku Bay, 1995 to 2005 (ng/dry g) (NOAA 2010).

The Skagway River juvenile coho salmon samples contained higher levels of HCBs, ∑CHLDs, and ∑DDTs than any other site sampled in or near SEAN parks as part of the same study (Figure 40). The Skagway River salmon also contained the second highest concentrations of ∑PCBs compared to the other sites. The Skagway and Taiya River salmon contained the only quantifiable levels of dieldrin (Nagorski et al. 2009). Concentrations of HCHs, BDEs, aldrin, and mirex were below limits of quantification in salmon samples from both the Taiya and Skagway Rivers (Table 29) (Nagorski et al. 2009).

Table 29. POP contamination levels (ng/g) in juvenile coho salmon samples from KLGO (Nagorski et al. 2009). LOQ= Limit of quantification.

Stream	∑CHLD	∑DDT	∑HCH	∑HCB	40CB	∑BDEs	dieldrin	aldrin	mirex
Taiya River	0.54	1.4	<LOQ	0.71	2.9	<LOQ	0.23	<LOQ	<LOQ
Skagway River	1.9	3.8	<LOQ	0.89	4.1	<LOQ	0.21	<LOQ	<LOQ

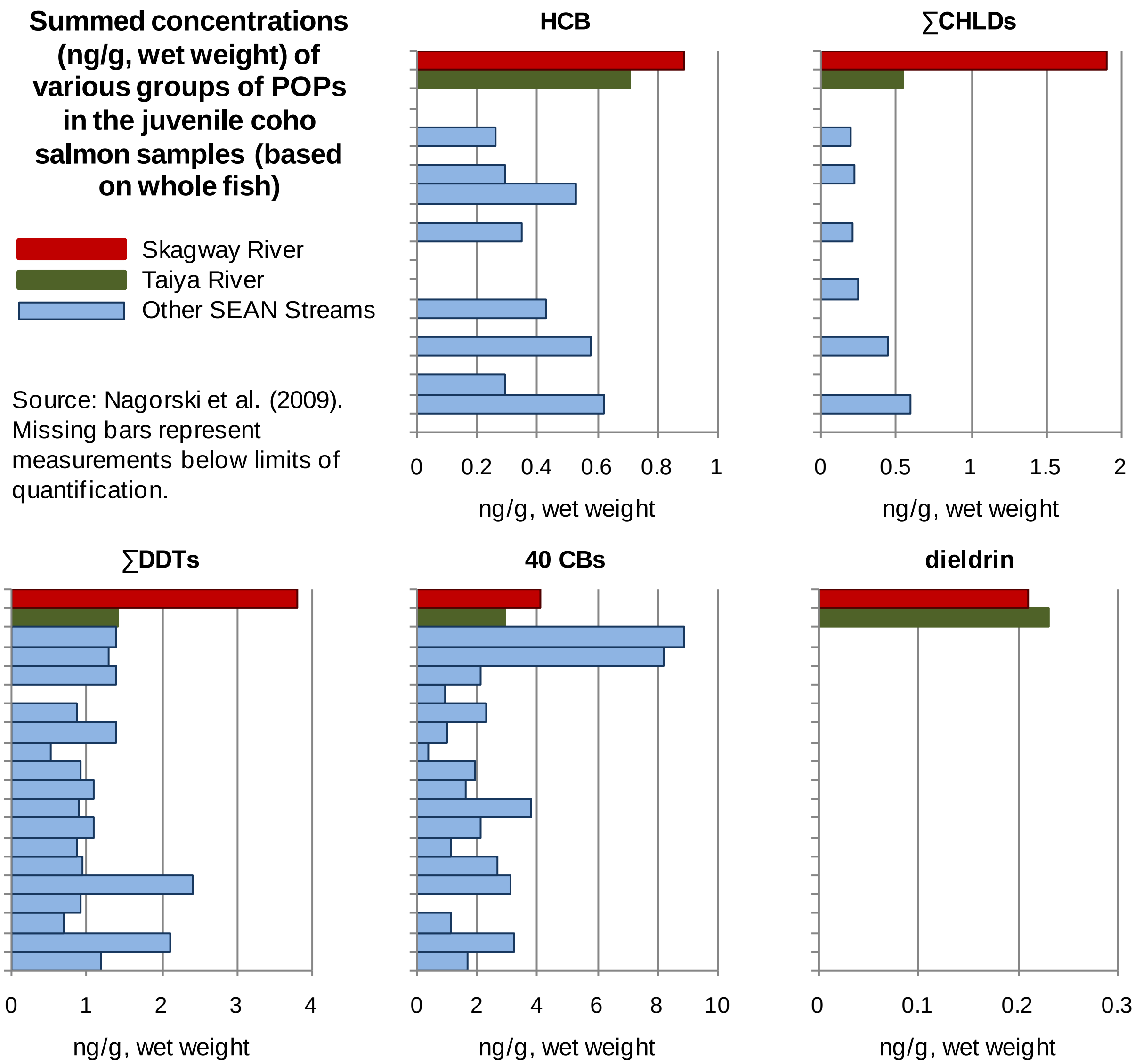


Figure 40. Summed concentrations (ng/g, wet weight) of various groups of POPs in the juvenile coho salmon samples (based on whole fish) (Nagorski et al. 2009).

Stressors

Klondike Gold Rush National Historical Park is subject to both local and global sources of pollution (Tallmon 2009). Various transportation methods are shown to bring contaminants from distant sources to high latitudes where they can accumulate in food chains (Dastoor and Larocque 2004, Wania 2003). Although several of the most harmful POPs are now illegal, others are still being produced and released into the environment (Nagorski et al. 2009). POPs are also slow to degrade and can repeatedly evaporate and re-condense, persisting in the environment long after their initial release (Nagorski et al. 2009). A possible source of mercury and POPs in southeast Alaska watersheds is spawning salmon. Some studies have found a correlation between salmon activity and mercury and POP levels in streams, suggesting salmon transport contaminants from marine environments into freshwater streams (Christensen et al. 2005, Zhang et al. 2001).

In addition to international sources, boat traffic associated with the heavy tourism in Skagway exposes KLGO's intertidal waters to potential oil spills and other contaminants (Tallmon 2009). PAHs and metals are released when low-grade marine fuel is combusted (Geiser et al. 2010). The presence of wetlands in KLGO may also be a risk factor for mercury accumulation. It has been suggested in literature that wetlands facilitate the conversion of deposited atmospheric mercury to toxic bioavailable forms such as methlymercury (Hurley et al. 1995, St. Louis et al. 1996). This form of mercury is 100 times more toxic than elemental mercury and easily biomagnifies in the food chain (Nagorski et al. 2009). Other local sources of pollutants include backcountry toilets, the White Pass & Yukon Railway, urban runoff, and air pollution (Hood et al 2006).

Reporting Zones

Measurements obtained from the Taiya River and Dyea are associated with the Chilkoot Trail reporting zone. Although no water quality data exist for the Skagway Unit, measurements have been obtained nearby. These measurements are included in this report due to the importance of the Lynn Canal and Skagway River to the park and the park's concerns regarding cruise ship and other anthropogenic impacts on water quality. The sites have been reported as part of the Skagway reporting zone in order to distinguish them from the Chilkoot Trail reporting zone. No data have been collected pertaining to mercury, POPs, and PAHs in the White Pass Unit; however, results for the Skagway River sample sites may reflect condition in the White Pass Unit.

Condition

Condition and trend for the White Pass reporting zone cannot be determined due to insufficient data. Despite all mercury, POP, and PAH concentrations falling well below any regulatory thresholds and generally considered low compared to national results, condition for the Skagway and Chilkoot Trail reporting zones is considered of moderate concern. This concern is in recognition of the high levels of POPs compared to other sites in Alaska, including SEAN streams, and the continued threat of boat traffic associated with tourism. The Skagway River site contained the highest levels of HCBs, ∑CHLDs, ∑DDTs and the second highest concentrations of ∑PCBs of all streams sampled in SEAN. Of the three SEAN parks, the two KLGO sites reported the only quantifiable measurement of dieldrin (Nagorski et al. 2009). Concentrations of chlordanes, DDTs, and dieldrins measured at Nahku Bay were the highest of the five Alaskan Mussel Watch Program sites (Kimbrough et al. 2008).

A trend for the Chilkoot Trail cannot be determined because of the lack of historic data. The trend for the Skagway reporting zone is considered stable. Mercury concentrations at Nahku Bay have almost doubled since monitoring began in 1995, but the values are still considered low and are within the values observed at the other four Alaskan sites. The MWP has reported no overall national trend for mercury and no regional trend for mercury in the northwest United States (Kimbrough et al. 2008). DDTs and PCBs are at their lowest levels since 1995. Butyltins, chlordanes, and dieldrins reported in 2005 were within the range of values reported from 1995 to 2003. Total PAH concentration observed at Nahku Bay in 2005 was also within the range of values reported from 1995 to 2003.

Data Needs

Consistent water quality monitoring protocols are needed to establish a trend for trace inorganic and organic contaminants in KLGO. In order to report condition for the White Pass reporting zone, baseline measurements need to be obtained. Consistent water quality monitoring is planned for the Taiya River. This location will be sampled every 5 to 10 years for mercury and POPs using resident or juvenile anadromous fish, macroinvertebrates, streambed sediments, and water as part of the SEAN I&M Program (Moynahan and Johnson 2008).

Literature Cited

Agency for Toxic Substances and Disease Registry. 1995. Public health statement for polycyclic aromatic hydrocarbons (PAHs). Center for Disease Control, Agency for Toxic Substances and Disease Registry. Online. (http://www.atsdr.cdc.gov/toxprofiles/tp69-c1.pdf). Accessed 2 October 2009.

Christensen, J. R., M. Macduffee, R. W. Macdonald, M. Whiticar, and P. S. Ross. 2005. Persistent organic pollutants in British Columbia grizzly bears: Consequence of divergent diets. Environmental Science and Technology 39 (18):6952–6960.

Dastoor, A. P., and Y. Larocque. 2004. Global circulation of atmospheric mercury: a modeling study. Atmospheric Environment 38:147-161.

Eisler, R. 2000, Mercury, Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Boca Raton, FL, Lewis Publishers, p. 313-409.

Environmental Protection Agency. 2002. Persistent organic pollutants: A global issue, a global response. U.S. Environmental Protection Agency, Office of International Affairs, Washington, DC.

Environmental Protection Agency. 2010. National recommended water quality criteria. United States Environmental Protection Agency. Online. (http://www.epa.gov/waterscience/criteria/wqctable/index.html). Accessed 21 June 2010.

Geiser, L., D. Schirokauer, A. Bytnerowicz, K. Dillman, and M. Fenn. 2010. Effects of cruise ship emissions on terrestrial vegetation in Southeast Alaska. Prepared for publication in Alaska Park Science.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Hurley, J. P., J. M. Benoit, C. L. Babiarz, M. M. Shafer, A. W. Andren, J. R. Sullivan, R. Hammond, and D. A. Webb. 1995. Influences of watershed characteristics on mercury levels in Wisconsin rivers. Environmental Science & Technology 29(7):1867-1875.

Kimbrough, K. L., W. E. Johnson, G. G. Lauenstein, J. D. Christensen, and D. A. Apeti. 2008. An assessment of two decades of contaminant monitoring in the nation’s coastal zone. NOAA Technical Memorandum NOS NCCOS 74. Silver Spring, Maryland.

Meyer, D. F., H. R. Best, R. H. Host, R. P. Murray, and G. L. Solin. 2005. Water resources data Alaska water year 2004. Water-Data Report AK-04-1. U.S. Geological Survey, Anchorage, Alaska.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

Nagorski, S., D. Engstrom, J. Hudson, D. Krabbenhoft, J. DeWild, E. Hood, and G. Aiken. 2009. Scale and distribution of global pollutants in Southeast Alaska Network park watersheds. Natural Resource Technical Report NPS/NRWRD/NRTR—2009/XXX, *in press*. National Park Service, Fort Collins, Colorado.

National Oceanic and Atmospheric Administration. 2010. Mussel watch - analyte data: All. NCCOS Mussel Watch Program Data. Online. (http://www8.nos.noaa.gov/cit/nsandt/download/mw_monitoring.aspx). Accessed 21 June 2010.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

National Park Service. 1998. Baseline water quality data inventory and analysis: Klondike Gold Rush National Historical Park. Technical Report NPS/NRWRD/NRTR-98/160. National Park Service, Water Resources Division, Fort Collins, Colorado, USA.

St. Louis, V. L., J. W. M. Rudd, C. A. Kelly, K. G. Beaty, R. J. Flett, and N. T. Roulet. 1996. Production and loss of methylmercury and loss of total mecury from boreal foest catchments containing different types of wetlands. Environmental Science & Technology 30(9):2719-2729.

Tallmon, D. A. 2009. Contaminants assessment of intertidal resources in southeast Alaska national parks (Draft). Natural Resource Technical Report NPS/SEAN/NRTR-2009/yyy, *in press*. National Park Service, Natural Resource Program Center, Fort Collins, CO, USA.

Wania, F. 2003. Assessing the potential of persistent organic chemicals for long-range transport and accumulation in polar regions. Environmental Science & Technology 37(7): 1344-1351.

Zhang, X., A. S. Naidu, J. J. Kelley, S. C. Jewett, D. Dasher, L. K. Duffy. 2001. Baseline concentrations of total mercury and methyl mercury in salmon returning via the Bering Sea (1999-2000). Marine Pollution Bulletin 42:993-997.

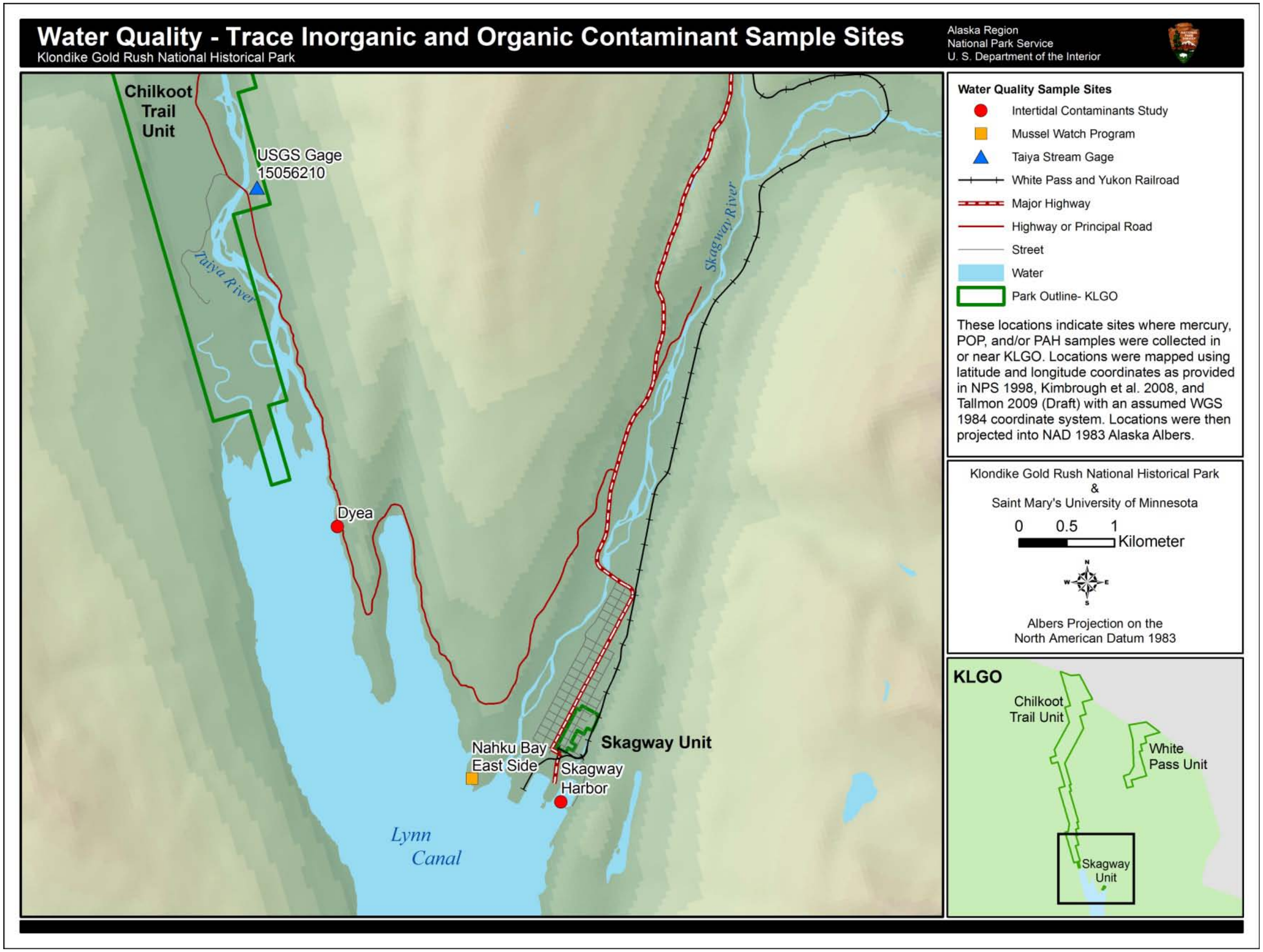
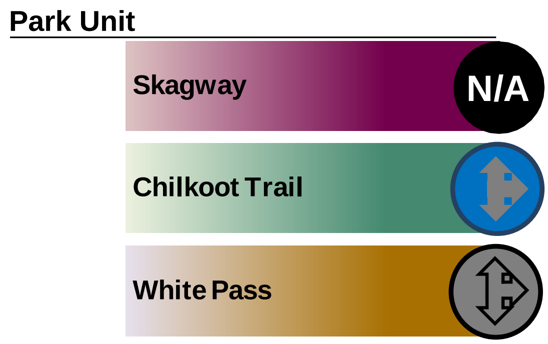


Plate 11. Trace contaminant sample sites in or near KLGO (Kimbrough et al. 2008, NPS 1998, Tallmon 2009, and NPS 2009).

4.15 Water Quality – Physical Properties

Measures
Turbidity
Temperature



Background

Physical properties of water, such as temperature and turbidity, are critical for aquatic species and can have far reaching effects on both aquatic and terrestrial ecosystems. The KLGO watershed is home to three species of Pacific salmon: chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbushca*), and coho salmon (*Oncorhynchus kisutch*) (Hood et al. 2006). The anadromous and resident Dolly Varden char (*Salvelinus malma*) is also found in KLGO. The health of these fish is not only important because of their intrinsic value but also because of their significant impact on terrestrial and aquatic ecosystems (Hood et al. 2006). Bryant (2009) reports on potential consequences of global climate change for salmonids in southeast Alaska. Increased water temperatures may alter timing of entry into the ocean for pink and chum salmon and affect the growth and survival of juvenile coho salmon (Bryant 2009). Water temperature also affects habitat and the ability of organisms to resist pollutants (USGS 2010a).

The importance of water quality has been recognized by the National I&M Program, which designated freshwater water quality as a core vital sign (Moynahan and Johnson 2008). Temperature is one of the four core water quality parameters identified by the NPS Water Resources Division and is included in the SEAN I&M plan (Moynahan and Johnson 2008). Turbidity has also been identified as an important water quality parameter by KLGO and SEAN, and it is considered a principal physical characteristic of water by the U.S. Environmental Protection Agency (1999).

Turbidity measures the relative clarity of a liquid (EPA 1999). Suspended matter or impurities (e.g., clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisims) absorb and scatter light, which increases turbidity (EPA 1999). Sources of turbidity include runoff, waste discharge, algae, compounds from decaying plants, and elevated iron concentrations. Turbidity was historically considered mostly an aesthetic characteristic of water, but evidence now suggests a relationship between turbidity and pathogens in water (EPA 1999). Turbidity is also related to glacial melt and therefore might provide a method for detecting change in quantity and timing of glacial runoff (Robinson et al. 2001).

It is worth noting that methods for measuring turbidity and the resulting units of measurement have changed over the last century. This presents a challenge when comparing data over a long period of time. The three primary units of measurement are Jackson turbidity units (JTUs) measured using a Jackson candle turbidimeter, formazin turbidity units (FTUs) measured using an improved Jackson candle turbidimeter calibration method, and nephelometric units (NTUs) measured using a nephelometer. The nephelometric method is now considered the preferred technique for measuring turbidity (EPA 1999). According to the EPA (1999), 40 Jackson turbidity units are approximately equal to 40 nephelometric units (NTUs), but it cannot be assumed that the measurements are equivalent at all levels of turbidity.

Reference Condition

Some historic readings of temperature and turbidity exist for KLGO, primarily along the Taiya River (NPS 1998). While these data do not necessarily provide a complete picture of historic condition, they may indicate the values for the natural range of variability during the time period of measurment. These historic measurements are included in the measures section below.

The following reference criteria are not specific to condition in KLGO, but provide some context for interpreting measurements of water temperature and turbidity. The criteria are from the Alaska Department of Environmental Conservation (ADEC) and are the water quality standards for the growth and propagation of fish, shellfish, other aquatic life, and wildlife (Table 30). These criteria were also referred to in KLGO's coastal watershed condition assessment (Hood et al. 2006). It is important to note that salmon live in a variety of climatic conditions along the Pacific coast; however, individual stocks often have uniquely adapted life history strategies specific to a region or watershed, including emergence, run timing, and residence time in freshwater (Bryant 2009). Therefore, salmon in KLGO's streams may have water temperature requirements that are not reflected in generalized water quality criteria for the entire state.

Table 30. Water quality standards for temperature and turbidity from the Alaska Department of Environmental Conservation (ADEC 2009).

Parameter	Criteria
Temperature	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes: 15°C Spawning areas: 13°C Rearing areas: 15°C Egg & fry incubation: 13°C For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.
Turbidity	May not exceed 25 nephelometric turbidity units (NTUs) above natural conditions. For all lake waters, may not exceed 5 NTUs above natural conditions.

Data

There has not been consistent long-term monitoring of water temperature or turbidity in KLGO. The available measurements span a variety of years and locations. In 1998, the National Park Service published a collection of water quality data in and around KLGO from six of the EPA national databases (Storage and Retrieval (STORET) water quality database management system, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), Water Gages (GAGES), and Water Impoundments (DAMS)). These records include measurements made in 1993 as part of an ecological inventory of KLGO and adjacent national forest lands (Paustian et al. 1994, NPS 1998). The retrieval resulted in over 4,000 observations of various parameters from 70 monitoring sites between 1949 and 1993. Only thirteen of the stations were located within the park boundaries, and only a subset of these stations reported turbidity and/or temperature measurements. These stations are depicted on Plate 12, and the observations at these stations are summarized in the measures section below. At the Taiya River gauge, water temperature is measured every 15 minutes.

In 2007, temperature and turbidity measurements were obtained from the Taiya and Skagway Rivers as part of a study of freshwater contaminant concentrations (Nagorski et al. 2009). While general descriptions of stream location were included, the exact locations of the measurements along the rivers were not detailed in the report.

Measures

Turbidity

There have been relatively few measurements of turbidity within the KLGO boundary (Table 31). Some additional measurements of turbidity were made at the Skagway River near Skagway in the late 1970s and early 1980s. This location was outside the park boundary but near the Skagway Unit. Of the 28 samples at the Skagway River near Skagway, two measurements exceeded 50 FTU (NPS 1998). Hood et al. (2006) summarized the existing measurements of turbidity at locations in the KLGO watershed as reported in NPS (1998) and concluded that the limited data suggest turbidity is usually low but occasionally becomes elevated to levels similar to silt-laden glacial rivers in southeast Alaska (50-200 FTU). These elevated turbidity events are likely related to heavy rainfall or increased glacier melt (e.g., during rare proglacial lake drainage events) (Hood et al 2006).

In 2007, the single measurements of turbidity in the Taiya and Skagway Rivers were 29 and 22 NTUs, respectively (Nagorski et al. 2009). Changes in instruments used to measure turbidity over time make comparison to historical data from the Taiya River difficult; however, given the similarity between measurement units, it appears likely that all recorded data are within the threshold of 25 NTUs above natural condition required by ADEC (2009).

Table 31. Turbidity measurements in KLGO from various studies. Dates and locations are reported in as much detail as was provided in the study reports.

Park Unit	Location	Date	Turbidity	Study
Chilkoot Trail	Taiya River Near Skagway	18 March 1976 to 29 September 1976[a]	1 – 25 Jackson Candle Units[a]	NPS 1998
Chilkoot Trail	Taiya River	3 July 2007	29 NTUs	Nagorski et al. 2009
Outside Park	Skagway River	3 July 2007	22 NTUs	Nagorski et al. 2009

[a] There were 3 observations of turbidity at this location from 18 March 1976 to 29 September 1976. The values ranged from 1 to 25 Jackson Candle Units with a mean of 10 and a standard deviation of 13.077 (NPS 1998). The median of the observations was 4 Jackson Candle Units.

Temperature

Temperature measurements have occurred in a variety of locations in KLGO, but only the Taiya River near Skagway has been sampled substantially both historically and recently (Table 32, Figure 41, and Figure 42). The only temperature measurement from the White Pass Unit occurred in 1979 and was reported as 10.1°C. The maximum water temperature measured at the Taiya River near Skagway is 10°C, which occurred on 21 May 1974. Water temperature of the Taiya River appears to typically peak between 8 and 9°C during late May to early July. All measurements are below the maximum temperature thresholds determined by the ADEC for the growth and propagation of fish, shellfish, other aquatic life, and wildlife (see Table 30).

Table 32. Water temperature measurements in KLGO from various sources. See Plate 12 for the locations of these measurement sites.

Park Unit	Location	Date	Temp (°C)	Study
White Pass	467667	7 September 1979	10.1	NPS 1998
Chilkoot Trail	467914	26 September 1979	5.5	NPS 1998
Chilkoot Trail	467672	7 September 1979	4.9	NPS 1998
Chilkoot Trail	467675	7 September 1979	6	NPS 1998
Chilkoot Trail	467682	7 September 1979	6.5	NPS 1998
Chilkoot Trail	467683	7 September 1979	9.2	NPS 1998
Chilkoot Trail	West Creek Near Skagway	1 August 1963 to 5 May 1977[a]	0 – 9.5[a]	NPS 1998
Chilkoot Trail	Taiya River	3 July 2007	4.48	Nagorski et al. 2009
Outside Park	Skagway River	3 July 2007	6.91	Nagorski et al. 2009

[a] There were 27 observations of temperature at this location from 1 August 1963 to 5 May 1977. The values ranged from 0 to 9.5°C with a mean of 3.7°C and a standard deviation of 2.2°C (NPS 1998). The median of the observations was 4°C.

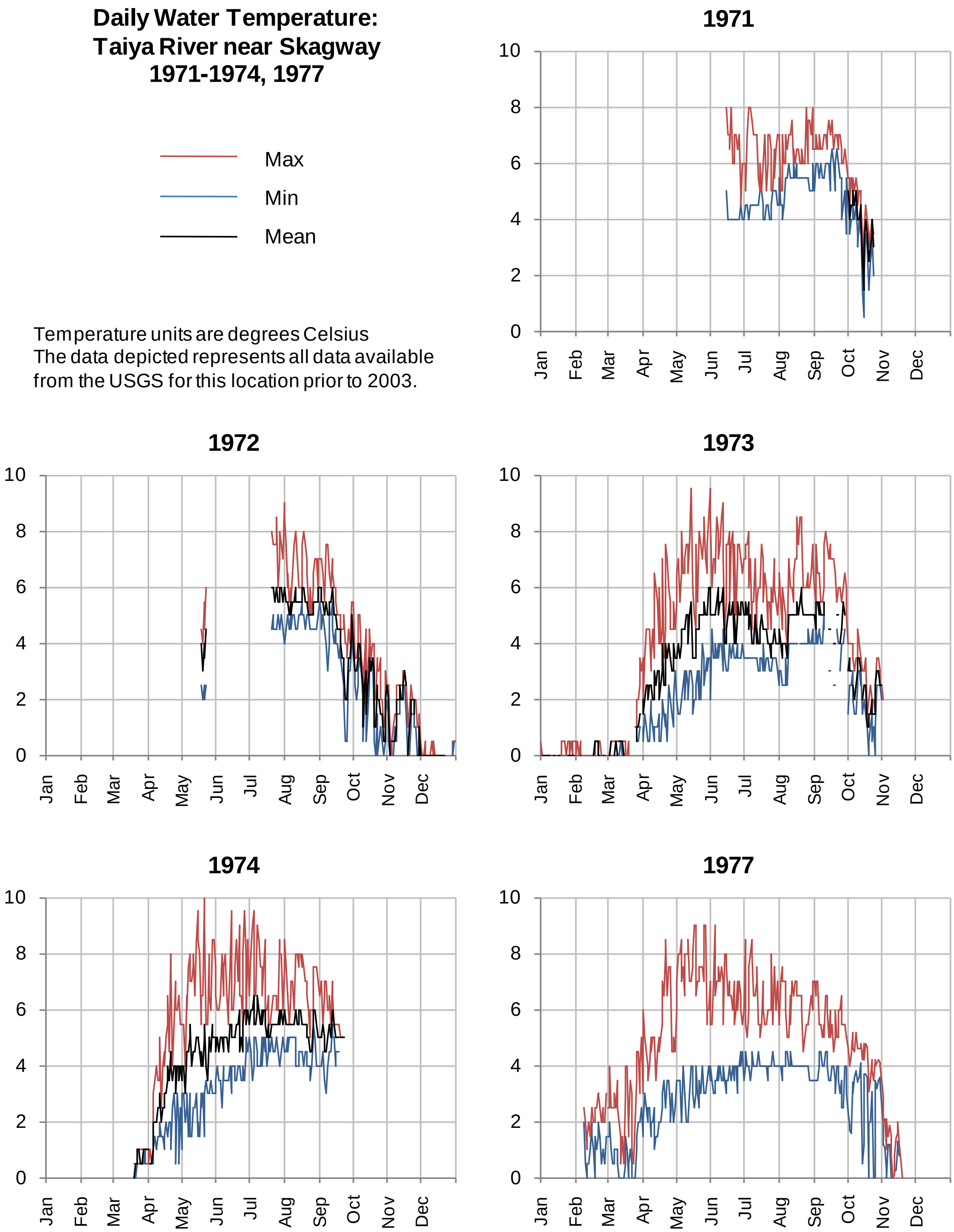


Figure 41. Daily water temperature (°C): Taiya River near Skagway. 1971 to 1974, 1977 (USGS 2010b).

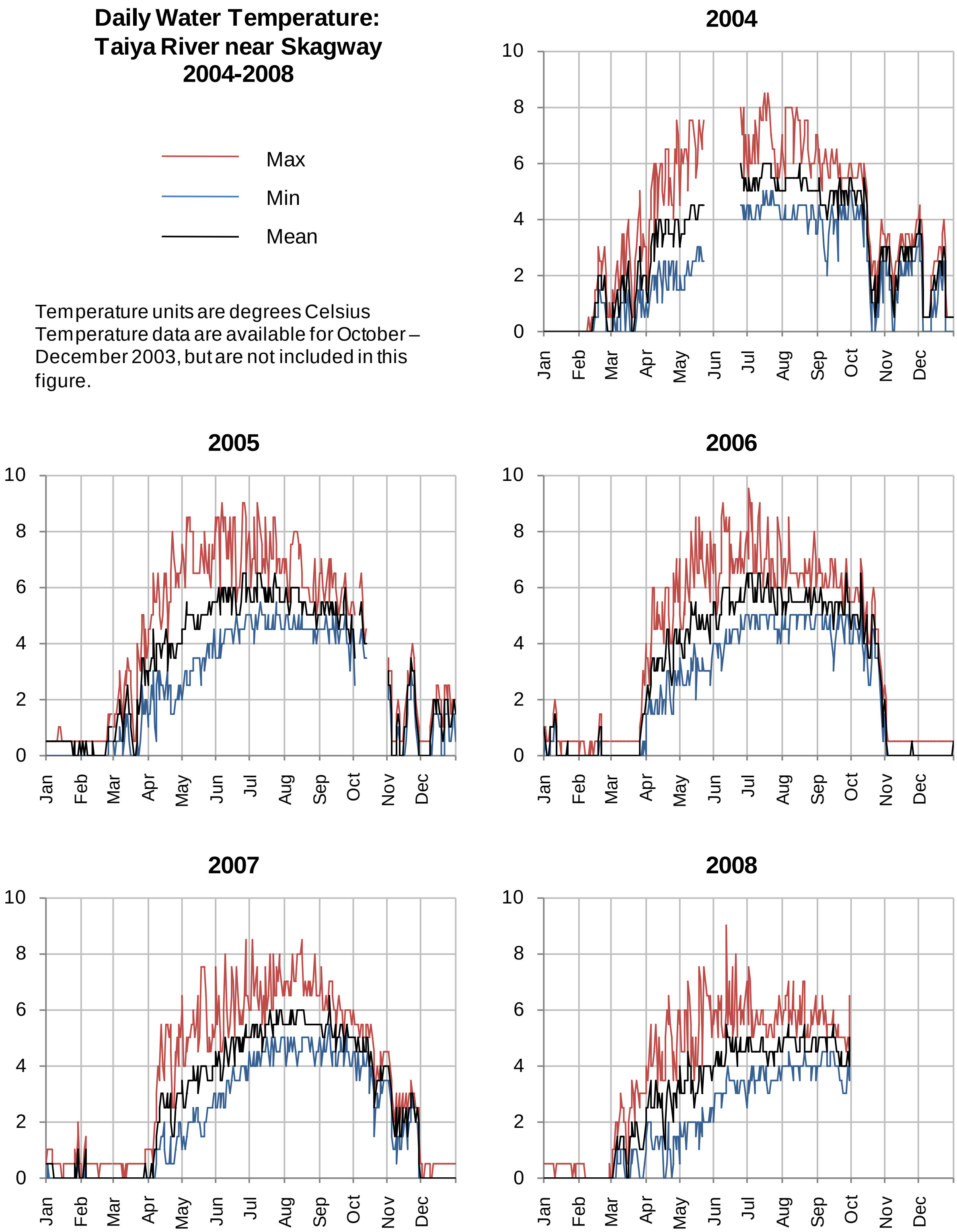


Figure 42. Daily water temperature (°C): Taiya River near Skagway. 2004 to 2008 (USGS 2010b).

Other

Macroinvertebrates are used as biological indicators of aquatic ecosystem health (Gabrielson 1993). Gabrielson (1993) conducted a macroinvertebrate water quality study in 1993. Seven locations in KLGO were sampled in July and August of 1993. Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) families (EPT) were found in the samples, which are indicators of good water quality and diverse aquatic habitat (Paustian et al. 1994). Some samples were found to have lower numbers of these three families and higher numbers of Chironomids (midges). Chironomids can be found in pristine water but often dominate degraded water quality samples (Gabrielson 1993). The samples containing high numbers of Chironomids were obtained from streams with high amounts of silt and sand from glacial meltwater (Gabrielson 1993, Paustian et al. 1994). The site by site results from this study are summarized in Hood et al. (2006). Low EPT taxa diversity was observed in West Branch Creek and in the Warm Pass Fork of the Skagway River (Hood et al. 2006). In addition to low EPT diversity, high numbers of Chironomids were found in the the Warm Pass Fork of the Skagway River. Remaining sites, including the Upper Taiya River, were considered to have fair to good water quality (Hood et al. 2006).

Stressors

Climate change is a primary driver of change in water temperature and turbidity. Summer air temperatures measured at locations in the KLGO region have increased since record keeping started (Hood et al. 2006). According to Bryant (2009), increased air temperatures predicted by general circulation models will change thermal regimes in freshwater ecosystems. One pathway for the change in thermal regime is increased glacial melt. Glacier extent in the KLGO watershed has declined, and increased glacial melt can affect downstream sediment, streamflows, and water temperatures (Hood et al. 2006, Feierabend and Schirokauer 2008). Climate could also impact the frequency of outburst flood events, which can destroy sediment trapping lakes resulting in increased turbidity. Changes in climate can also lead to changes in soil composition and vegetation communities, which can ultimately lead to changes in water quality (Hood et al. 2006).

Urbanization and development in a watershed also threaten water quality (Hood et al. 2006). Impervious surfaces result in more surface water runoff than natural ground cover, and this runoff can contribute to increased sediment loads from erosion, construction sites, and road sanding (Hood et al. 2006). Both the Taiya and Skagway watersheds presently contain impervious surface area; however, the extent of their impact is limited, especially in the Taiya watershed (Hood et al. 2006). The projected modest growth rate of Skagway and present land protection in place suggest development is not of major concern for KLGO's water quality (Hood et al. 2006).

Reporting Zones

The Skagway reporting zone is considered not applicable for physical properties of water quality because KLGO does not have jurisdiction over Pullen Creek. Measurements obtained from the Taiya River and Dyea are associated with the Chilkoot Trail reporting zone. One historic measurement of water temperature was obtained in the White Pass reporting zone, but it is not sufficient for reporting current condition.

Condition

The condition of water temperature and turbidity in the Chilkoot Trail reporting zone is considered good. Turbidity data are very limited for KLGO, however turbidity levels are typically believed to be good with occasional high turbidity events related to runoff from high rainfall or increased glacial melt (Hood et al. 2006). The single measurement of turbidity at the Taiya River in 2007 appears to be an acceptable value. All water temperature readings in KLGO have been less than 13°C, and maximum summer temperatures in the Taiya River from 2004 to 2008 are within the range of maximum summer temperatures measured in the 1970s. The limited recent turbidity data prevent the determination of a trend.

A portion of Pullen Creek runs through the Skagway Unit. The creek is listed on the EPA 303(D) list of impaired water bodies due to impacts from urbanization and development beyond the park unit boundaries (EPA 2010, Hood et al. 2006). One source of pollution in Pullen Creek is fugitive dust from historic transport of ore (KLGO D. Schirokauer pers. comm. 31 August 2010); however, since Pullen Creek is not within the jurisdiction of KLGO, its water quality is not considered applicable to the Skagway reporting zone (Moynahan and Johnson 2008). Insufficient data exist to be able to report condition or trend for the White Pass reporting zone.

Data Needs

Long-term monitoring of water temperature and turbidity are needed throughout the park to effectively assess condition and determine trend. Water quality monitoring equipment will be installed during the summer of 2011, and water quality will be monitored as part of the SEAN I&M Program (KLGO D. Schirokauer pers. comm. 22 March 2010, Moynahan and Johnson 2008). The SEAN monitoring program has selected the Taiya River in KLGO for ongoing monitoring. Temperature and turbidity, as well as pH, specific conductance, and dissolved oxygen, will be measured every 15 minutes from May to October. This dataset will allow for detection of trends, determining adherence to aquatic life and human health criteria, as well as comparison to additional water quality monitoring parameters collected at the Taiya River (Moynahan and Johnson 2008). While greatly improving the available water quality data for the park, these measurements will not provide a direct indication of water quality in the White Pass Unit. Current temperature and turbidity information for this unit is completely lacking.

Literature Cited

Alaska Department of Environmental Conservation. 2009. Water quality standards. 18 AAC 70. Alaska Department of Environmental Conservation, Juneau, Alaska.

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

Environmental Protection Agency. 2010. Listed water information: Pullen Creek. Online. (http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=AK-10303-004_00&p_cycle=). Accessed 29 November 2010.

Environmental Protection Agency. 1999. Importance of turbidity. Pages 7-1 – 7-16 in Guidance manual for compliance with the interim enhanced surface water treatment rule: Turbidity provisions. EPA-815-R-99-010. United States Environmental Protection Agency, Office of Water.

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

Gabrielson, E. 1993. Macroinvertebrate summary data for Klondike Gold Rush National Historical Park. Report to USDA Forest Service. Environment and Natural Resources Institute, University of Alaska, Anchorage, Alaska.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

Nagorski, S., D. Engstrom, J. Hudson, D. Krabbenhoft, J. DeWild, E. Hood, and G. Aiken. 2009. Scale and distribution of global pollutants in Southeast Alaska Network park watersheds. Natural Resource Technical Report NPS/NRWRD/NRTR—2009/XXX, *in press*. National Park Service, Fort Collins, Colorado.

National Park Service. 1998. Baseline water quality data inventory and analysis: Klondike Gold Rush National Historical Park. Technical Report NPS/NRWRD/NRTR-98/160. National Park Service, Water Resources Division, Fort Collins, Colorado, USA.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Robinson, C. T., U. Uehlinger, and M. Hieber. 2001. Spatio-temporal variation in macroinvertebrate assesmblages of glacial streams in the Swiss Alps. Freshwater Biology(46):1663-1672.

Tallmon, D. A. 2009. Contaminants assessment of intertidal resources in southeast Alaska national parks (Draft). Natural Resource Technical Report NPS/SEAN/NRTR-2009/yyy, *in press*. National Park Service, Natural Resource Program Center, Fort Collins, CO, USA.

U.S. Geological Survey. 2010a. Common water measurements from USGS water science for schools. U.S. Geological Survey. Information from A Primer on Water Quality by Swanson, H.A., and Baldwin, H.L., U.S. Geological Survey, 1965. Online. (http://ga.water.usgs.gov/edu/ characteristics.html). Accessed 20 April 2010.

U.S. Geological Survey. 2010b. USGS 15056210 Taiya River near Skagway, AK. U.S. Geological Survey National Water Information System. Online. (http://waterdata.usgs.gov/nwis). Accessed 22 April 2010.

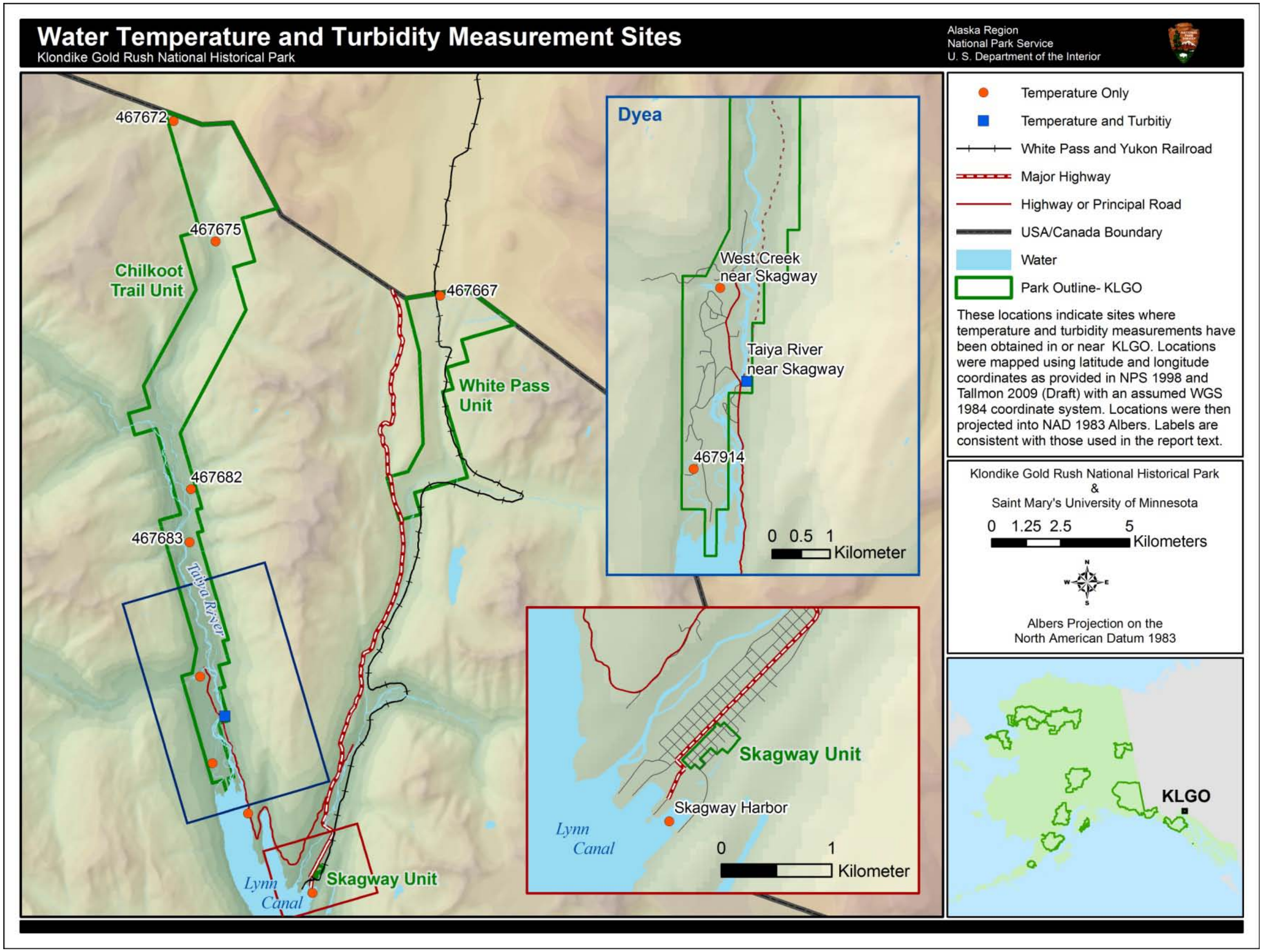
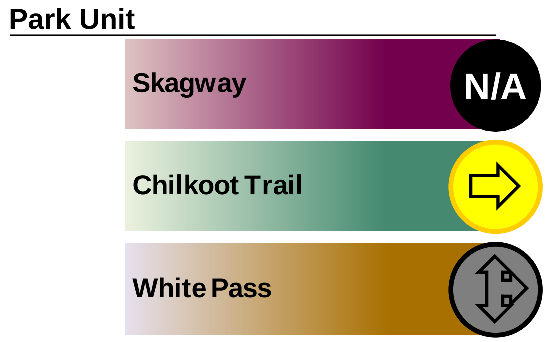


Plate 12. Water temperature and turbidity measurement sites in or near KLGO (NPS 1998, Tallmon 2009, NPS 2009).

4.16 Hydrology

Measures
Total Annual Discharge
Average Daily Discharge
Peak Discharge and Timing
Center of Mass Date
Fractional Flows
Date of Spring Pulse Onset



Background
Klondike Gold Rush National Historical Park contains two main rivers: the Skagway and the Taiya (Plate 13). The Skagway River travels through a basin of approximately 375 km^2, flowing through the southern portion of the White Pass Unit and continuing down the valley past the community of Skagway (Paustian et al. 1994). Its flow regime is largely driven by runoff from glaciers and snowfields. A station downstream from the White Pass Unit, in Skagway, collected discharge data for the Skagway River from 1963 to 1986. Since the gauge was discontinued by Alaska Power and Light, daily river levels have been collected at the Skagway River bridge, but these data were not available for this report and the rating curve has not been maintained for this site (KLGO D. Schirokauer pers. comm. 1 September 2010). Due to the lack of recent hydrological data for the Skagway River, the focus of this summary is the Taiya River.

The Taiya River drainage is approximately 26 kilometers long and includes the entire Chilkoot Trail Unit of the park (Hood et al. 2006). With its headwaters in the snow and glaciers of the mountains, the streamflow of the Taiya is heavily influenced by seasonal runoff. This influence is greater than experienced by the Skagway River, because there is more glacial and snowmelt input (National Weather Service Flood Forecast Center, Juneau, AK A. Jacobs pers. comm. 2 September 2010). Four subwatersheds comprise the Taiya River watershed, the largest being the Nourse River subwatershed (approximately 205 km^2) (Capps 2004). The remaining three are West Creek (~115 km^2), Lower Taiya (~111km^2), and Upper Taiya (~59km^2) (Capps 2004). The watershed spans from sea level to a maximum elevation of over 2,500 meters, including the highest mountains and largest glaciers in the western portion of the Nourse subwatershed (Capps 2004).

The Taiya River enters the Taiya Inlet at Dyea. This area is largely composed of estuarine intertidial and riverine wetlands and provides habitat for species such as the western toad (Hood et al. 2006). The flow regime of the Taiya River affects the number and size of the wetlands in this area and also influences chemical and physical properties of water quality (Moynahan and Johnson 2008). The Taiya River also supports anadromous fish spawning and associated aquatic and terrestrial predatory species. In addition to habitat and water quality concerns, there are erosion issues in Dyea. As a center of activity during the gold rush, the area is home to many culturally significant artifacts. Erosion along the banks of the Taiya River and shifts in course over time have washed away historic structures and destroyed part of a cemetery (KellerLynn 2009). While most erosion appears to have occurred prior to 1992, additional loss of cultural resources remains a concern for the park (Inglis 2002).

Both quantity and timing of streamflow are important characteristics of hydrology. Recent hydrologic studies have found trends toward earlier snowmelt runoff across most of western North America (Cayan et al. 2001, Peterson et al. 2005, and Stewart et al. 2005). Applying metrics of streamflow quantity and timing to data from the Taiya River gauge provides a method for analyzing variations in hydrology. Results can also indicate how changes in climate will potentially impact hydrology and related aquatic habitat in the park.

Reference Condition
Limited historical data are available for the Taiya River stream gauge. Daily discharge values were measured from 1 October 1969 to 18 November 1977. Although this likely does not represent the full range of natural variability for the Taiya River, this dataset is the only available reference and is included in this report to provide some context for recent measurements. It is important to note that studies investigating changes in streamflow usually use multiple decades of data to determine trends (Cayan et al. 2001, Stewart et al. 2005).

Data
The daily mean discharge data for the Taiya stream gauge were retrieved from the USGS website (USGS 2010a). The period of record for the Taiya stream gauge is from 1 October 1969 to 18 November 1977 and from 1 October 2003 to the present. When applicable, mean values from the 1969 to 1977 time period and the 2003 to present time period were compared using an unpaired, two-tailed Student's t-test. Snow depth, snow water equivalent, temperature, and precipitation data for the Moore Creek Snow Course (which is in the Skagway River watershed) were retrieved from the Natural Resource Conservation Service (NRCS) website. Data were analyzed using Microsoft Excel.

Measures

<u>Total Annual Discharge</u>
The daily mean discharge values were totaled for each year in order to compare total annual discharge for the water years with available data (Figure 43). The highest value occurred in 2004 and the lowest value in 1973. A Student's t-test comparison of the 1970's mean and the 2000's

mean found no significant difference. Values appeared to be decreasing starting in 2004 until a higher value was reported in 2009.

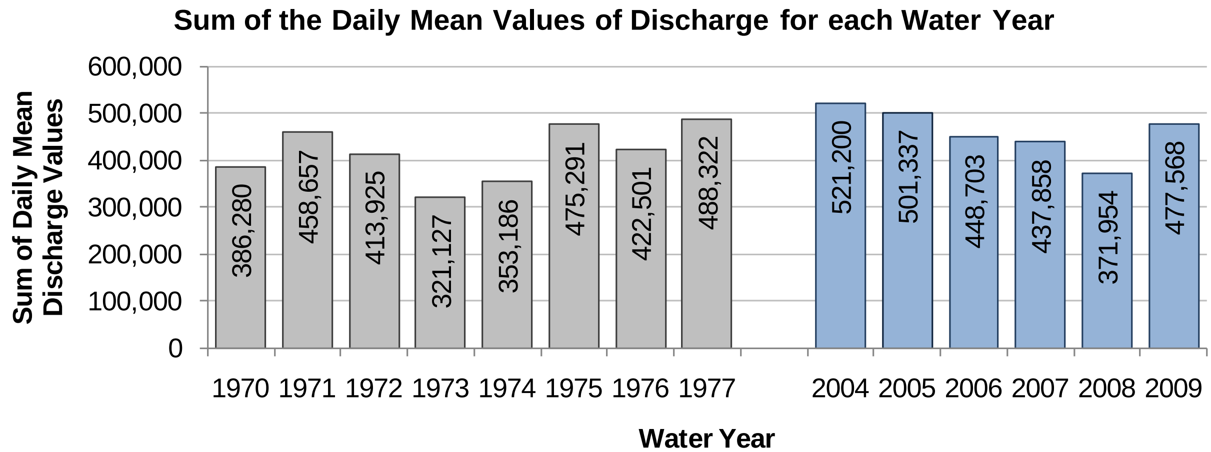


Figure 43. Taiya River near Skagway: Sum of daily mean discharge per water year, 1970 to 1977 and 2004 to 2009. The daily mean discharge values were reported in cubic feet per second. (USGS Gage 15056210) (USGS 2010a).

Average Daily Discharge

Average mean daily discharge was calculated for each water year from 1970 to 1977 and from 2004 to 2009 (Figure 44). Results followed a similar pattern as total annual discharge. A comparison of the mean from the 1970s and the mean from the 2000s using a Student's t-test found no significant difference.

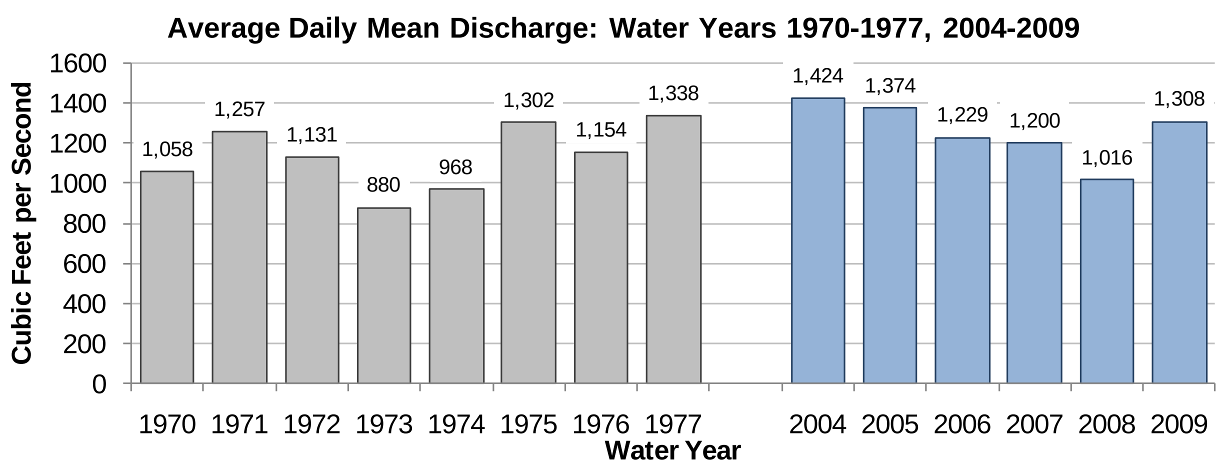


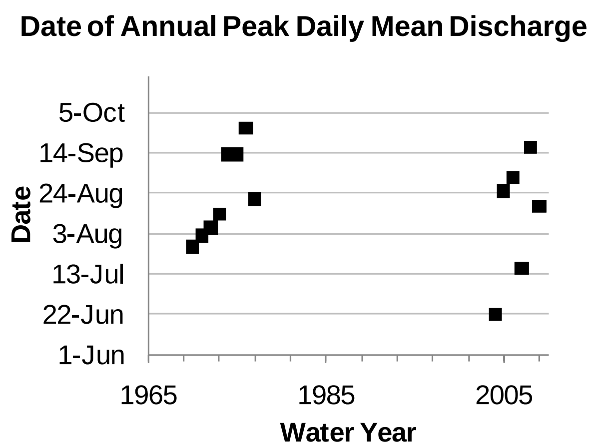
Figure 44. Taiya River near Skagway: Average daily discharge, water years 1970 to 1977 and 2004 to 2009 (USGS Gage 15056210) (USGS 2010a).

Peak Discharge and Timing

The peak daily mean discharge following onset of spring snowmelt was determined for each water year (Table 33). The earliest reported date occurred in 2004 (22 June), and the latest occurred in 1976 (27 September). The average peak mean daily discharge and date of peak discharge are not significantly different between the 1970s and the 2000s, but on average, peak discharge occurs earlier and with less volume recently than in the 1970s (Figure 45).

Table 33. Taiya River near Skagway: Date of annual peak discharge and annual peak discharge during period of record (cfs = cubic feet per second) (USGS Site 15056210) (USGS 2010a).

Water Year	Date of Peak Discharge	Peak Discharge (cfs)
1970	27 July 1970	4950
1971	2 August 1971	7000
1972	6 August 1972	7580
1973	13 August 1973	6610
1974	13 September1974	7160
1975	13 September 1975	9620
1976	27 September 1976	8600
1977	21 August 1977	7170
1970-1977 Average	23 August	7336 (SD = 1377)
2004	22 June 2004	6960
2005	25 August 2005	6140
2006	1 September 2006	5060
2007	16 July 2007	6390
2008	17 September 2008	6370
2009	17 August 2009	8460
2004-2008 Average	11 August	6563 (SD = 1119)



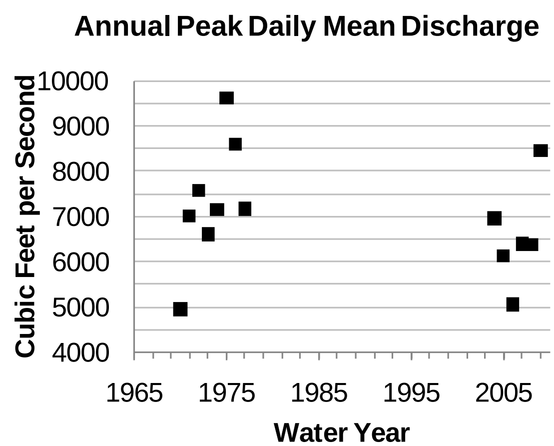


Figure 45. Taiya River near Skagway: Date of peak discharge (left) and peak daily mean discharge following snowmelt (right) during period of record (USGS Site 15056210) (USGS 2010a).

Center of Mass Date

The center of mass date is a measure of stream flow timing. A later date indicates a greater amount of discharge occurred in the later part of the year compared to earlier in the year. The center of mass date was calculated using the equation described in Stewart et al. (2005) for each water year. On average the center of mass occurred earlier in the 2000s than the 1970s but there is substantial variability that limits any conclusions that can be drawn from the results (Figure

46). The average center of mass date in the 1970s was 26 June (13 day standard deviation). The average center of mass date in the 2000s was 20 June (7 day standard deviation).

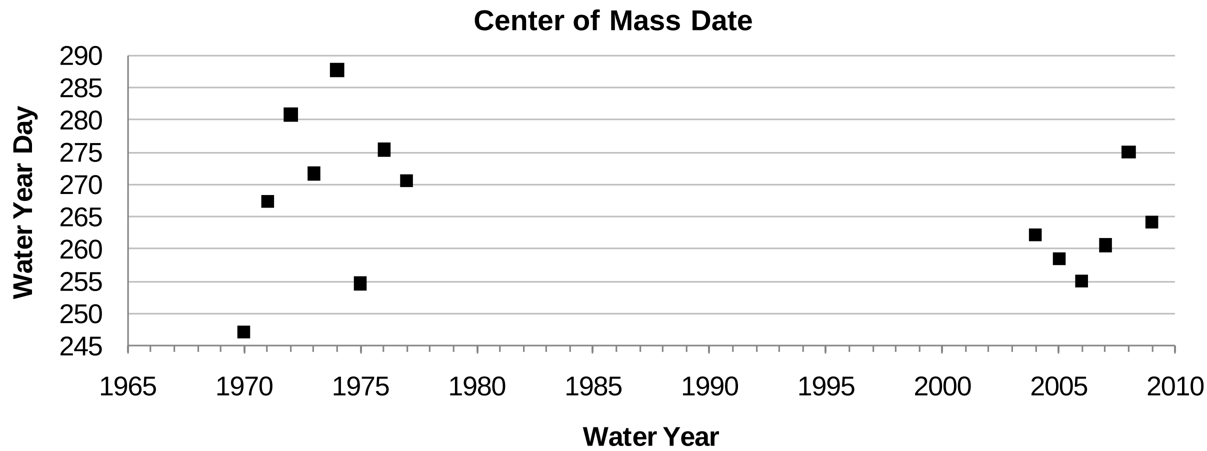


Figure 46. Taiya River near Skagway: Center of mass day each year during the period of record (USGS Site 15056210) (USGS 2010a).

<u>Fractional Flows</u>

Fractional flows represent the percent of total annual discharge that occurs during a particular time of year. Fractional flows were calculated by summing the mean daily discharge for all days within the month or season and dividing by the sum of all daily discharge values for the entire water year (1 October through 30 September). The seasonal fractional flow for the Taiya River was calculated for May through August. Fractional flows were also calculated for May and June combined and July and August combined, as well as individual monthly fractional flows for May, June, July, and August (Figure 47).

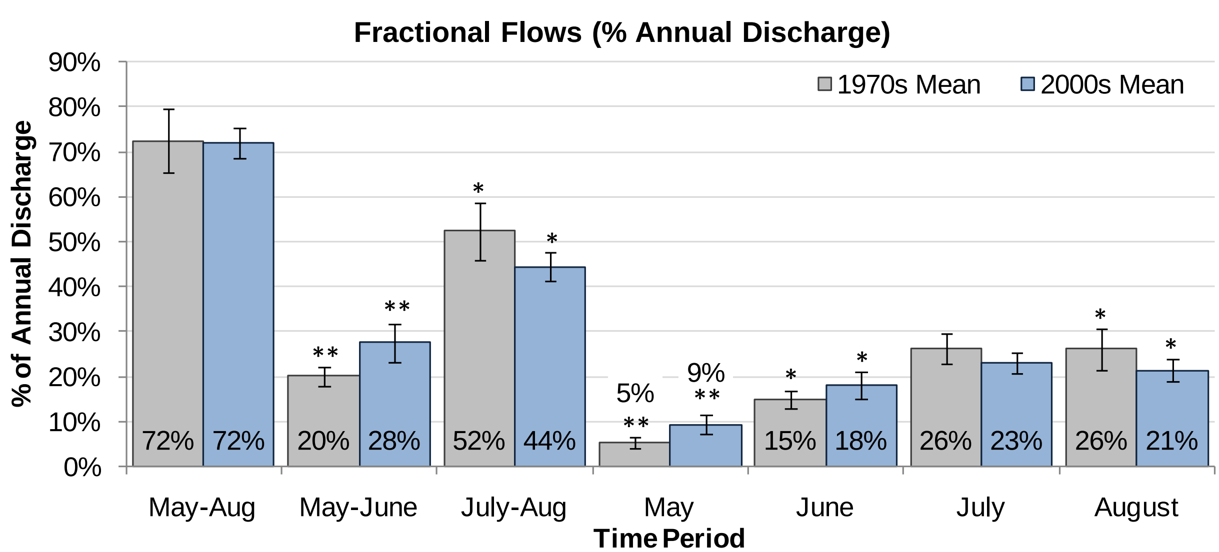


Figure 47. Taiya River near Skagway: 1970s (gray) and 2000s (blue) mean fractional flows (% of annual discharge) for various time periods (USGS Gage 15056210) (USGS 2010a). * indicates significant

difference between the 1970s mean and 2000s mean at a probability greater than 95%. ** indicates significant difference at a probability greater than 99%. Bars represent ± one standard deviation.

No significant change in seasonal fractional flow (May through August) appeared between the 1970s and the 2000s; however, a statistically significant higher percentage of the annual discharge occurred during May and June in the 2000s compared to the 1970s (Figure 48). The opposite trend appeared in July and August, when on average, a lower percentage of the annual discharge occurred in the 2000s compared to the 1970s. Monthly fractional flows reflect these differences. Fractional flows for the month of May show the most statistical difference (probability greater than 99%), but June and August fractional flows for the 1970s and 2000s are also significantly different at a probability greater than 95% (Figure 47).

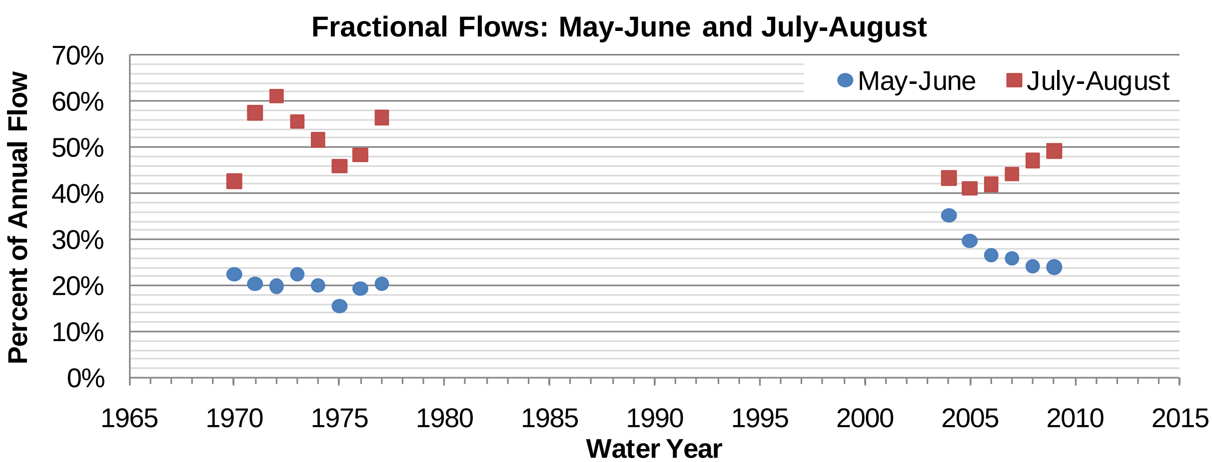


Figure 48. Taiya River near Skagway: Percent of annual flow from May to June (blue circles) and July to August (red squares) each year during the period of record (USGS Site 15056210) (USGS 2010a).

The May through June fractional flow appears to be decreasing in recent years, and the July-August fractional flows appears to increasing over the same period (Figure 49). The monthly fractional flows for May, June, July, and August do not show the same pattern. A trend in the data may be emerging; however, more years of data collection are required before conclusions can be drawn.

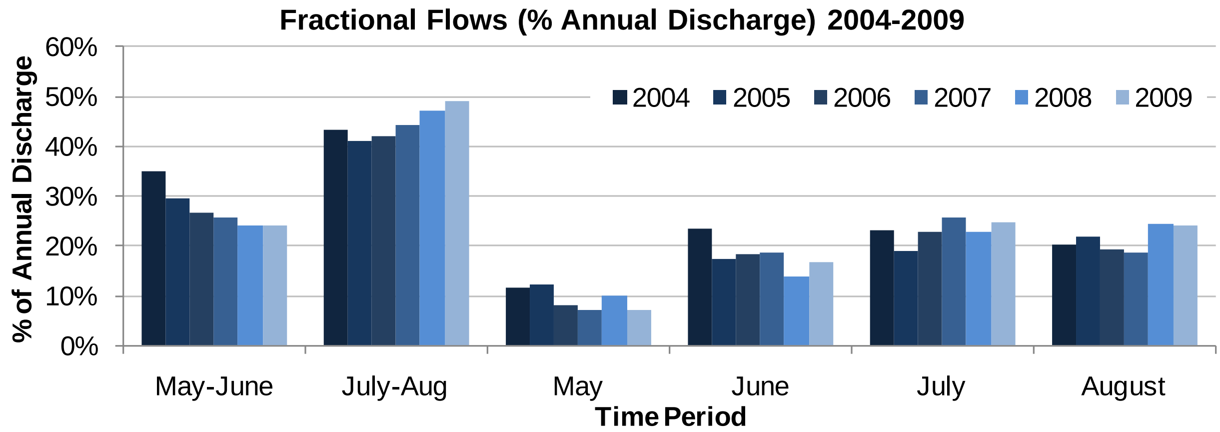


Figure 49. Taiya River near Skagway: Fractional flows (% of Annual Discharge) for 2004-2009 (USGS Gage 15056210) (USGS 2010a).

<u>Spring Pulse Onset</u>

The spring pulse onset is an estimate of the first day in which spring snowmelt contributes to a substantial increase in discharge. It is calculated based on methods described in Cayan et al. (2001) using Julian days 9 through 248 (Stewart et al. 2005). The spring pulse onset occurred earlier in the 2000s than in the 1970s (significantly different at a probability greater than 95%) (Figure 50). The average date of spring pulse onset in the 1970s was 1 June (7 day standard deviation). The average date of spring pulse onset in the 2000s was 18 May (6 day standard deviation).

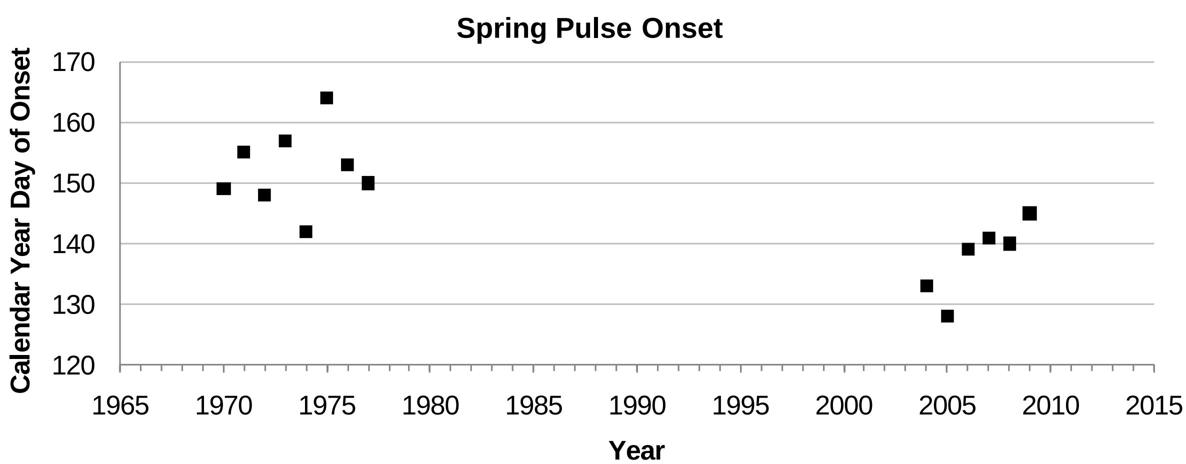


Figure 50. Taiya River near Skagway: Julian day of spring pulse onset each year during the period of record (USGS Site 15056210) (USGS 2010a).

<u>Daily Accumulative Percent of Annual Discharge</u>

Another way to visualize the timing of stream flow is to graph the daily accumulative percent of annual discharge. This was calculated for each day of each water year, and the average for each water year day was determined for 1970 through 1977 and 2004 through 2009 (Figure 51). There appears to be a divergence between the historical average and the recent average around the beginning of the high discharge part of the year, which suggests that a greater percent of the annual discharge occurred earlier in the 2000s compared to the 1970s.

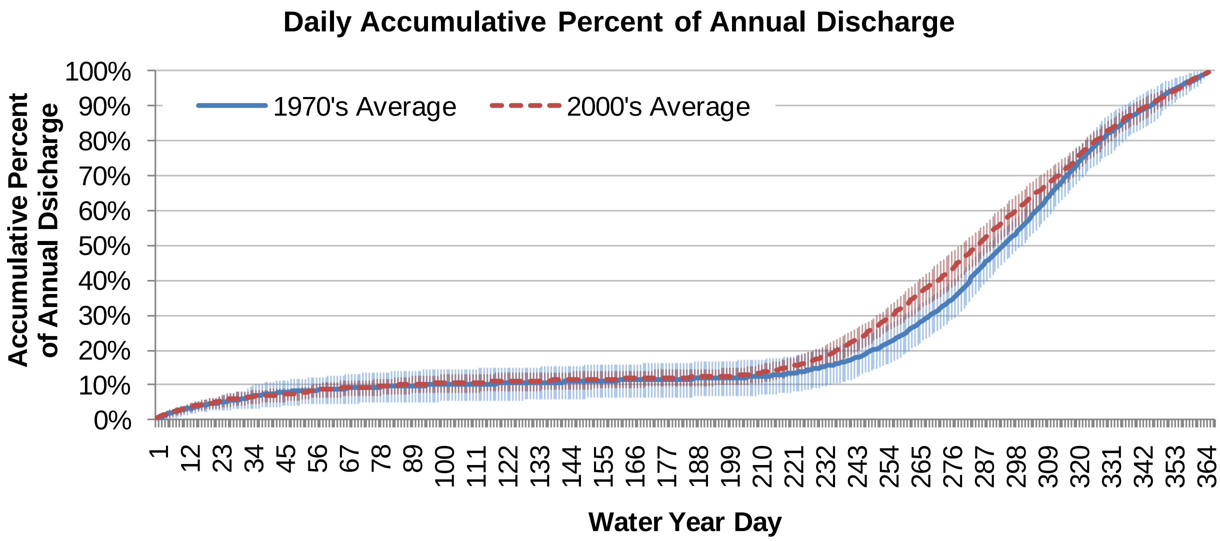


Figure 51. Taiya River near Skagway: Historical average (1970s) and recent average (2000s): Percent of total annual discharge accumulation 1 October through 30 September (USGS 2010a). Shaded area represents one standard deviation.

Additional Analysis

Additional analysis was conducted to explore relationships between climate and hydrology. Specifically, the relationship between snow pack, temperature, and streamflow were investigated. The data available for calculation of these measures are limited at this time. Results, however, are presented here in order to provide a starting point from which future analysis can be undertaken. Analysis of water temperature data is summarized in the water quality section of this report.

<u>Snow Water Equivalent and Maximum Daily Discharge</u>

Peterson et al. (2005) explored the relationship between snow pack and discharge in California. The authors found spring pulse timing was more related to air temperature than snow pack but that the maximum discharge is related to the snow pack. Peterson et al. (2005) plotted the 1 April snow water equivalent (SWE) versus the maximum daily snowmelt discharge (SMD). The only snowpack telemetry (SNOTEL) station with multiple years of data near KLGO is the Moore Creek Bridge station located in the Skagway River watershed (not within the Taiya watershed); however, plotting the Moore Creek Bridge 1 May SWE versus the max daily SMD on the Taiya River appears to indicate a correlation similar to Peterson et al. (2005) (R^2=0.85) (Figure 52 left). It should be noted that there are only data points for five years. Similar to the results in Peterson et al. (2005), there appeared to be no correlation between SWE and the date of the maximum daily discharge (Figure 52 right). If the correlation between the 1 May snow water equivalent measure and the maximum daily snowmelt discharge is as strong as it appears, the 1 May snow water equivalent could be used as an early predictor of maximum daily snowmelt discharge (Peterson et al. 2005). A new snow course station in the Taiya River watershed at West Creek was established in 2007 and can be used in the future for further analysis. Currently, only three years of data are available from this station.

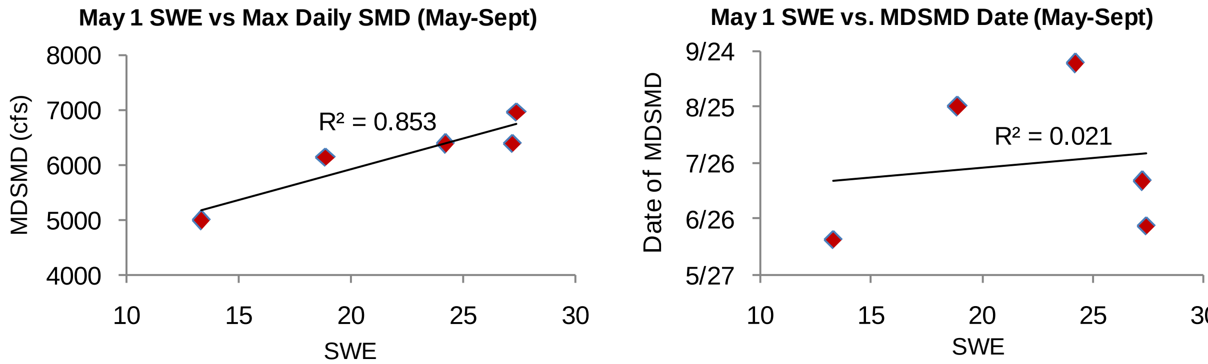


Figure 52. Taiya River near Skagway: 1 May snow water equivalent (SWE) at the Moore Creek Bridge SNOTEL station versus maximum daily snowmelt discharge (left) and the date of maximum daily snowmelt discharge (right) (USGS site 15056210) (NRCS 2009, USGS 2010a). Maximum daily snowmelt discharge was calculated using May through September. Note: The Moore Creek Bridge SNOTEL station is not in the Taiya river watershed, so results presented above are purely speculative.

Temperature and Discharge

Although daily temperature records for the park are limited, an attempt was made to investigate the relationship between temperature and the onset of snowmelt. The average daily temperature at the Moore Creek Bridge SNOTEL station was plotted with the mean daily discharge of the Taiya near Skagway (Figure 53). Due to the variability in temperature and snowpack, more data and analysis would be needed to understand the relationship between temperature and onset of snowmelt. It should again be noted that the Moore Creek Bridge SNOTEL station is not within the Taiya River watershed.

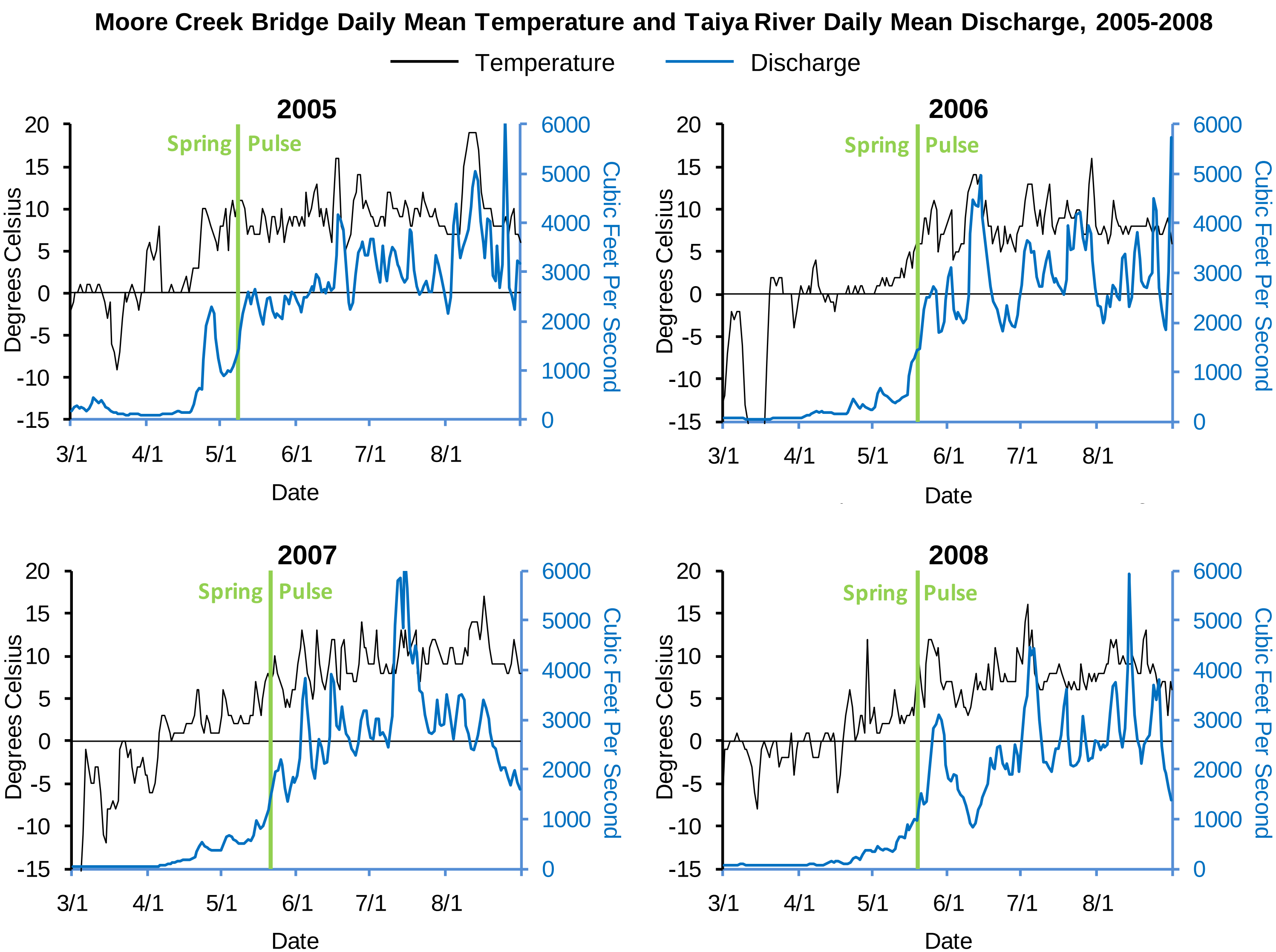


Figure 53. Moore Creek Bridge daily mean temperature (°C) and Taiya River daily mean discharge, 2005-2008 (NRCS 2009, USGS 2010a).

Stressors

Climate is a primary driver of hydrology. Precipitation affects the quantity of water moving through the system. Temperature affects the timing and rate of snowmelt, which is a strong factor of KLGO's hydrology. Climate also affects glaciers, which in turn impact hydrology (Fountain and Tangborn 1985). Ice cover in KLGO's watershed has declined in the last fifty years, and climate models predict warming trends in the future (Feierabend and Schirokauer 2008, Scenarios Network for Alaska Planning 2009). Average annual temperatures will likely rise from near freezing to well above freezing by the year 2080 (Scenarios Network for Alaska Planning 2009); however this change in temperature is very elevation dependent and may not apply to all locations in the park. Climate models also predict an increase in summer precipitation; however, any increase in water availability would likely be more than offset by increased evapotranspiration resulting from warmer temperatures and a longer growing season (Scenarios Network for Alaska Planning 2009). Warmer winter temperatures could also affect glacier firn lines, snow lines, the timing of river ice freeze-up and break-up, and how much precipitation falls as snow, ice, and rain, which are all factors directly impacting the streamflow regime.

Climate fluctuates on a variety of temporal scales (Davey et al. 2007). One climate fluctuation of particular importance to hydrology in the region is the Pacific (inter) Decadal Oscillation (PDO) (Figure 54). Mantua et al. (1997) formally identified this pattern of climate variability in a study relating climate oscillation and salmon production. The PDO is related to sea surface temperature in the northern Pacific Ocean, but the mechanisms that drive the PDO are unknown (Mantua 2010a). The cycle alternates between positive and negative phases. A positive phase is associated with a relatively strong Aleutian Low, which moves warmer air into the region (Wendler and Shulski 2009). Phase shifts occurred in 1925 (negative to positive), 1947 (positive to negative), and 1977 (negative to positive) (Mantua et al. 1997). A change from positive to negative might have occurred in 1998, but this is uncertain (Mantua 2010a). More information about the PDO and climate predictions can be found in Mantua (2010a).

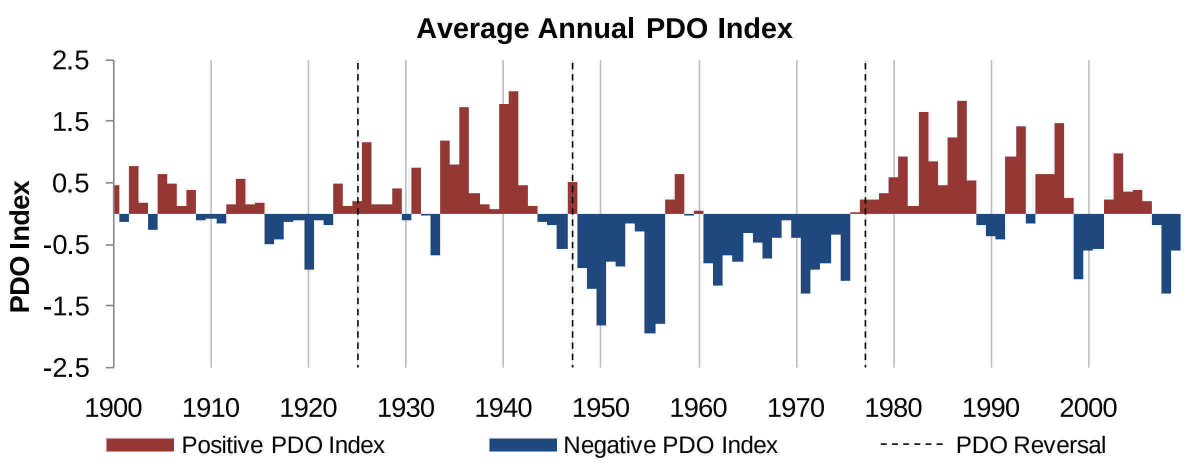


Figure 54. Average annual PDO index, 1900 to 2009 (Mantua 2010b). Vertical dashed lines represent reversals in PDO polarity in 1925, 1947, and 1977.

The Pacific Decadal Oscillation affects regional climate, especially during the winter months (Hartmann and Wendler 2005, Redmond and Simeral 2006). Hartmann and Wendler (2005) compared several climatic variables in Alaska during the cold phase from 1951 to 1975 and the warm phase from 1977 to 2001. Alaska was divided into six climatic regions for analysis including a southeast region which encompasses KLGO (Hartmann and Wendler 2005). The correlation coefficient (r) between mean annual temperature and the PDO index was 0.715 in the southeast region. This value was significant at a probability greater than 99%. All regions experienced statistically significant increases in mean winter surface air temperature between the two time periods (Hartmann and Wendler 2005). Temperature differences in mean surface air temperature for the southeast region are included in Table 34.

The total annual precipitation also increased in the southeast region during the warm phase, although not significantly ($p < 0.05$) (Hartmann and Wendler 2005). Although total precipitation increased, snowfall decreased significantly (Hartmann and Wendler 2005). This may be explained by the increase in temperature associated with the cold to warm phase shift. Mean winter temperatures in southeast Alaska are near freezing at sea level, so the increase in temperature would result in more precipitation falling as rain instead of snow (Hartmann and Wendler 2005).

Table 34. Change in mean surface air temperature, total precipitation and snowfall (1977-2001 minus 1951-1975) for the southeast Alaska region. Bold indicates significance at a probability greater than 95%. Shading indicates significance at a probability greater than 99% (adapted from Hartmann and Wendler 2005).

	March, April, and May	June, July, and August	September, October, and November	December, January, and February	Annual
Temperature	**+1.4ºC**	**+0.7 ºC**	+0.4 ºC	**+1.7 ºC**	**+1.1 ºC**
Total Precip.	+4%	+6%	+8%	+7%	+7%
Snowfall	**-49%**	-	-18%	**-34%**	**-36%**

Neal et al. (2002) found dramatic differences in monthly and seasonal stream discharge patterns between the most recent cold and warm phases of the PDO. Six watersheds in southeast Alaska (not in KLGO) were analyzed. The average annual streamflows were not significantly different between the two time periods; however, there were significant differences in monthly and seasonal discharges (Neal et al. 2002). During the warm winter seasons, more precipitation fell as rain, which correlated with typically higher winter streamflows compared to the cold phase years. During the cold years, more precipitation was stored in the snowpack and contributed to higher summer streamflows compared to the warm years. Although the dataset for the Taiya stream gauge is much more limited than what was used by Neal et al. (2002), similar patterns were observed when average annual flows and fractional flows were calculated.

Reporting Zones

The Skagway reporting zone is considered not applicable for hydrology. Twenty-three years of historic discharge data are available for the Skagway River, which is partially in the White Pass Unit, but no recent data were available for this report. Taiya River hydrology is monitored by a USGS gauge located at the Dyea Road bridge crossing (Plate 13). As the only park unit with current monitoring, the Chilkoot Trail Unit is the only reporting zone for which condition can be determined.

Condition

Various metrics suggest a difference in the Taiya River flow regime between the 1970s and recent years; however, historic data available for comparison are limited. This difference appears to be related to timing of discharge as opposed to quantity of water. These findings are consistent with trends of earlier snowmelt runoff observed across most of western North America and other research investigating climate changes related to the Pacific (inter) Decadal Oscillation (Cayan et al. 2001, Peterson et al. 2005, and Stewart et al. 2005). Although limited conclusions can be made regarding the cause of the observed differences, the appearance of a possible change in streamflow timing is of concern. The Taiya River is an important source of water for wetlands in the Dyea area, a habitat which species such as the western toad (a species of management concern) are dependent upon. Recent data from 2004 to 2009 do not show a consistent trend for either water quantity or timing.

There is insufficient information about the current hydrology of the Skagway River to determine condition or trend for the White Pass Unit. The Skagway Unit is not applicable.

Data Needs

Discharge, precipitation, snowpack, and temperature data are useful for developing a more complete understanding of watershed hydrology. The current data collection locations create difficulty when attempting to analyze hydrologic data for either the Taiya or Skagway watersheds or for the park as a whole. The Taiya River watershed has the only current discharge data in the park. There is a new snow course station within the Taiya watershed (West Creek), but this station does not collect daily temperature or precipitation data. It is also located at a relatively low elevation and may not fully reflect what is happening at higher elevations.

There is a SNOTEL data collection station in the Skagway watershed (Moore Creek Bridge). This station collects monthly snowpack data as well as daily temperature and precipitation; however, discharge data collection for the Skagway River ended in 1986 (USGS 2010b). The 23 years of historical discharge data from 1963 to 1986 is the longest period of record for the park, but there are no current data for comparison.

Streamflow is a vital sign for the SEAN I&M Program. Ongoing monitoring of Taiya River hydrology is planned using the existing USGS gauge (Moynahan and Johnson 2008). The SEAN I&M Program would like to install gauges at remote sites in the watershed, but this expansion of the monitoring program is unlikely because of the cost and effort required.

Literature Cited

Capps, D. L. 2004. Geohazards of the Taiya watershed. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Cayan, D.R., S.A. Kammerdiener, M.D. Dettinger, J.M. Caprio, and D.H. Peterson. 2001. Changes in the onset of spring in the western United States. Bulletin of the American Meteorological Society 82:399-415.

Davey, C. A., K. T. Redmond, and D. B. Simeral. 2007. Weather and climate inventory. National Park Service, Southeast Alaska Network. Natural Resource Technical Report NPS/SEAN/NRTR-2007/012. National Park Service, Fort Collins, USA.

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

Fountain, A. G., and W. V. Tangborn. 1985. The effect of glaciers on streamflow variations. Water Resources Research 21(4):579-586.

Hartmann, B., and G. Wendler. 2005. The significance of the 1976 Pacific climate shift in the climatology of Alaska. Journal of Climate. 18:4824-4839.

Hood, E., G. Eckert, S. Nagorski, and C. Talus. 2006. Assessment of coastal water resources and watershed conditions at Klondike Gold Rush National Historical Park, Alaska. Technical Report NPS/NRWRD/NRTR-2006/349. National Park Service Water Resources Division, Fort Collins, USA.

Inglis, R. 2002. Assessment of bank retreat monitoring data from 1979 to 2002 for the Taiya River at Klondike Gold Rush National Historical Park. USGS Water Resources Division.

Jones, S. H., and C. B. Fahl. 1994. Magnitude and frequency of floods in Alaska and conterminous basins of Canada. Water-Resources Investigations Report 93-4179. U.S. Geological Survey, Reston, Virginia.

KellerLynn, K. 2009. Geologic resources inventory scoping summary Klondike Gold Rush National Historical Park, Alaska. Draft. National Park Service Geologic Resources Division, Denver, Colorado.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society. 78(6):1069-1079.

Mantua, N. 2010a. The pacific decadal oscillation and climate forecasting for North America. Online. (http://www.atmos.washington.edu/~mantua/REPORTS/PDO/PDO_cs.htm). Accessed 21 November 2010.

Mantua, N. 2010b. PDO index. Online. (http://jisao.washington.edu/pdo/PDO.latest). Accessed 22 February 2010.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

Natural Resource Conservation Service (NRCS). 2009. SNOTEL data: Moore Creek Bridge. U.S. Department of Agriculture, Natural Resource Conservation Service, Weather and Climate Center. Online. (http://www.wcc.nrcs.usda.gov/). Accessed 21 November 2009.

Neal, E. G., M. T. Walter, and C. Coffeen. 2002. Linking the pacific decadal oscillation to seasonal stream discharge patterns in Southeast Alaska. Journal of Hydrology 263: 188-197.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Peterson, D. R. Smith, I. Stewart, N. Knowles, C. Souland, and S. Hager. 2005. Snowmelt discharge characteristics Sierra Nevada, California. Scientific Investigations Report 2005-5056. U.S. Geological Survey, Reston, Virginia, USA.

Redmond, K. T., and D. B. Simeral. 2006. Weather and climate inventory, National Park Service, Central Alaska Network. Natural Resource Technical Report NPS/CAKN/NRTR—2006/004. National Park Service, Fort Collins, Colorado.

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/downloads/climate-change-summary-reports). Accessed 7 July 2010.

Stewart, I.T., D.R. Cayan, and M.D. Dettinger. 2005. Changes toward earlier streamflow timing across western North America. Journal of Climate 18:1136-1155.

U.S. Geological Survey. 2010a. Daily Mean Flow Tab Delimited Text File for the Taiya River Stream Gauge. Online. (http://waterdata.usgs.gov). Accessed 7 July 2010.

U.S. Geological Survey. 2010b. USGS 15056100 Skagway r at Skagway AK. Online. (http://waterdata.usgs.gov/nwis/inventory/?site_no=15056100&agency_cd=USGS&). Accessed 9 August 2010.

Wendler, G. and M. Shulski. 2009. A century of climate change for Fairbanks, Alaska. Arctic. 62(3):295-300.

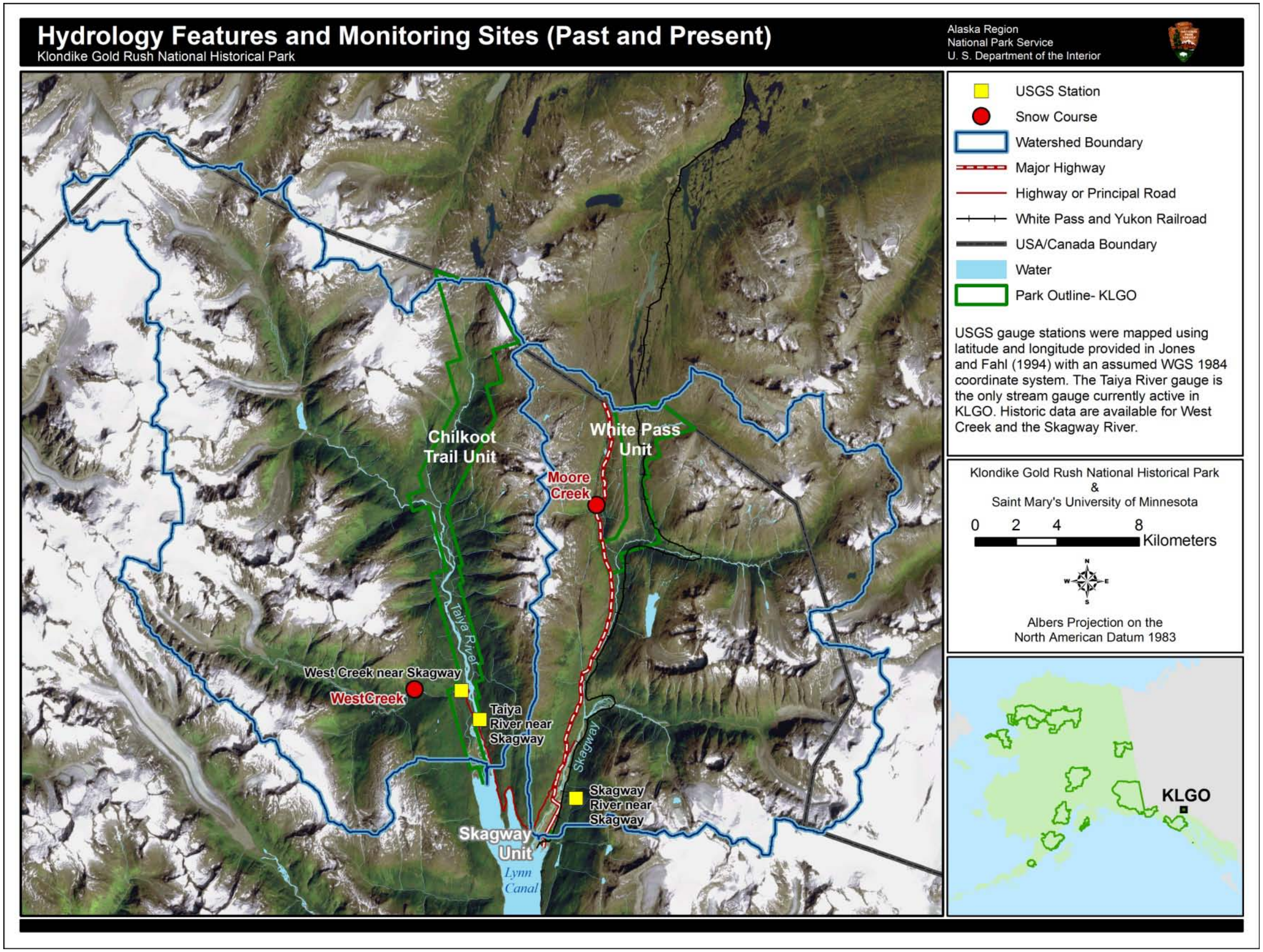
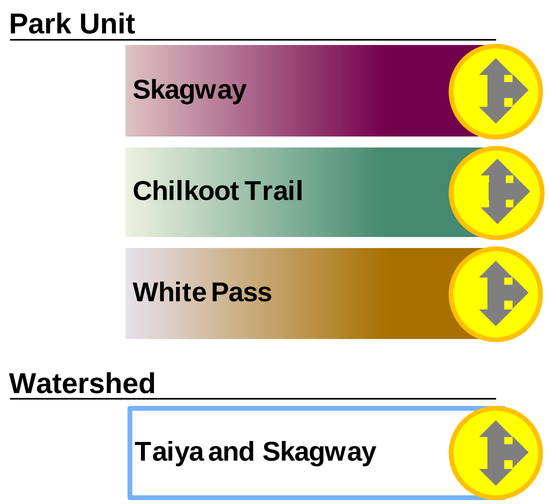


Plate 13. Hydrology features and monitoring sites (past and present) (Jones and Fahl 1994, NPS 2009).

4.17 Proglacial Lakes

Measures
Number of Proglacial Lakes Upstream From KLGO
Number of Proglacial Lakes Upstream From KLGO That Are Hazardous



Background
A proglacial lake forms as a glacier retreats, leaving meltwater and moraine dams in its wake (Feierabend and Schirokauer 2008). Proglacial lakes in KLGO's watershed are potential geohazards for the park's natural and cultural resources, as well as a safety issue for residents and visitors (Feierabend and Schirokauer 2008). The failure of a moraine dam at a proglacial lake can result in damaging flash floods that occur with little or no warning. The hazard is not without precedent. In 2002, the failure of a moraine at the West Creek Glacier in the Taiya River watershed led to a flood event exceeding the estimated 500-year flood discharge for West Creek. During this event, an estimated 8 million cubic meters of a lateral moraine liquefied and slid into a proglacial lake (Capps 2004). The debris entering the lake displaced a large volume of water which overtopped the terminal moraine (Denton et al. 2005). The 16,209 cubic feet per second peak discharge (459 cubic meters per second) forced the evacuation of campers and residents of Dyea and damaged private property and public infrastructure (Denton et al. 2005). In 1897, an outburst flood killed at least one person and destroyed part of Sheep Camp (Capps 2004). Other outburst flood events originating from Nourse Glacier in the Taiya River watershed are believed to have occurred approximately 150 and 250 years ago (KellerLynn 2009).

Reference Condition
Reference condition for proglacial lakes is defined in terms of the hazard the lakes represent to the park, as opposed to what is considered geomorphologically natural and healthy condition. It is recognized that proglacial lakes are a natural part of the ecosystem; however, they can also cause great destruction if a moraine dam fails precipitating a flood. From a geohazard perspective, the reference condition for proglacial lakes is defined as no hazardous proglacial lakes within the Taiya and Skagway watershed.

Data

In 2003, a volunteer student geologist from the Geoscientists-in-the-Parks program conducted a six-month investigation of geologic hazards in the Taiya River watershed with an emphasis on glacial outburst floods (Capps 2004, Denton et al. 2005). Methods included fieldwork and a review of literature, maps, and aerial photos.

In September of 2004, an evaluation of two moraines identified in 2003 (West Creek and Nourse Lake glaciers) was conducted to determine the potential risk of glacial lake outbursts (Denton et al. 2005). Two hydrologists from the BLM Anchorage Field Office inspected the sites to provide information regarding the moraines' stability. The stability was to be assessed through surface and subsurface measurements of its internal structure (Denton et al. 2005). Malfunction of the instrumentation necessary to collect subsurface information limited the assessment to a surface inspection consisting of aerial and on-the-ground observations and measurements. Subsurface measurements made prior to an equipment issue on a subsequent survey were inconclusive (KLGO D. Schirokauer pers. comm. 8 November 2010).

In 2007, Dan Lawson from Cold Regions Research and Engineering Laboratory (CRREL), in partnership with KLGO and the Municipality of Skagway, conducted a survey of moraine-dammed lakes in the Taiya and Skagway River watersheds. The survey included aerial flights and site visits. The result of the survey was the identification of proglacial lakes in need of further, on the ground investigation (NPS et al. 2007).

Measures

<u>Number of Proglacial Lakes Upstream From KLGO</u>
Capps (2004) determined several lakes are impounded by moraines in the Taiya watershed, but some were deemed not hazardous due to their perceived stability or low water volume. Two sites, Nourse Lake and the eastern lateral moraine from the West Glacier, were identified as potential hazards. Survey work in 2007 in both the Taiya and Skagway watersheds identified three additional sites warranting further study: Lake 1161 and Goat Lake in the Skagway watershed and Lateral Moraine Lake in the Taiya watershed (NPS et al. 2007).

<u>Number of Proglacial Lakes Upstream From KLGO That Are Hazardous</u>
Denton et al. (2005) determined that the eastern lateral moraine from the West Glacier has a low potential to cause further flooding. Nourse Lake was considered presently stable but capable of producing a large flood event if the moraine was to fail. Brief descriptions of Nourse Lake as well as Lake 1161, Goat Lake, and Lateral Moraine Lake identified during surveys in 2007 are provided below. The locations of the lakes are depicted on Plate 14**.** More research is needed to determine their hazard risk; however, these four lakes were prioritized for further study.

Nourse Lake: Nourse Lake, also known as Boat Ramp Lake, lies on BLM land in the Taiya River watershed. The lake has formed over the past fifty years. It exists behind a 120 meter high terminal moraine and has a surface area of approximately 170 acres (0.69 square kilometers) (Denton et al. 2005). The maximum lake depth is approximately 29 meters. A failure of the terminal moraine could result in a flood with a peak discharge twice as large as the West Creek flood in 2002 (Capps 2004). Indications of melting ice within the moraine include hummocks with slopes showing signs of recent movement, collapse structures, rock aggregate slope features, and tilted vegetation in areas of slope movement (NPS et al. 2007).

Lateral Moraine Lake: Lateral Moraine Lake is located in the Taiya River watershed near Nourse Lake. The extent of bedrock below and within the lateral moraine is unknown, but if it were to fail, Nourse Lake's moraine could be affected by a resulting flood (NPS et al. 2007).

Goat Lake: Goat Lake is in the Skagway watershed. Lack of knowledge regarding the relationship between the glacier ice, the debris cover, and the lake's extent, bottom topography and water depth is the main reason for concern (NPS et al. 2007). There are signs of ice beneath the debris cover next to the lake. Observers have not determined if the south end of the lake is formed by bedrock or debris covered ice. The risk of an outburst flood event is much greater in the case of debris covered ice compared to bedrock. White Pass and Yukon railroad (WPYR) tracks lie in the path of the flood if the southern end were to give way.

Lake 1161: Lake 1161 is in the Skagway watershed and is dammed by an end moraine lying on bedrock (NPS et al. 2007). The moraine shows signs of buried ice that is slowly melting. Further melting could trigger a sudden loss of stability and an outburst flood; however, if the bedrock surface lies above the lake's elevation, the risk of flood is much lower (NPS et al. 2007). In addition, if material on adjacent slopes suddenly fails into the lake, enough water could be displaced to cause a wave to overtop or erode the terminal moraine. Water has been observed running out of the glacial deposits on adjacent slopes suggesting the presence of buried ice (NPS et al. 2007). An outburst flood of this lake has the potential to impact the WPYR railroad bridge at Denver Station.

Stressors
Many glaciers in southeast Alaska have experienced rapid retreat due to climate change (NPS et al. 2007). Extent of glaciated area in the Skagway and Taiya watersheds declined by approximately 13% between 1948 and 2002 (Feierabend and Schirokauer 2008). Ongoing warming and resulting glacial recession will increase the size of proglacial lakes and potentially weaken the associated moraines (KellerLynn 2009). The risk could increase as newly exposed rock adjacent to ice absorbs solar radiation leading to additional melting (Feierabend and Schirokauer 2008).

Reporting Zones
Proglacial lakes are not present within KLGO, but the park units lie downstream of proglacial lakes in the watershed and would be in the path of an outburst flood event. The proglacial lakes in the Taiya watershed occur on Bureau of Land Management land, and the U.S. Forest Service owns the land in the Skagway watershed where proglacial lakes are found. Insufficient information is available at this time to determine if one watershed is in more danger than the other of experiencing an outburst flood event. However, the magnitude of a potential outburst flood from Boat Ramp Lake exceeds the potential from any proglacial lakes in the Skagway watershed.

Condition
The presence of proglacial lakes in KLGO's watershed is a concern for park management because of the potential implications of an outburst flood event. Documented ice cover retreat

creates additional concern, as new proglacial lakes may form or existing lakes may become unstable. Four sites in KLGO's watershed have been identified as potential hazards, but more investigation is needed to determine the composition of the moraines at these sites and assess their stability. More proglacial lakes are likely to appear if glaciers continue to receed.

Data Needs

In order to accurately determine the risk of a proglacial lake, it is important to understand the composition of the associated moraines and whether or not they contain ice (Denton et al. 2005). Additional assessment of sites identified as potential hazards is needed. The 2007 survey specifically identified four priority sites for additional assessment: Boat Ramp Lake, Goat Lake, Lake 1161, and Lateral Moraine Lake (NPS et al. 2007). Additional data collection was also recommended, including:

- A detailed bathymetric survey of each lake
- Geophysical surveys of areas with possible buried glacier ice
- Analysis of shore and valley slope conditions affecting stability
- Analysis of glacier dynamics and ice face stability
- Continued biennial surveys to look for changing conditions, new proglacial lakes and ice-dammed lakes

In an effort to identify new moraine-dammed lakes, KLGO is participating in an anecdotal survey of geohazards and is monitoring ice retreat through aerial surveys and image interpretation. When potential hazards are identified, the site is visited and assessed for vulnerability (KLGO D. Schirokauer pers. comm. 26 August 2009). Monitoring is still in its initial stages, but biennial surveys are planned.

Proglacial lakes are one of many landforms the SEAN plans to monitor as part of the I&M landcover and landform vital sign. Change detection will be conducted using IKONOS or other high resolution satellite imagery obtained approximately every ten years (Moynahan and Johnson 2008). Medium-resolution imagery every five years will be considered for possible enhancement of temporal change resolution.

Literature Cited

Capps, D. L. 2004. Geohazards of the Taiya watershed. Klondike Gold Rush National Historical Park, Skagway, Alaska.

Denton, C., L. Standley, and B. Lewis. 2005. A field investigation of glacial lake outburst potential in the Taiya River watershed, Skagway, Alaska. BLM-Alaska Open File Report 99. BLM/AK/ST-05/013+3033+040. Bureau of Land Management, Anchorage, USA.

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

KellerLynn, K. 2009. Geologic resources inventory scoping summary Klondike Gold Rush National Historical Park, Alaska. Draft. National Park Service Geologic Resources Division, Denver, Colorado.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service, Cold Regions Research Lab, and the Municipality of Skagway. 2007. Geohazard survey. Presentation. A partnership between the National Park Service, the Cold Regions Research Lab, and the Municipality of Skagway.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

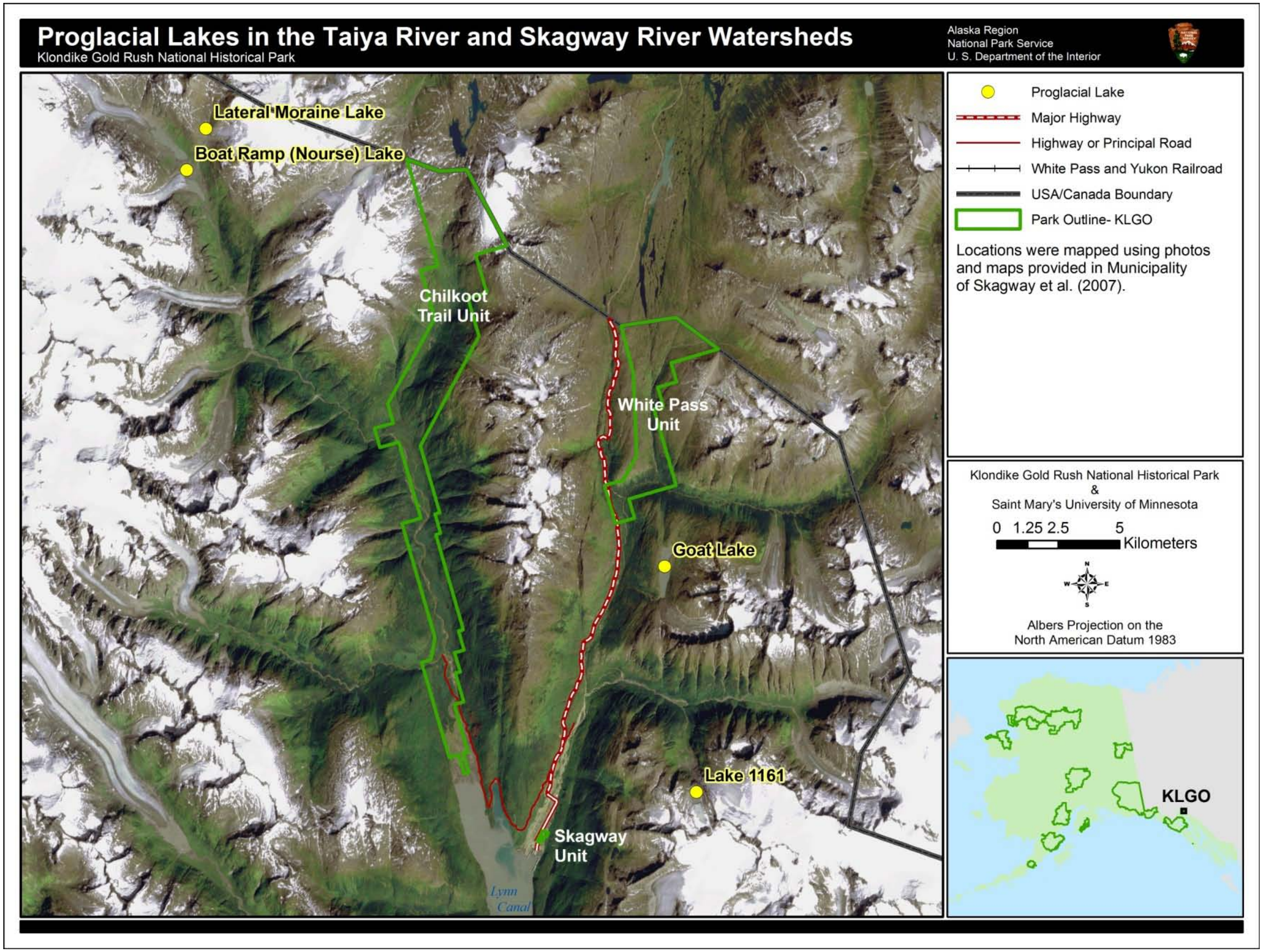
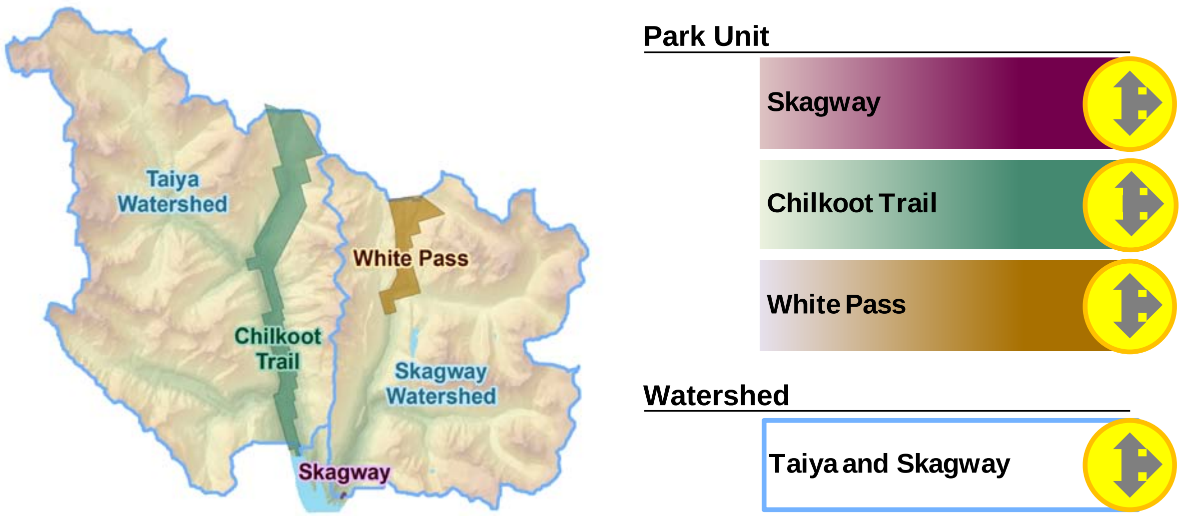


Plate 14. Proglacial lakes in the Taiya River and Skagway River watersheds (NPS et al. 2007, NPS 2009).

4.18 Ice Cover

Measures

Extent of Ice Cover
Percent Change in Ice Cover



Background

Glaciers once covered the entire park but now have little presence within KLGO's boundaries. The last major glacial recession likely began approximately 13,000 years ago (KellerLynn 2009). The glaciers remaining at high altitudes in the park's watershed are probably remnants from the Little Ice Age (1,500 to 250 years ago) (KellerLynn 2009). As the glaciers receded, the U-shaped valleys characteristic of KLGO remained.

The landscape in KLGO is still changing in response to glacial recession. Coastal areas were depressed an estimated 100 to 250 meters by the weight of ice, which was approximately 1,524 meters thick during the glaciated period (KellerLynn 2009). Relieved of this burden, the land is gradually rebounding through a process called glacio-isostatic uplift. Former beaches are moving inland and the extent and distribution of wetlands is changing (Larsen et al. 2005, KellerLynn 2009). Larsen et al. (2005) reported that southeast Alaska is experiencing the fastest rate of present-day glacio-isostatic uplift documented anywhere. Estimated rates of uplift at KLGO range from 14 to 16 mm per year, suggesting that land has risen approximately 1.6 to 2.1 meters since the gold rush (Larsen et al. 2005, KellerLynn 2009). Other possible contributing factors to uplift are present day thinning of ice, tectonic forces, and global glacial isostatic adjustment (KellerLynn 2009).

Glacial extent is an important component of both natural and cultural resources in KLGO. Covering approximately 33 percent of the Taiya River watershed and 17 percent of the Skagway River watershed, ice is a substantial part of the historic landscape that KLGO was established to protect (Jones and Fahl 1994). Glaciers are also an influential part of the natural ecosystem - affecting climate, changing terrain, creating habitat, and discharging ice, water, sediment, and organic matter into aquatic systems (Moynahan and Johnson 2008). The flow regimes of both the Taiya and Skagway Rivers are heavily influenced by glacial runoff (KellerLynn 2009).

A retreat of glaciers in correlation with climate change has been documented throughout the world (IPCC 2007). This change in glacial extent has important implications in terms of hydrology, sediment budgets, landscape ecology, and vegetative succession (Feirabend and Schirokauer 2008). Glacial recession also poses a direct threat to KLGO as proglacial lakes and moraines left in their wake can, if unstable, produce large floods with little or no warning (Feierabend and Schirokauer 2008). Proglacial lakes are discussed in detail within their own section of this report.

Reference Condition

Glacial extent in 1948 is considered the reference condition for this indicator. Feierabend and Schirokauer (2008) mapped glacial coverage within a 221,000 acre area encompassing the park using USGS topographic maps from 1948. Of the entire study area, 160,000 acres were based on 1:24,000 scale surveys, with the remaining 61,000 acres based on 1:63,360 scale surveys. The two-dimensional glacial area calculated using these maps was 30,138 acres. It should be noted that this study did not include all glaciers within KLGO's watershed and included glaciers outside the watershed. The study area is represented on Plate 15.

Data

To determine change in glacial extent from 1948, Feierabend and Schirokauer (2008) used black and white digital orthophoto quadrangle imagery from 2002 to delineate glaciers. Landsat satellite imagery from 2000 was used as a secondary reference.

Measures

Extent of Ice Cover

The mapped extent of ice cover reported in Feierabend and Schirokauer (2008) using 2002 imagery is 26,223 acres, but the study area excluded some glaciers within the watershed and included some outside the watershed. Using the drainage area and percent glaciated area for each watershed published in Jones and Fahl (1994), the approximate extent of glaciers is 153 km^2 in the Taiya River watershed and 64 km^2 in the Skagway River watershed. Change in glacial extent since 1994 is not represented in these numbers.

Percent Change in Ice Cover

The percent loss in two dimensional glaciated area between 1948 and 2002 within the area studied by Feierabend and Schirokauer (2008) is 13%, or 0.24% (72.5 acres) per year. Separate values were not calculated for the Taiya and Skagway watersheds, but a visual inspection of the maps does not show an obvious difference in ice cover change between the two watersheds (Plate 15).

Stressors

Climate is a primary driver of glacial dynamics. If warm temperatures melt more ice during ablation than is added by new snow and ice each year, a glacier will recede over time. Retreat of glaciers in correlation with climate change has been documented throughout the world (IPCC 2007). A positive feedback mechanism can develop from glacial recession as newly exposed rock adjacent to ice absorbs solar radiation leading to additional melting (Feierabend and Schirokauer 2008).

Reporting Zones

Little ice cover is found within KLGO's boundaries, but the presence of glaciers in KLGO's watershed impacts each park unit. Of the two watersheds, glaciers are more prevalent in the Taiya River watershed (Jones and Fahl 1994), but this does not diminish the importance of glaciers to the Skagway River watershed.

Condition

Feierabend and Schirokauer (2008) reported an estimated 13% decline in glacial extent in the area around KLGO from 1948 to 2002. This is a concern for both the Taiya and Skagway River watersheds, since glaciers impact hydrology, landscape ecology, water quality, and vegetation in the park. The fact that glacial extent was calculated for 1948 and 2002 by different people using different methods should be noted when interpreting the results. Change in glacial extent since 2002 is not known, so a current trend cannot be reported at this time.

Data Needs

Follow-up study is needed to determine a recent trend in ice cover for both the Taiya and Skagway watersheds. Glacial dynamics (extent) is a vital sign of the SEAN I&M Program and will be monitored once every ten years (Moynahan and Johnson 2008). All glaciers in KLGO and GLBA will be identified and aerial and/or satellite imagery will be used to determine each glacier's spatial extent (terminus position), surface area, and elevation. By collecting photographs at the end of the summer ablation season, accurate delineation of the equilibrium line will be possible and lowland features will be maximally exposed (Moynahan and Johnson 2008). Mass-balance monitoring is not planned at this time but may be part of an expanded future monitoring effort depending on available funding (Moynahan and Johnson 2008).

Literature Cited

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

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

Jones, S. H., and C. B. Fahl. 1994. Magnitude and frequency of floods in Alaska and conterminous basins of Canada. Water-Resources Investigations Report 93-4179. U.S. Geological Survey, Reston, Virginia.

KellerLynn, K. 2009. Geologic resources inventory scoping summary Klondike Gold Rush National Historical Park, Alaska. Draft. National Park Service Geologic Resources Division, Denver, Colorado.

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.

Moynahan, B. J., and W. F. Johnson. 2008. Vital signs monitoring plan: Southeast Alaska Network. Natural Resources Report NPS/SEAN/NRR-2008/059. National Park Service, Fort Collins, Colorado.

National Park Service. 2009. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska, USA.

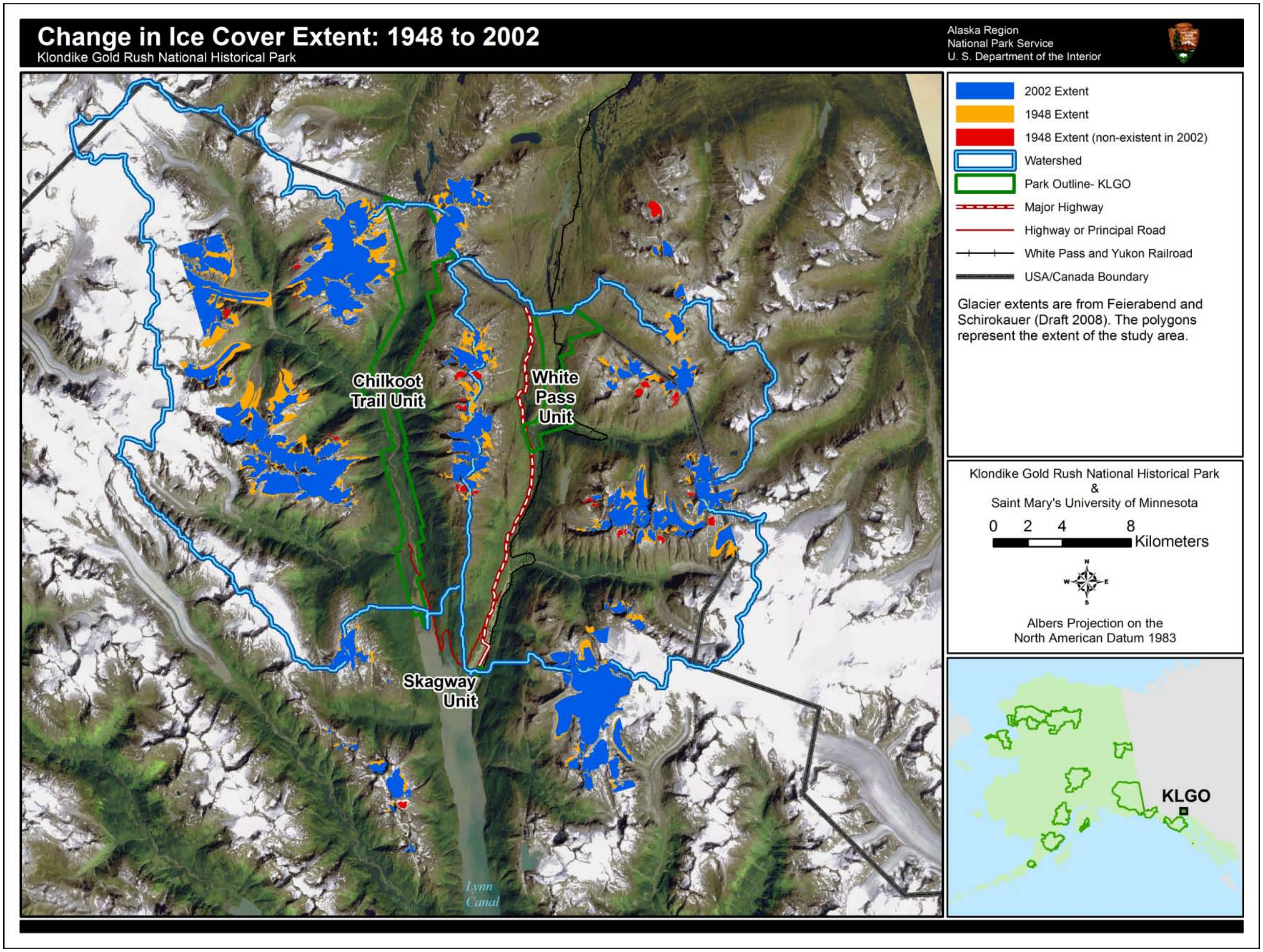


Plate 15. Change in ice cover extent: 1948 to 2002 (Feierabend and Schirokauer 2008, NPS 2009).

Chapter 5 Discussion

5.1 Park-wide Condition

Assessing the condition of KLGO natural resources at a park-wide or landscape level is problematic. First, to assert that KLGO is a single landscape is a significant oversimplification. Second, defining a sole condition for the whole park implies it is possible to understand the complex interrelationships between all of the components comprising this diverse park. Indeed, the park's diverse landscape is what allows so many species to thrive and survive. Inventories of plants, breeding birds, coastal birds, and lichens have uncovered a rich variety of species supported by the KLGO landscape and climate. Situated at the head of the Lynn Canal, the area is thought to be the greatest center of plant diversity in the state (Pojar and MacKinnon 2004). Lichen diversity exceeds that of any other inventoried park in the United States. Lichen species never before documented have been discovered in the park in recent years (Spribille et al. 2010).

The diverse landscape and the park's location also contribute to many of the threats faced by its natural resources. Some habitats are restricted to small areas as the elevation and ecological gradient changes rapidly proceeding up the Taiya and Skagway River valleys. The western toad, for example, relies on wetlands in the Dyea area for breeding habitat. Breeding at only a few ponds each year, the entire population can be significantly impacted by a single outburst flood from a proglacial lake, a change in the hydrological regime, or a disease outbreak. Some plant species, such as those in the beach fringe community, also occupy a small ecological niche in the Dyea area and are shriking due to isostatic rebound and forest encroachment (Paustian et al. 1994). The many available ecological niches also provide an opportunity for exotic species to establish and spread into native vegetation.

The park's proximity to Skagway enables hundreds of thousands of people to visit the park each year. KLGO received more visitors in 2009 than any other national park in Alaska. The majority of the visitors arrive on cruise ships, which compromise the area's air quality and viewshed. Cruise ships operate diesel and bunker fuel generators while in port, releasing visible exhaust. Additional transportation, facilities, and services necessary to support the large summer population emit compounds such as NO_x and SO_2 into the air. Visiblity limiting anthropogenic haze is not uncommon in the KLGO area, and air and water quality measurements near Skagway have detected higher levels of some contaminants compared to undisturbed sites in other parts of the region. Visitors may also unknowingly introduce exotic species to the park, and high visitation increases the likelihood of bear-human encounters.

Approximately 400,000 people travel through the White Pass Unit each year by train, but many fewer visitors explore the White Pass Unit on foot compared to the Skagway and Chilkoot Trail Units. The steep and rugged landscape is not easily traversed by hikers, and the unit is completely undeveloped. No established trails exist to reach or travel through the unit (KLGO 1996). The challenges faced by visitors wanting to explore the White Pass unit are also faced by researchers. This is reflected in the limited quantity of data and reports pertaining to this region of the park. The lack of recent data regarding water quality, air quality, hydrology, and wetlands in this unit is a significant data gap and limits the conclusions that can be made regarding the condition of the entire park.

Climate is an additional factor which contributes to the diversity of the park and also presents a potential stress to many ecosystem components. The drier climate in KLGO compared to much of southeast Alaska allows some species to survive in the park that are not found elsewhere in the region. Changes in climate, however, can alter habitats that already have a limited distribution. Ice cover in the park's watershed has declined over the last fifty years, and climate models predict continued warming in the coming decades (Feierabend and Schirokauer 2008, Scenarios Network for Alaska Planning 2009). This has important implications for several resources. Glacial melt influences the quantity and timing of stream discharge and also impacts water quality, which in turn affects the abundance and distribution of wetlands. Plant and animal species dependent upon these resources, including western toads and fish, face possible habitat disruption. Receding glaciers can also leave proglacial lakes in their wake, threatening natural and cultural resources with the potential for outburst flood events. Warming temperatures may also alter the composition of plant communities and allow for exotic species to invade from warmer regions.

The condition and trend of each indicator included in the NRCA framework is summarized in Table 35. This allows for comparison between reporting zones and the ability to view the condition of all indicators with an ecosystem category. It is important to note that the framework does not include all possible indicators and measures within an ecosystem component. The condition and trend of the selected indicators may not fully represent the condition and trend of the larger ecosystem component or the entire park. It is also important to consider that condition assessments were made with varying amounts of available data and with varying degrees of confidence. A more complete assessment of each indicator is available in chapter four.

Table 35. Summary of indicator condition and trend.

Component	Indicator	Reporting Zone: Chilkoot Trail	Reporting Zone: White Pass	Reporting Zone: Skagway
Extent and Pattern				
Landscape Composition				
	Landcover Extent			
	Landcover Pattern			
	Landform			
Biological Components				
Biotic Composition				
	Lichens			
	Invasives and Exotics			
	Flora			N/A
	Breeding Birds			
	Coastal Birds		N/A	
	Bears			
	Western Toads			N/A
Habitat				
	Wetlands			N/A
Chemical and Physical Characteristics				
Air Quality				
	Air Quality			
	Soundscape			
	Dark Night Skies			N/A
Water Quality				
	Chemistry			N/A
	Trace Inorganic and Organic Chemicals			
	Physical Properties			N/A
Hydrology				
	Hydrology			N/A
	Proglacial Lakes			
	Ice Cover			

5.2 Indicator Condition Summaries

Definition of reference condition proved to be the most significant obstacle in defining the condition of indicators in this NRCA. The concept of a 'natural range of variability' has often been used by resource managers as a way of defining reference condition, but this idea is difficult to quantify with limited historic data or when changes in circumstance prevent current condition from mirroring historic condition. Many resource managers are rethinking resource management definitions in view of natural changes such as isostatic rebound and anthropogenic changes beyond the immediate control of mangers (Cole and Yung 2010). Definition of reference condition is further complicated by the fact that KLGO is a historic park managed to protect the cultural artifacts of the gold rush in addition to natural resources. When a specific reference condition for the park was unknown, an attempt was made to include state and federal standards or data from other relevant locations in order to provide some context for interpreting results.

As an urban park unit, the Skagway reporting zone was not applicable for several ecosystem indicators. In some cases, the condition of a resource in the area adjacent to the unit was reported using the Skagway reporting zone in order to draw attention to an issue that could have implications for the condition of the park as a whole. These indicators included air quality, water quality, exotic species, and bears.

5.3 Data Needs

There are significant data gaps for several natural resource indicators in KLGO. Data collection for some indicators is underway or planned as part of the I&M Program. These indicators include landscape composition, lichen communities, air quality, water quality, and hydrology. Monitoring of other indicators, such as soundscape and dark night skies, is unplanned or in the very early stages of planning.

Despite expected development of important datasets as part of the I&M Program, data gaps for multiple indicators in the White Pass Unit are likely to persist without additional monitoring. For example, water quality and hydrology monitoring is planned for the Taiya River in the Chilkoot Trail Unit but not for the Skagway River in the White Pass Unit.

Literature Cited

Cole, D. N., and L. Yung. 2010. Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change. Island Press, Washington D.C., USA.

Feierabend, D., and D. Schirokauer. 2008. Glacial extent mapping: A pilot study. Draft. Natural Resources Division Klondike Gold Rush National Historical Park. Skagway, Alaska.

Klondike Gold Rush National Historical Park. 1996. General management plan development concept plan and environmental impact statement. U.S. Department of Interior, National Park Service, Skagway, Alaska and Seattle, Washington.

Paustian, S. J., S. J. Trull, R. A. Foster, N. D. Atwood, B. J. Krieckhaus, and J. R. Rickers. 1994. Ecological inventory of Klondike Gold Rush National Historical Park and adjacent national forest lands. USDI National Park Service, Alaska Regional Office and USDA Forest Service, Tongass National Forest, Chatham Area, USA.

Pojar, J., and A. MacKinnon. 2004. Plants of the Pacific Northwest coast: Washington, Oregon, British Columbia & Alaska. Rev. ed. Lone Pine Publishing, Canada.

Scenarios Network for Alaska Planning. 2009. Climate change implications for Klondike Gold Rush National Historical Park & surrounding area. Scenarios Network for Alaska Planning, National Park Service, and The Wilderness Society. Online. (http://www.snap.uaf.edu/downloads/climate-change-summary-reports). Accessed 7 July 2010.

Spribille, T., S. Pérez-Ortega, T. Tønsberg, and D. Schirokauer. 2010. Lichens and lichenicolous fungi of the Klondike Gold Rush National Historic Park, Alaska, in a global biodiversity context. The Bryologist 113(3):439-515.

Appendices

Appendix A. **Exotic species documented in or near KLGO by location and year (4 = 2004, 5 = 2005, 6 = 2006, 7 = 2007, 8 = 2008, and 9 =2009) (adapted from Wilbarger and Feierabend 2009).**

Scientific Name	Common Name	Chilkoot Trail	Nelson Slough	Dyea	White Pass[b]	Dyea Road[c]	Klondike Highway[a]
Anthemis arvensis	corn chamomile	Found only in Skagway (First documented in 2009)					
Anthemis cotula	stinking chamomile	Found only in Skagway (First documented in 2009)					
Bromus inermis	smooth brome				8		8
Capsella bursa-pastoris	shepherd's purse		4,5,6			5,6	8
Cerastium fontanum	mouse-ear chickweed		5,6				8
Chenopodium album	lambsquarters		4,6			5,6	8
Collomia linearis	narrow-leaved collomia	Found only in Skagway (First documented in 2009)					
Crepis tectorum	narrowleaf hawksbeard			4,5,6,7,8,9	8	5,6,7,8,9	8
Elymus repens	quackgrass			9		8	8
Erysimum cheiranthoides	wormseed mustard		4,5,6			5,6	
Euphrasia nemorosa	common eye-bright		4,5,6,7,8,9	5,6,9			
Galeopsis tetrahit	bristlestem hempnettle		4,5,6				
Galeopsis bifida	splitlip hempnettle	Found only in Skagway					
Hordeum jubatum	foxtail barley			8	8	8	8
Impatiens glandulifera	ornamental jewelweed	Found only in Skagway					
Lepidium densiflorum	common pepperweed	Found only in Skagway (First documented in 2009)					
Leucanthemum vulgare	oxeye daisy			4,5,6,8,9		5,6,7,8,9	8
Linaria vulgaris	yellow toadflax		4,5,6	9	4	5,6,7,8,9	
Lupinus polyphyllus	large-leaf lupine			8,9			
Matricaria discoidea	pineapple weed		4,5,6,7,8,9	4,5,6,7,8,9	4,8	5,6,7,8,9	
Medicago lupulina	black medic	Found only in Skagway (First documented in 2009)					
Melilotus alba	white sweet-clover						9
Papaver nudicaule	iceland poppy	Found only in Skagway (First documented in 2009)					
Phalaris arundinacea	reed canary grass				8	8,9	8,9
Phleum pratense	timothy grass						8
Plantago major	plantain		4,5,6,7,8,9	4,5,6,7,8,9	4,8	5,6,7,8,9	8,9
Poa pratensis	Kentucky bluegrass	4,5,6		4,6	4		

Appendix A. **Exotic species documented in or near KLGO by location and year (4 = 2004, 5 = 2005, 6 = 2006, 7 = 2007, 8 = 2008, and 9 =2009) (adapted from Wilbarger and Feierabend 2009). (continued).**

Scientific Name	Common Name	Chilkoot Trail	Nelson Slough	Dyea	White Pass[b]	Dyea Road[c]	Klondike Highway[a]
Polygonum aviculare	prostrate knotweed		4,5,6	8	8	5,6	8
Polygonum convolvulus	black bindweed	Found only in Skagway (First documented in 2009)					
Potentilla gracilis	slender cinquefoil			8,9			
Ranunculus acris	tall buttercup	4,5,6,9	5,6,8,9	5,6,7,8,9	4,8	5,6,7,8,9	8,9
Ranunculus repens	creeping buttercup			6,7,8,9			
Rumex acetosella	sheep sorrel	4,5,6	4,5,6,7,8,9	5,6,7,8,9	4,8	5,6,7,8,9	8,9
Rumex crispus	curled dock		4,5,6			5,6	
Senecio viscosus	sticky ragwort			5,6		5,6	
Senecio vulgaris	common groundsel		4	8	8	8	8
Silene cucubalus	bladder campion		4,5			5,6	
Silene noctiflora	nightflowering silene	Found only in Skagway					
Sisymbrium altissimum	tumblemustard	Found only in Skagway (First documented in 2009)					
Sonchus arvensis	perennial sowthistle	Found only in Skagway					
Sorbus aucuparia	European mountain-ash	Found only in Skagway					
Stellaria media	common chickweed		4,5,6	8	8	5,6,8	8
Tanacetum vulgare	common tansy					5,6,9	
Taraxacum officinale	dandelion	4,5,6,7,9	4,5,6,7,8,9	4,5,6,7,8,9	4,8	5,6,7,8,9	8,9
Thlaspi arvense	field pennycress		4				8
Trifolium hybridum	Alsike clover					7,8	7,8
Trifolium pratense	red clover		7,8,9	7,8,9		7,8	7,8
Trifolium repens	white clover	4,5,6	4,5,6,7,8,9	4,5,6,7,8,9	4,8	5,6,7,8	8
Vicia cracca	bird vetch	Found only in Skagway					
Viola tricolor	johnny-jump-up violet		4				

[a] Klondike Highway was not completely surveyed in 2008 or 2009.
[b] White Pass was surveyed only in 2004 and 2008.
[c] Dyea Road was not surveyed in 2004.

Appendix B. **Draft species list from KLGO flora database (KLGO 2010).**

Abies lasiocarpa
Acer glabrum
Acer glabrum douglasii
Achillea millefolium
Achillea millefolium borealis
Achillea ptarmica
Aconitum delphiniifolium
Aconitum delphiniifolium delphiniifolium
Actaea rubra
Adiantum aleuticum
Adoxa moschatellina
Agoseris aurantiaca
Agoseris glauca
Agropyron repens
Agrostis exarata Trin.
Agrostis geminata
Agrostis gigantea
Agrostis mertensii Trin.
Agrostis stolonifera
Agrostis tenuis
Alectoria sarmentosa
Allium schoenoprasum
Alnus incana
Alnus incana tenuifolia
Alnus rubra
Alnus viridis
Alnus viridis (Vill.) Lam. sinuata (Regel)
Alopecurus aequalis
Alopecurus pratensis
Amanita muscaria
Amelanchier alnifolia
Amelanchier alnifolia semiintegrifolia
Amsinckia lycopsoides
Amsinckia menziesii
Anaphalis margaritacea
Andreaea rupestris
Andromeda polifolia
Androsace septentrionalis
Anemone narcissiflora
Anemone narcissiflora monantha
Anemone parviflora
Anemone richardsonii
Angelica genuflexa
Angelica lucida
Antennaria alpina
Antennaria microphylla
Antennaria monocephala
Antennaria pulcherrima
Antennaria rosea
Antennaria rosea pulvinata
Anthemis tinctoria
Aquilegia formosa ex
Arabis divaricarpa
Arabis drummondii
Arabis glabra
Arabis hirsuta
Arabis Holboellii
Arabis kamchatica
Arabis lyrata
Arceuthobium tsugense
Arctagrostis latifolia (R. Br.) Griseb.
Arctagrostis poaeoides
Arctostaphylos rubra
Arctostaphylos uvaursi
Arctous alpina
Argentina egedii (Wormsk.)
Argentina egedii (Wormsk.) egedii (Wormsk.)
Arnica amplexicaulis
Arnica angustifolia
Arnica chamissonis
Arnica cordifolia
Arnica frigida
Arnica latifolia
Arnica lessingii
Artemisia arctica
Artemisia campestris
Artemisia frigida
Artemisia tilesii
Aruncus dioicus
Aruncus dioicus vulgaris
Asplenium trichomanesramosum
Aster foliaceus
Aster sibericus
Aster subspicatus
Astragalus alpinus

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Astragalus bodinii
Astragalus robbinsii
Athyrium americanum
Athyrium filixfemina
Atrichum cf. undulatum
Atriplex alaskensis
Atriplex gmelinii
Atriplex patula
Aulacomnium palustre
Barbarea orthoceras
Bartramia cf. pomiformis
Beckmannia syzigachne
Betula nana
Betula papyrifera.
Betula papyrifera commutata
Blechnum spicant
Boschniakia rossica ( ) Fedtsch.
Botrychium ascendens H. Wagner
Botrychium lanceolatum
Botrychium lunaria
Botrychium multifidum
Botrychium pinnatum
Botrychium virginianum
Brachythecum albicans
Brassica juncea
Brassica rapa
Bromopsis inermis
Bromus ciliatus
Bromus commutatus
Bromus hordeaceus
Bromus inermis
Bromus secalinus
Bromus sitchensis
Bryocaulon divergens Karnfelt
Bryoria glabra
Bryoria nitidula
Bryum creberrimum
Bryum stenotrichum
Calamagrostis canadensis
Calamagrostis canadensis var. langsdorfii
Calamagrostis lapponica
Calamagrostis stricta
Callitriche palustris
Caltha leptosepala
Caltha palustris
Calypogeia integristipula
Calypso bulbosa
Campanula lasiocarpa
Campanula rotundifolia
Canadanthus modestus (Lindl.) Nesom
Capsella bursa-pastoris
Cardamine bellidifolia
Cardamine oligosperma
Cardamine oligosperma kamtschatica (Regel) Detling
Cardamine pensylvanica
Cardamine pratensis
Carex aenea
Carex anthoxanthea
Carex aquatilis
Carex aquatilis aquatilis
Carex aquatilis dives (Holm) kenth.
Carex athrostachya
Carex aurea
Carex bebbii
Carex bicolor
Carex brunnescens
Carex buxbaumii
Carex canescens
Carex capillaris
Carex cf. macrochaeta
Carex circinata
Carex disperma
Carex echinata
Carex filifolia
Carex flava
Carex garberi
Carex glacialis
Carex glareosa
Carex gmelinii
Carex gynocrates
Carex krausei
Carex Lachenalii
Carex laeviculmis
Carex lenticularis

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Carex lenticularis lipocarpa (Holm) A. Standley
Carex lenticularis dolia
Carex leptalea
Carex livida
Carex loliaceae
Carex lyngbyei
Carex mackenziei
Carex macrocephala
Carex magellanica
Carex maritima
Carex mertensii
Carex nardina
Carex nigricans C.A.
Carex norvegica inferalpina
Carex pachystachya Steud.
Carex pauciflora.
Carex phaecocephala
Carex pluriflora
Carex podocarpa
Carex pyrenaica
Carex pyrenaica. micropoda
Carex rossii
Carex rostrata
Carex saxatilis
Carex scirpoidea
Carex spectabilis
Carex stipata
Carex stylosa
Carex viridula
Cassiope lycopodioides
Cassiope mertensiana
Cassiope tetragona
Castilleja hyetophila
Castilleja hyperborrea
Castilleja miniata
Castilleja parviflora
Castilleja unalaschcensis ( ) Malte
Cavernularia hultenii
Cavernularia lophyrea
Centaurea biebersteinii
Cerastium arvense
Cerastium beeringianum
Cerastium fischerianum
Cerastium fontanum
Cerastium glomeratum
Ceratodon purpureus
Cetraria ericetorum
Cetraria islandica
Cetraria islandica orientalis
Cetraria laevigata
Cetraria nivalis
Chamaecyparis nootkatensis
Chamerion angustifolium Holub angustifolium
Chamerion latifolium Holub
Chenopodium album
Chenopodium berlandieri
Chenopodium capitatum
Chenopodium leptophyllum
Chimaphila umbellata
Chlamydomonas nivalis
Chrysanthemum arcticum
Chrysosplenium tetrandrum
Cicuta douglasii Coult.
Cicuta virosa
Cinclidium stygium
Cinna latifolia
Circaea alpina
Cirsium arvense
Cladia portentosa
Cladia stellaris
Cladina cf. stellaris
Cladina mitis
Cladina portentosa
Cladina rangiferina
Cladonia amaurocraea
Cladonia bellidiflora
Cladonia cornuta cornuta
Cladonia deformis
Cladonia ecmocyna
Cladonia ecmocyna intermedia
Cladonia fimbriata
Cladonia floerkeana
Cladonia furcata
Cladonia gracilis

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Cladonia gracilis turbinata
Cladonia pyxidata
Cladonia scabriuscula
Cladonia squamosa
Cladonia subfurcata
Cladonia sulphurina
Cladonia uncialis
Claytonia sarmentosa
Claytonia scammania
Claytonia sibirica
Climacium dendroides
Clintonia uniflora
Cochlearia groenlandica
Coeloglossum viride
Collinsia parfiflora
Collomia linearis
Comarum palustre
Conioselinum chinense
Conioselinum gmelinii ( ) Steud.
Conococephalum conicum
Coptis asplenifolia
Coptis trifolia
Corallorrhiza mertensiana
Corallorrhiza trifida Chatelain
Cornus canadensis
Cornus sericea
Cornus sericea sericea
Cornus suecica
Corydalis aurea
Corydalis pauciflora
Crepis elegans
Crepis tectorum
Cryptantha torreyana
Cryptogramma acrostichoides
Cryptogramma sitchensis
Cypripedium montanum
Cypripedium parviflorum
Cypripedium passerinum
Cystopteris fragilis
Cystopteris montana
Dactylis glomerata
Danthonia intermedia
Dasiphora floribunda (Pursh) Kartesz
Delphinium glaucum
Dendranthema arcticum Tzvelev arcticum Tzvelev
Deschampsia beringensis
Deschampsia cespitosa
Deschampsia danthonioides
Deschampsia elongata
Descurainia sophia
Descurainia sophioides
Dichodontium pellucidum
Dicranium fuscescens
Dicranum howellii Ren. Card.
Diplophyllum taxipholium
Dodecatheon frigidum
Dodecatheon jeffreyi
Dodecatheon pulchellum Merr.
Dodecatheon pulchellum Merr. macrocarpum (Gray) Taylor MacBryde
Draba alpina
Draba aurea
Draba borealis
Draba cana
Draba crassifolia
Draba glabella
Draba lonchocarpa
Draba lonchocarpa lonchocarpa
Draba nemorosa
Draba nivalis
Draba ruaxes
Draba stenoloba
Drosera angelica
Drosera rotundifolia
Dryas drummondii
Dryas integrifolia
Dryas octopetala
Dryopteris expansa (K. Presl) FraserJenkins Jermy
Dryopteris fragrans
Eleocharis acicularis
Eleocharis kamtschatica
Eleocharis palustris
Eleocharis uniglumis (Link)
Elliottia pyroliflorus

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Elymus alaskanus
Elymus alaskanus (Scribn. Merr.) A. Love latiglumis (Scribn. J. Sm.) A. Love
Elymus caninus
Elymus glaucus glaucus
Elymus glaucus Buckl.
Elymus hirsutus
Elymus trachycaulus (Link) GouldShinners
Empetrum nigrum
Epilobium adenocaulon
Epilobium anagallidifolium Lam.
Epilobium ciliatum
Epilobium hornemannii
Epilobium hornemannii Reichenb. hornemannii Reichenb.
Epilobium lactiflorum
Epilobium leptocarpum
Epilobium luteum
Epilobium palustre
Equisetum arvense
Equisetum fluviatile
Equisetum hyemale
Equisetum palustre
Equisetum pratense
Equisetum scirpoides
Equisetum variegatum
Erigeron acris
Erigeron acris politus
Erigeron compositus Pursh
Erigeron humilis
Erigeron lonchophyllus
Erigeron peregrinus
Erigeron purpuratus
Eriophorum angustifolium
Eriophorum angustifolium Honck. scabriusculum
Eriophorum angustifolium Honckeny subarcticum (Vassiljev) Hult n Kartesz Gandhi
Eriophorum chamissonis C.A.
Eriophorum russeolum
Eriophorum russeolum majus
Eriophorum scheuchzeri
Erysimum cheiranthoides
Erysimum inconspicuum
Euphrasia disjuncta
Euphrasia mollis
Euphrasia nemorosa
Fauria crista-gallii
Festuca altaica Trin.
Festuca brachyphylla
Festuca richardsonii
Festuca rubra
Festuca subulata
Fragaria chiloensis
Fritillaria camschatcensis KerGawl.
Fuscopannaria ahlneri
Galeopsis bifida
Galium aparine
Galium boreale
Galium trifidum
Galium triflorum
Gentiana douglasiana
Gentiana glauca
Gentiana platypetala
Gentiana prostrata
Gentianella amarella
Gentianella amarella Boerner acuta J. Gillett
Gentianella propinqua
Geocalyx graveolens
Geocaulon lividum
Geranium bicknellii
Geranium erianthum
Geum calthifolium MenziesSm.
Geum macrophyllum
Geum macrophyllum macrophyllum
Glaux maritima
Glyceria borealis
Gnaphalium uliginosum
Goodyera oblongifolia
Goodyera repens R. Br. f.
Gyalecta friesii
Gyalideopsis piceicola () Vezda
Gymnocarpium disjunctum
Gymnocarpium dryopteris

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Harrimanella Stelleriana
Hedysarum alpinum
Hedysarum boreale
Heracleum maximum Bartr.
Heuchera glabra
Hieracium albiflorum
Hieracium aurantiacum
Hieracium gracile
Hieracium triste
Hieracium umbellatum
Hierochloe alpina (S)
Hierochloe odorata
Hippuris montana
Hippuris tetraphylla
Hippuris vulgaris
Honckenya peploides Ehrh.
Honckenya peploides Ehrh. major Hultn
Hordeum brachyantherum Nevski
Hordeum jubatum
Hordeum vulgare
Huperzia chinensis
Huperzia selago
Huperziaakalae (Brack.) Holub
Hylocomium splendens
Hypnum circinale
Hypocenomyce leucococca
Hypogymnia apinnata Goward McCune
Hypogymnia enteromorpha
Hypogymnia occidentalis
Hypogymnia physodes
Hypogymnia rugosa
Icmadophila ericetorum
Impatiens noli-tangere
Iris setosaLink
Iris setosaLink setosaLink
Isoetes echinospora
Japewia tornoensis
Juncus albescens
Juncus alpinoarticulat
Juncus alpinus
Juncus arcticus
Juncus balticus
Juncus balticus montanus
Juncus biglumis
Juncus bufonius
Juncus castaneus
Juncus drummondii
Juncus ensifolius
Juncus filiformis
Juncus haenkei
Juncus mertensianus
Juncus prominens
Juncus tenuis
Juniperus communis
Kaernefeltia merrillii
Kalmia polifolia
Koenigia islandica
Kumlienia cooleyae (Vasey)
Lactarius cf. torminosus
Lactuca biennis
Lappula myosotis
Lappula occidentalis
Lathyrus japonicus
Lathyrus japonicus maritimus
Lathyrus palustris
Ledum groenlandicum
Ledum palustre decumbens Hultn
Lepidium densiflorum
Lepraria finkii
Lepraria neglecta
Leptarrhena pyrolifolia R. Br.Ser.
Leucanthemum vulgare
Leucolepis menziesii
Leymus mollis mollis
Leymus mollis
Ligusticum scothicum
Linaria vulgaris
Linnaea borealis
Linum lewisii
Linum perenne
Listera caurina
Listera cordata R. Br. f.
Lloydia serotina Reichenb.
Lobaria hallii
Lobaria linita
Lobaria oregana

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Lobaria pulmonaria
Lobaria retigera
Lobaria scrobiculata in
Loiseleuria procumbens
Lomatogonium rotatum
Lophozia inciza
Loxospora elatina
Luetkea pectinata (Pursh) Kuntze
Lupinus arcticus canadensis (C. Sm.) Dunn
Lupinus arcticus S. Wats.
Lupinus nootkatensis
Lupinus polyphyllus
Luzula arcuata
Luzula arcuata unalaschcensis
Luzula divaricata
Luzula multiflora
Luzula parviflora
Luzula rufescens
Luzula spicata
Luzula wahlenbergii Rupr.
Luzula wahlenbergii Piperi
Lycopodium alpinum
Lycopodium annotinum
Lycopodium clavatum
Lycopodium clavatum monostachyon
Lycopodium complanatum
Lycopodium dendroideum
Lycopodium sitchense Rupr.
Lysichiton americanum
Madia glomerata
Maianthemum dilatatum
Maianthemum stellatum Link
Malaxis brachypoda
Malaxis diphyllos
Malaxis monophyllus
Malus fusca
Matricaria matricarioides
Medicago lupulina
Melanelia hepatizon
Melilotus alba
Mentha canadensis
Menyanthes trifoliata
Menziesia ferruginea Sm.
Mertensia maritima maritima
Mertensia maritima
Mertensia paniculata
Mimulus guttatus
Minuartia macrocarpa
Minuartia rubella
Mitella nuda
Mitella pentandra
Mnium spinulosum
Moehringia lateriflora
Moneses uniflora
Monotropa hypopithys
Montia chamissoi
Montia fontana
Mycoblastus affinis (Schaerer) Schauer
Mycoblastus sanguinanius
Mylia taylori ()
Myosotis asiatica
Myosotis scorpioides
Myrica gale
Myriophyllum sibiricum
Nephroma arcticum
Nephroma bellum
Nephroma helveticum
Nephroma isidiosum
Nephroma parile
Nuphar lutea Sm. polysepala O. Beal
Nuphar luteum
Ochrolechia androgyna
Ochrolechia laevigata
Ochrolechia oregonensis
Ophioparma lapponica
Oplopanax horridus Miq.
Orthilia secunda
Orthocaulous floerkei
Osmorhiza berteroi
Osmorhiza depauperata
Osmorhiza purpurea
Oxyria digyna
Oxytropis campestris
Oxytropis campestris varians
Oxytropis deflexa
Oxytropis maydelliana

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Parmelia hygrophila
Parmelia saxatilis
Parmelia squarrosa
Parmelia sulcata
Parmeliella triptophylla
Parmeliopsis hyperopta
Parnassia fimbriata Koenig
Parnassia kotzebuei
Parnassia palustris
Pedicularis capitata
Pedicularis labradorica
Pedicularis langsdorfii
Pedicularis oederi
Pedicularis parviflora
Pedicularis sudetica
Pedicularis verticillata
Peltigera aphthosa
Peltigera britannica
Peltigera canina
Peltigera cf. pacifica
Peltigera collina
Peltigera membranaceae
Peltigera neopolydactyla
Peltigera retifoveata
Peltigera venosa
Penstemon procerus Dougl.Graham
Petasites frigidus
Petasites frigidus nivalis
Phalaris arundinacea
Phegopteris connectilis Watt
Philonotus fontana americana
Phleum alpinum
Phleum pratense
Phlox gracilis
Phyllodoce empetriformis (SM.)
Phyllodoce glanduliflora ()
Picea glauca
Picea sitchensis
Pilophorus acicularis
Pinguicula macroceras
Pinguicula villosa
Pinguicula vulgaris
Pinus contorta Dougl.Loud.
Piperia unalascensis (Spren)
Placopsis gelida
Plagiobothrys orientalis
Plagiobothrys scouleri
Plagiobothrys scouleri H. A. hispidulus
Plagiomnium ellipticum
Plagiomnium insigne
Plagiothecium denticulatum
Plagiothecium laetum in B.S.
Plagiothecium striatella
Plagiothecium undulatum
Plantago macrocarpa
Plantago major
Plantago major major
Plantago maritima
Platanthera dilatata (Pursh) Lindl.Beck
Platanthera hyperborea
Platanthera hyperborea hyperborea
Platanthera obtusata (BanksPursh) Lindl.
Platanthera stricta Lindl.
Platismatia glauca
Platismatia herrei C.
Platismatia norvegica C.
Poa alpina
Poa annua
Poa arctica
Poa arctica R. BR. arctica
Poa compressa
Poa eminens J. Presl
Poa glauca
Poa leptocoma
Poa macrocalyx
Poa nemoralis
Poa palustris
Poa paucispicula
Poa pratensis
Poa pratensis pratensis
Poa pseudoabbreviata Rosh.
Poa secunda
Poa stenantha
Poa trivialis
Pogonatum urnigerum
Polemonium acutiflorum

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Polemonium boreale M.F. Adams
Polemonium pulcherrimum
Polychidium contortum
Polychidium juniperum
Polygonum alpinum
Polygonum aviculare
Polygonum bistorta
Polygonum caurianum
Polygonum convolvulus
Polygonum fowleri
Polygonum hydropiper
Polygonum lapathifolium
Polygonum ramosissimum
Polygonum viviparum
Polypodium glycyrrhiza
Polypogon monspeliensis
Polystichum andersonii
Polystichum braunii
Polystichum lonchitis
Polystichum setigerum
Polytrichastrum alpinum alpinum (Hed) Sm.
Polytrichium formosum
Polytrichum juniperinum
Polytrichum piliferum
Polytrichum sexangulare Brid.
Polytrichum strictum Brid.
Populus balsamifera
Populus balsamifera trichocarpa ( ) Brayshaw
Populus tremuloides
Porella cordeanna
Porpidia flavocaerulescens
Potamogeton alpinus
Potamogeton cf. epihydrus
Potamogeton filiformis
Potamogeton gramineus
Potamogeton natans
Potamogeton pectinatus
Potamogeton pusillus
Potamogeton richardsonii
Potamogeton vaginatus
Potamogeton zosteriformis
Potentilla diversifolia
Potentilla gracilis
Potentilla nana ex
Potentilla nivea
Potentilla norvegica
Potentilla pensylvanica
Potentilla uniflora
Potentilla vahliana Lehm.
Potentilla villosa
Prenanthes alata
Primula cuneifolia
Primula cuneifolia. saxifragifolia
Primula cuneifoliais
Primula egaliksensis
Prunella vulgaris
Pseudephebe pubescens
Pseudocyphellaria anomala
Pseudocyphellaria crocata
Psora nipponica
Psoroma hypnorum
Pteridium aquilinum
Ptilidium californicum ()
Ptilidium ciliare
Ptilidium pulcherrimum ()
Ptilium cristacastrensis
Puccinellia kamtschatica
Puccinellia kurilensis
Puccinellia nuttalliana
Pucinellia nutkaensis
Pulsatilla occidentalis (S. Wats.) Freyn
Pulsatilla patens Mill.tifida (Pritz.) Zamels
Pyrola asarifolia
Pyrola chlorantha
Pyrola minor
Racomitrium canescens
Racomitrium lanuginosum
Radula complanata
Ramalina farinacea
Ranunculus abortivus
Ranunculus acris
Ranunculus cymbalaria
Ranunculus eschscholtzii
Ranunculus flammula

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Ranunculus hyperboreus
Ranunculus macounii Britt.
Ranunculus nivalis
Ranunculus occidentalis
Ranunculus pacificus
Ranunculus pedatifidus
Ranunculus pygmaeus
Ranunculus repens
Ranunculus trichophyllus
Ranunculus uncinatus
Rheum rhabarbarum
Rhinanthus minor
Rhizocarpon geographicum
Rhizocarpon superficiale
Rhizomnium glabrescens
Rhizomnium magnifolium
Rhizomnium nudum
Rhodiola integrifolia
Rhodiola integrifolia integrifolia
Rhytidiadelphus loreus
Rhytidiadelphus triquetrus
Rhytidiopsis robusta
Ribes bracteosum
Ribes hudsonianum
Ribes lacustre in
Ribes laxiflorum
Ribes triste
Rinodina degeliana
Rinodina disjuncta
Romanzoffia sitchensis
Rorippa palustris Bess.
Rosa acicularis Lindl.
Rosa nutkana
Rubus arcticus
Rubus arcticus stellatus
Rubus chamaemorus
Rubus idaeus
Rubus leucodermis
Rubus parviflorus
Rubus pedatus Sm.
Rubus spectabilis
Rumex acetosella
Rumex acetosella acetosella
Rumex aquaticus
Rumex aquaticus fenestratus
Rumex crispus
Rumex longifolius
Rumex obtusifolius
Rumex salicifolius
Rumex transitorius f.
Ruppia cirrhosa
Sagina maxima
Sagina nivalis
Sagina saginoides
Salix alaxensis
Salix alaxensis longistylis
Salix arctica
Salix barclayi
Salix barrattiana
Salix bebbiana
Salix brachycarpa
Salix brachycarpa niphoclada
Salix commutata
Salix glauca
Salix lucida
Salix monticola
Salix myrtillifolia
Salix ovalifolia
Salix planifolia
Salix polaris
Salix pulchra
Salix reticulata
Salix reticulata reticulata
Salix scouleriana
Salix sitchensis
Salix stolonifera
Sambucus racemosa
Sanguisorba canadensis
Sanguisorba menziesii
Sanguisorba officinalis
Saussurea americana
Saxifraga adscendens
Saxifraga bronchialis
Saxifraga caespitosa
Saxifraga cernua
Saxifraga ferruginea

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Saxifraga hirculus
Saxifraga lyalii
Saxifraga mertensiana
Saxifraga nelsoniana
Saxifraga nelsoniana pacifica (Hultn) Hultn
Saxifraga nivalis
Saxifraga occidentalis S.
Saxifraga oppositifolia
Saxifraga rivularis
Saxifraga rufidula
Saxifraga serpyllifolia
Saxifraga tenuis
Saxifraga tricuspidata Rottb.
Scapania bolanderi
Scapania subalpina
Scapania undulata
Schizachne purpurascens
Scirpus microcarpus
Scirpus tabernaemontani
Scouleria aquatica
Sedum oreganum
Selaginella selaginoides
Senecio cymbalarioides
Senecio pauperculus
Senecio pseudoarnica
Senecio triangularis
Senecio viscosus
Senecio vulgaris
Shepherdia canadensis
Sibbaldia procumbens
Silene acaulis
Silene latifolia
Silene menziesii
Silene uralensis
Sinapis arvensis
Siphula ceratites
Sisymbrium altissimum
Sisyrinchium littorale
Solidago canadensis lepida Cronq.
Solidago multiradiata
Solidago simplex
Solidagotiradiata.
Solorina crocea
Sonchus arvensis
Sorbus scopulina
Sorbus sitchensis
Sparganium angustifolium
Sparganium hyperboreum
Sparganium natans
Sparganium nutans
Spergula arvensis
Spergularia canadensis
Spergularia rubra
Sphaerophoropsis fragilis
Sphaerophoropsis globosus
Sphaerophorus fragilis
Sphaerophorus globosus
Sphagnum fuscum
Sphagnum girgensohnii
Sphagnum teres
Spiraea douglasii
Spiraea stevenii
Spiranthes romanzoffia
Stellaria borealis borealis
Stellaria borealis
Stellaria borealis sitchana
Stellaria calycantha
Stellaria crispa
Stellaria humifusa
Stellaria longifolia
Stellaria longipes
Stellaria media
Stereocaulon alpinum
Stereocaulon grande
Stereocaulon paschale
Stereocaulon rivulorum
Stereocaulon tomentosum
Sticta fuliginosa
Sticta weigelii
Streptopus amplexifolius
Streptopus roseus
Streptopus streptopoides
Suaeda calceoliformis
Subularia aquatica
Swertia perennis
Symphoricarpus albus

Appendix B. **Draft species list from KLGO flora database (KLGO 2010). (continued).**

Tanacetum officinale vulgare (Lam.) Schinz R. Keller.
Tanacetum vulgare
Taraxacum lyratum
Taraxacum officinale
Taraxacum officinale Weber Wiggers ceratophorum Schinz Thellung
Taraxacum phymatocarpum
Tellima grandiflora
Thalictrum alpinum
Thalictrum sparsiflorum Turcz. C.A.
Thamnolia subuliformis ()
Thelypteris quelpaectensis
Thlaspi arcticum
Thlaspi arvense
Tiarella trifoliata
Tiarella unifoliata
Tofeldia glutinosa
Tofeldia pusilla
Tofieldia coccinea
Torreyochloa pauciflora
Tortella tortuosa
Trapeliopsis granulosa
Trichophorum caespitosum
Trientalis europaea
Trientalis europaea arctica Hultn
Trifolium hybridum
Trifolium pratense
Trifolium repens
Triglochin maritima
Triglochin maritimum
Triglochin palustre
Trimorpha acris
Trisetum cernuum
Trisetum spicatum
Tsuga heterophylla Sar
Tsuga mertensiana
Tuckermannopsis chlorophylla
Tuckermannopsis orbata
Umbilicaria hyperborea
Umbilicaria torrefacta
Urtica diocia
Utricularia intermedia
Utricularia macrorhiza
Utricularia minor
Vaccinium caespitosum
Vaccinium ovalifolium
Vaccinium oxycoccos
Vaccinium parvifolium
Vaccinium uliginosum
Vaccinium vitusidaea
Vahlodea atropurpurea Fries Hartman
Valeriana capitata
Valeriana sitchensis
Veratrum viride
Veronica americana
Veronica arvensis
Veronica peregrina
Veronica serpyllifolia
Veronica wormskjoldii
Viburnum edule
Vicia cracca
Viola adunca
Viola epipsila repens
Viola glabella
Viola langsdorfii Gingins
Viola palustris
Viola renifolia
Viola selkirkii
Wilhelmsia physodes
Woodsia alpina
Woodsia scopulina
Xanthoria borealis
Xanthoria fallax
Zigadenus elegans Pursh
Zostera marina

Appendix C. **KLGO Expected Bird Species (Skagway Bird Club 2010).**

Alder Flycatcher *(Empidonax alnorum)*
American Coot *(Fulica Americana)*
American Dipper *(Cinclus mexicanus)*
American Golden-Plover *(Pluvialis dominica)*
American Goldfinch *(Carduelis tristis)*
American Kestrel *(Falco sparverius)*
American Pipit *(Anthus rubescens)*
American Redstart *(Setophaga ruticilla)*
American Robin *(Turdus migratorius)*
American Three-toed Woodpecker *(Picoides dorsalis)*
American Tree Sparrow *(Spizella arborea)*
American Wigeon *(Anas americana)*
Anna's Hummingbird *(Calypte anna)*
Arctic Tern *(Sterna paradisaea)*
Bald Eagle *(Haliaeetus leucocephalus)*
Band-tailed Pigeon *(Patagioenas fasciata)*
Bank Swallow *(Riparia riparia)*
Barn Swallow *(Hirundo rustica)*
Barred Owl *(Strix varia)*
Barrow's Goldeneye *(Bucephala islandica)*
Belted Kingfisher *(Ceryle alcyon)*
Black Oystercatcher *(Haematopus bachmani)*
Black Scoter *(Melanitta nigra)*
Black-billed Magpie *(Pica hudsonia)*
Black-capped Chickadee *(Poecile atricapillus)*
Black-legged Kittiwake *(Rissa tridactyla)*
Blackpoll Warbler *(Dendroica striata)*
Blue-winged Teal *(Anas discors)*
Bohemian Waxwing *(Bombycilla garrulus)*
Bonaparte's Gull *(Larus philadelphia)*
Boreal Chickadee *(Poecile hudsonica)*
Boreal Owl *(Aegolius funereus)*
Brant *(Branta bernicla)*
Brown Creeper *(Certhia americana)*
Brown-headed Cowbird *(Molothrus ater)*
Bufflehead *(Bucephala albeola)*
Canada Goose *(Branta canadensis)*
Canvasback *(Aythya valisineria)*
Cassin's Vireo *(Vireo cassinii)*
Cedar Waxwing *(Bombycilla cedrorum)*
Chestnut-backed Chickadee *(Poecile rufescens)*
Chipping Sparrow *(Spizella passerina)*
Cliff Swallow *(Petrochelidon pyrrhonota)*
Common Goldeneye *(Bucephala clangula)*
Common Loon *(Gavia immer)*
Common Merganser *(Mergus merganser)*
Common Murre *(Uria aalge)*
Common Nighthawk *(Chordeiles minor)*
Common Raven *(Corvus corax)*
Common Redpoll *(Carduelis flammea)*
Common Yellowthroat *(Geothlypis trichas)*
Dark-eyed Junco *(Junco hyemalis)*
Double-crested Cormorant *(Phalacrocorax auritus)*
Downy Woodpecker *(Picoides pubescens)*
Dunlin *(Calidris alpina)*
Eurasian Wigeon *(Anas penelope)*
European Starling *(Sturnus vulgaris)*
Fork-tailed Storm-Petrel *(Oceanodroma furcata)*
Fox Sparrow *(Passerella iliaca)*
Gadwall *(Anas strepera)*
Glaucous Gull *(Larus hyperboreus)*
Glaucous-winged Gull *(Larus glaucescens)*
Golden Eagle *(Aquila chrysaetos)*
Golden-crowned Kinglet *(Regulus satrapa)*
Golden-crowned Sparrow *(Zonotrichia atricapilla)*
Gray Jay *(Perisoreus canadensis)*
Gray-cheeked Thrush *(Catharus minimus)*
Gray-crowned Rosy-Finch *(Leucosticte tephrocotis)*
Great Blue Heron *(Ardea herodias)*
Great Gray Owl *(Strix nebulosa)*
Great Horned Owl *(Bubo virginianus)*
Greater Scaup *(Aythya marila)*
Greater White-fronted Goose *(Anser albifrons)*
Greater Yellowlegs *(Tringa melanoleuca)*
Green-winged Teal *(Anas crecca)*
Gyrfalcon *(Falco rusticolus)*

Hairy Woodpecker *(Picoides villosus)*
Hammond's Flycatcher *(Empidonax hammondii)*
Harlequin Duck *(Histrionicus histrionicus)*
Hermit Thrush *(Catharus guttatus)*
Herring Gull *(Larus argentatus)*
Herring x Glaucous winged gull hybrid
Hoary Redpoll *(Carduelis hornemanni)*
Hooded Merganser *(Lophodytes cucullatus)*
Horned Grebe *(Podiceps auritus)*
Horned Lark *(Eremophila alpestris)*
Hudsonian Godwit *(Limosa haemastica)*
Killdeer *(Charadrius vociferus)*
Kittlitz's Murrelet *(Brachyramphus brevirostris)*
Lapland Longspur *(Calcarius lapponicus)*
Least Flycatcher *(Empidonax minimus)*
Least Sandpiper *(Calidris minutilla)*
Lesser Scaup *(Aythya affinis)*
Lesser Yellowlegs *(Tringa flavipes)*
Lincoln's Sparrow *(Melospiza lincolnii)*
Long-billed Dowitcher *(Limnodromus scolopaceus)*
Long-eared Owl *(Asio otus)*
Long-tailed Duck *(Clangula hyemalis)*
MacGillivray's Warbler *(Oporornis tolmiei)*
Mallard *(Anas platyrhynchos)*
Marbled Murrelet *(Brachyramphus marmoratus)*
Merlin *(Falco columbarius)*
Mew Gull *(Larus canus)*
Mountain Bluebird *(Sialia currucoides)*
Mountain Chickadee *(Poecile gambeli)*
Mourning Dove *(Zenaida macroura)*
Northern Flicker *(Colaptes auratus)*
Northern Goshawk *(Accipiter gentilis)*
Northern Harrier *(Circus cyaneus)*
Northern Hawk Owl *(Surnia ulula)*
Northern Mockingbird *(Mimus polyglottos)*
Northern Pintail *(Anas acuta)*
Northern Pygmy-Owl *(Glaucidium gnoma)*
Northern Rough-winged Swallow *(Stelgidopteryx serripennis)*
Northern Saw-whet Owl *(Aegolius acadicus)*
Northern Shoveler *(Anas clypeata)*
Northern Shrike *(Lanius excubitor)*
Northern Waterthrush *(Seiurus noveboracensis)*
Northwestern Crow *(Corvus caurinus)*
Olive-sided Flycatcher *(Contopus cooperi)*
Orange-crowned Warbler *(Vermivora celata)*
Pacific Loon *(Gavia pacifica)*
Pacific-slope Flycatcher *(Empidonax difficilis)*
Pectoral Sandpiper *(Calidris melanotos)*
Peregrine Falcon *(Falco peregrinus)*
Pigeon Guillemot *(Cepphus columba)*
Pine Grosbeak *(Pinicola enucleator)*
Pine Siskin *(Carduelis pinus)*
Purple Finch *(Carpodacus purpureus)*
Red Crossbill *(Loxia curvirostra)*
Red Phalarope *(Phalaropus fulicarius)*
Red-breasted Merganser *(Mergus serrator)*
Red-breasted Nuthatch *(Sitta canadensis)*
Red-breasted Sapsucker *(Sphyrapicus ruber)*
Red-eyed Vireo *(Vireo olivaceus)*
Redhead *(Aythya americana)*
Red-necked Grebe *(Podiceps grisegena)*
Red-necked Phalarope *(Phalaropus lobatus)*
Red-tailed Hawk *(Buteo jamaicensis)*
Red-throated Loon *(Gavia stellata)*
Red-winged Blackbird *(Agelaius phoeniceus)*
Ring-billed Gull *(Larus delawarensis)*
Ring-necked Duck *(Aythya collaris)*
Rock Pigeon *(Columba livia)*
Rock Ptarmigan *(Lagopus muta)*
Rock Sandpiper *(Calidris ptilocnemis)*
Ruby-crowned Kinglet *(Regulus calendula)*
Rufous Hummingbird *(Selasphorus rufus)*
Rusty Blackbird *(Euphagus carolinus)*
Sanderling *(Calidris alba)*
Sandhill Crane *(Grus canadensis)*
Savannah Sparrow *(Passerculus sandwichensis)*
Say's Phoebe *(Sayornis saya)*

Appendix C. **KLGO Expected Bird Species (Skagway Bird Club 2010). (continued).**

Semipalmated Plover *(Charadrius semipalmatus)*
Semipalmated Sandpiper *(Calidris pusilla)*
Sharp-shinned Hawk *(Accipiter striatus)*
Short-eared Owl *(Asio flammeus)*
Snow Bunting *(Plectrophenax nivalis)*
Snow Goose *(Chen caerulescens)*
Snowy Owl *(Bubo scandiacus)*
Solitary Sandpiper *(Tringa solitaria)*
Song Sparrow *(Melospiza melodia)*
Sooty (Blue) Grouse *(Dendragapus fuliginosus)*
Spotted Sandpiper *(Actitis macularius)*
Spruce Grouse *(Falcipennis canadensis)*
Steller's Jay *(Cyanocitta stelleri)*
Surf Scoter *(Melanitta perspicillata)*
Surfbird *(Aphriza virgata)*
Swainson's Hawk *(Buteo swainsoni)*
Swainson's Thrush *(Catharus ustulatus)*
Tennessee Warbler *(Vermivora peregrina)*
Thayer's Gull *(Larus thayeri)*
Townsend's Solitaire *(Myadestes townsendi)*
Townsend's Warbler *(Dendroica townsendi)*
Tree Swallow *(Tachycineta bicolor)*
Trumpeter Swan *(Cygnus buccinator)*
Tundra Swan *(Cygnus columbianus)*
Upland Sandpiper *(Bartramia longicauda)*
Varied Thrush *(Ixoreus naevius)*
Vaux's Swift *(Chaetura vauxi)*
Violet-green Swallow *(Tachycineta thalassina)*
Wandering Tattler *(Tringa incana)*
Warbling Vireo *(Vireo gilvus)*
Western Grebe *(Aechmophorus occidentalis)*
Western Meadowlark *(Sturnella neglecta)*
Western Sandpiper *(Calidris mauri)*
Western Screech-Owl *(Megascops kennicottii)*
Western Tanager *(Piranga ludoviciana)*
Western Wood-Pewee *(Contopus sordidulus)*
Whimbrel *(Numenius phaeopus)*
White-crowned Sparrow *(Zonotrichia leucophrys)*
White-tailed Ptarmigan *(Lagopus leucura)*
White-winged Crossbill *(Loxia leucoptera)*
White-winged Scoter *(Melanitta fusca)*
Willow Ptarmigan *(Lagopus lagopus)*
Wilson's Snipe *(Gallinago delicata)*
Wilson's Warbler *(Wilsonia pusilla)*
Winter Wren *(Troglodytes troglodytes)*
Yellow Warbler *(Dendroica petechia)*
Yellow-billed Loon *(Gavia adamsii)*
Yellow-rumped Warbler *(Dendroica coronata)*

Appendix D. **Expected waterbird species in KLGO (Skagway Bird Club 2010).**

American Coot *(Fulica americana)*
American Golden-Plover *(Pluvialis dominica)*
American Wigeon *(Anas americana)*
Arctic Tern *(Sterna paradisaea)*
Barrow's Goldeneye *(Bucephala islandica)*
Belted Kingfisher *(Ceryle alcyon)*
Black Oystercatcher *(Haematopus bachmani)*
Black Scoter *(Melanitta nigra)*
Black-legged Kittiwake *(Rissa tridactyla)*
Blue-winged Teal *(Anas discors)*
Bonaparte's Gull *(Larus philadelphia)*
Brant *(Branta bernicla)*
Bufflehead *(Bucephala albeola)*
Canada Goose *(Branta canadensis)*
Canvasback *(Aythya valisineria)*
Common Goldeneye *(Bucephala clangula)*
Common Loon *(Gavia immer)*
Common Merganser *(Mergus merganser)*
Common Murre *(Uria aalge)*
Dunlin *(Calidris alpina)*
Eurasian Wigeon *(Anas penelope)*
Gadwall *(Anas strepera)*
Glaucous Gull *(Larus hyperboreus)*
Glaucous-winged Gull *(Larus glaucescens)*
Great Blue Heron *(Ardea herodias)*
Greater Scaup *(Aythya marila)*
Greater White-fronted Goose *(Anser albifrons)*
Greater Yellowlegs *(Tringa melanoleuca)*
Green-winged Teal *(Anas crecca)*
Harlequin Duck *(Histrionicus histrionicus)*
Herring Gull *(Larus argentatus)*
Herring x Glaucwing gull hybrid
Hooded Merganser *(Lophodytes cucullatus)*
Horned Grebe *(Podiceps auritus)*
Hudsonian Godwit *(Limosa haemastica)*
Killdeer *(Charadrius vociferus)*
Kittlitz's Murrelet *(Brachyramphus brevirostris)*
Least Sandpiper *(Calidris minutilla)*
Lesser Scaup *(Aythya affinis)*
Lesser Yellowlegs *(Tringa flavipes)*
Long-billed Dowitcher *(Limnodromus scolopaceus)*
Long-tailed Duck *(Clangula hyemalis)*
Mallard *(Anas platyrhynchos)*
Marbled Murrelet *(Brachyramphus marmoratus)*
Mew Gull *(Larus canus)*
Northern Pintail *(Anas acuta)*
Northern Shoveler *(Anas clypeata)*
Pacific Loon *(Gavia pacifica)*
Pectoral Sandpiper *(Calidris melanotos)*
Pigeon Guillemot *(Cepphus columba)*
Red Phalarope *(Phalaropus fulicarius)*
Red-breasted Merganser *(Mergus serrator)*
Redhead *(Aythya americana)*
Red-necked Grebe *(Podiceps grisegena)*
Red-necked Phalarope *(Phalaropus lobatus)*
Red-throated Loon *(Gavia stellata)*
Ring-billed Gull *(Larus delawarensis)*
Ring-necked Duck *(Aythya collaris)*
Rock Sandpiper *(Calidris ptilocnemis)*
Sanderling *(Calidris alba)*
Sandhill Crane *(Grus canadensis)*
Semipalmated Plover *(Charadrius semipalmatus)*
Semipalmated Sandpiper *(Calidris pusilla)*
Snow Goose *(Chen caerulescens)*
Solitary Sandpiper *(Tringa solitaria)*
Spotted Sandpiper *(Actitis macularius)*
Surf Scoter *(Melanitta perspicillata)*
Surfbird *(Aphriza virgata)*
Thayer's Gull *(Larus thayeri)*
Trumpeter Swan *(Cygnus buccinator)*
Tundra Swan *(Cygnus columbianus)*
Upland Sandpiper *(Bartramia longicauda)*
Wandering Tattler *(Tringa incana)*
Western Grebe *(Aechmophorus occidentalis)*
Western Sandpiper *(Calidris mauri)*
Whimbrel *(Numenius phaeopus)*
White-winged Scoter *(Melanitta fusca)*
Wilson's Snipe *(Gallinago delicata)*
Yellow-billed Loon *(Gavia adamsii)*

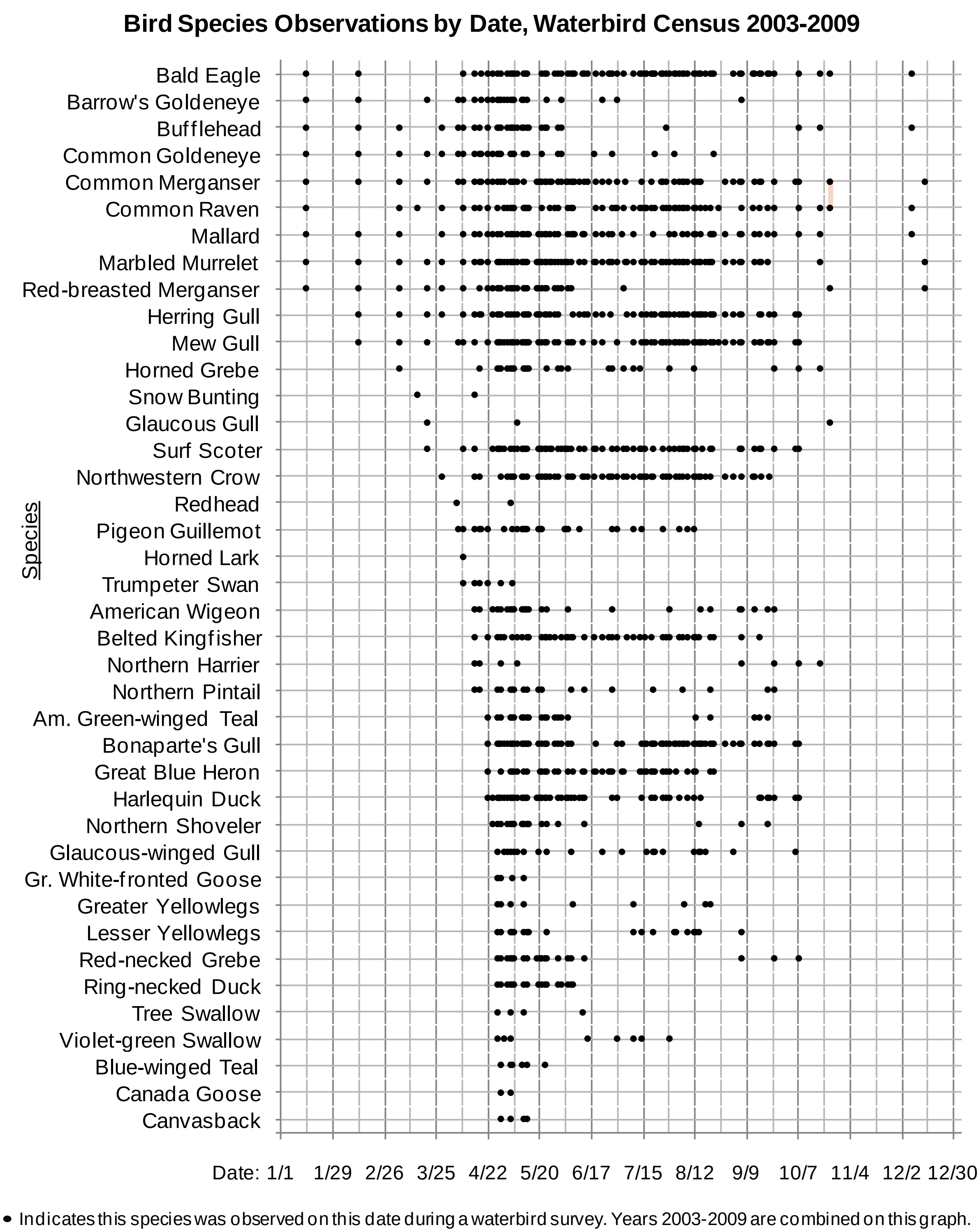
Appendix E. **Bird species observations by waterbird census unit (KLGO 2009a). Y = Bird species was observed in the census unit at least once from 2003-2009.**

Name	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Total Units
American Green-winged Teal	Y	Y	Y	Y	Y	Y	Y	Y	8
Arctic Tern	Y	Y	Y	Y	Y	Y	Y	Y	8
Bald Eagle	Y	Y	Y	Y	Y	Y	Y	Y	8
Barrow's Goldeneye	Y	Y	Y	Y	Y	Y	Y	Y	8
Belted Kingfisher	Y	Y	Y	Y	Y	Y	Y	Y	8
Bonaparte's Gull	Y	Y	Y	Y	Y	Y	Y	Y	8
Bufflehead	Y	Y	Y	Y	Y	Y	Y	Y	8
Common Goldeneye	Y	Y	Y	Y	Y	Y	Y	Y	8
Common Merganser	Y	Y	Y	Y	Y	Y	Y	Y	8
Greater Scaup	Y	Y	Y	Y	Y	Y	Y	Y	8
Harlequin Duck	Y	Y	Y	Y	Y	Y	Y	Y	8
Herring Gull	Y	Y	Y	Y	Y	Y	Y	Y	8
Mallard	Y	Y	Y	Y	Y	Y	Y	Y	8
Marbled Murrelet	Y	Y	Y	Y	Y	Y	Y	Y	8
Mew Gull	Y	Y	Y	Y	Y	Y	Y	Y	8
Red-breasted Merganser	Y	Y	Y	Y	Y	Y	Y	Y	8
Spotted Sandpiper	Y	Y	Y	Y	Y	Y	Y	Y	8
Surf Scoter	Y	Y	Y	Y	Y	Y	Y	Y	8
Pigeon Guillemot	Y	Y	Y	Y	Y	Y		Y	7
Wandering Tattler	Y	Y	Y	Y		Y	Y	Y	7
American Wigeon	Y	Y	Y		Y	Y	Y	Y	7
Northwestern Crow	Y	Y		Y	Y	Y	Y	Y	7
Common Raven	Y		Y	Y	Y	Y	Y	Y	7
Horned Grebe		Y	Y	Y	Y	Y	Y	Y	7
Glaucous-winged Gull	Y	Y			Y	Y	Y	Y	6
Great Blue Heron	Y	Y			Y	Y	Y	Y	6
Long-tailed Duck	Y	Y			Y	Y	Y	Y	6
Northern Shoveler	Y	Y			Y	Y	Y	Y	6
Common Loon	Y		Y	Y	Y	Y		Y	6
Red-necked Grebe		Y	Y	Y	Y	Y	Y		6
Trumpeter Swan		Y	Y	Y		Y	Y	Y	6
Greater Yellowlegs	Y	Y				Y	Y	Y	5
Green-winged Teal	Y	Y				Y	Y	Y	5
Red-throated Loon		Y		Y	Y	Y	Y		5
Ring-necked Duck				Y	Y	Y	Y	Y	5
Violet-green Swallow	Y	Y					Y	Y	4
White-winged Scoter		Y	Y		Y	Y			4
Semipalmated Sandpiper		Y		Y			Y	Y	4
Double-crested Cormorant		Y				Y	Y	Y	4
Pacific Loon				Y	Y	Y	Y		4
Lesser Yellowlegs				Y		Y	Y	Y	4
Eurasian Wigeon	Y	Y				Y			3
Barn Swallow	Y	Y					Y		3
Sharp-shinned Hawk	Y					Y	Y		3
Semipalmated Plover	Y						Y	Y	3
Tree Swallow	Y						Y	Y	3
Greater White-fronted Goose		Y					Y	Y	3

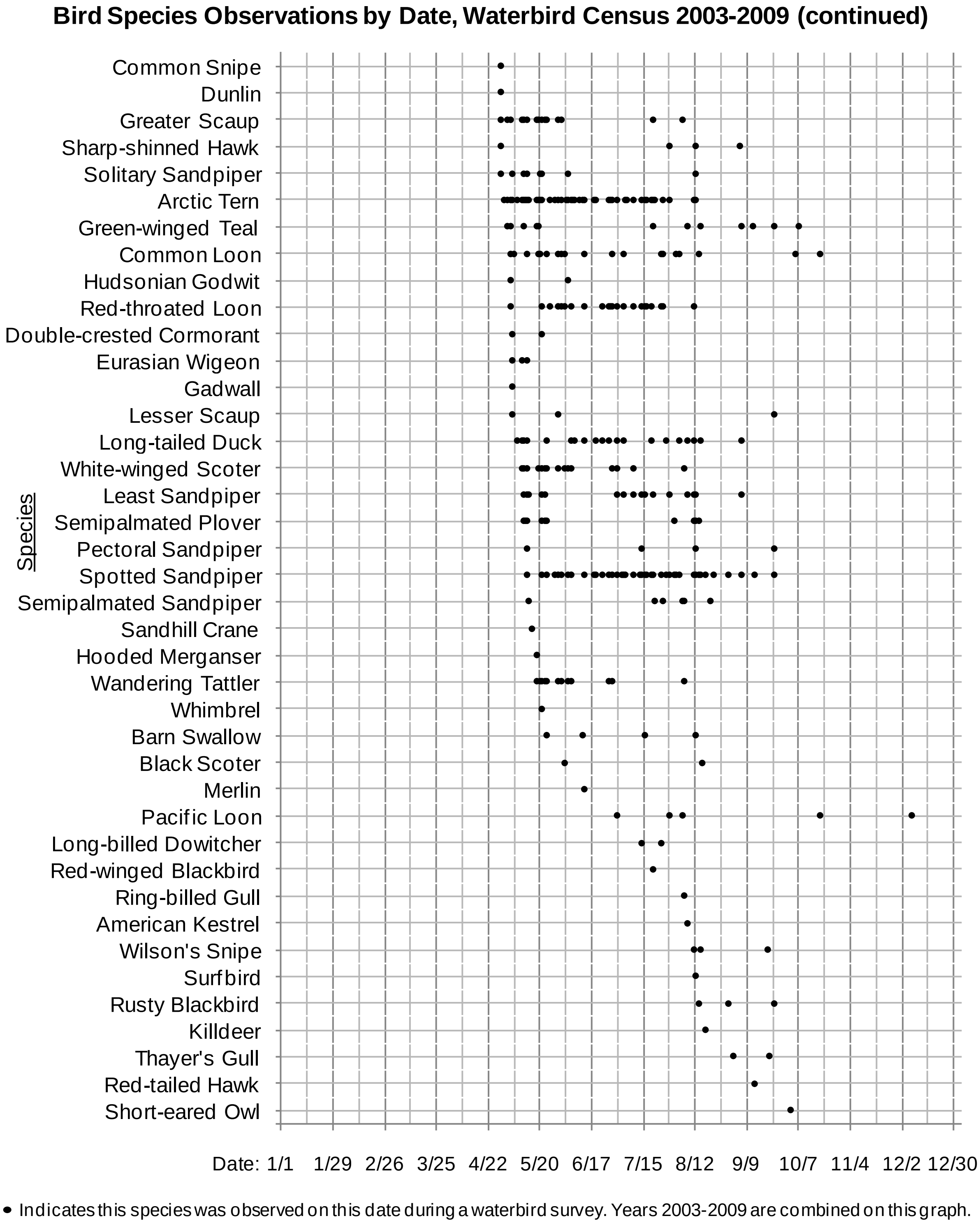
Appendix E. **Table of bird species observations by waterbird census unit (KLGO 2009a). Y = Bird species was observed in the census unit at least once from 2003-2009. (continued).**

Name	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Total Units
Canvasback				Y		Y		Y	3
Lesser Scaup						Y	Y	Y	3
Northern Harrier						Y	Y	Y	3
Northern Pintail						Y	Y	Y	3
Pectoral Sandpiper						Y	Y	Y	3
Solitary Sandpiper						Y	Y	Y	3
Glaucous Gull	Y					Y			2
Black Scoter		Y	Y						2
Blue-winged Teal		Y					Y		2
Thayer's Gull						Y		Y	2
Least Sandpiper							Y	Y	2
Long-billed Dowitcher							Y	Y	2
Rusty Blackbird							Y	Y	2
Snow Bunting							Y	Y	2
Gadwall	Y								1
Killdeer	Y								1
Ring-billed Gull		Y							1
Surfbird		Y							1
Dunlin						Y			1
Hooded Merganser						Y			1
Redhead						Y			1
Canada Goose							Y		1
Common Snipe							Y		1
Horned Lark							Y		1
Hudsonian Godwit							Y		1
Merlin							Y		1
Red-winged Blackbird							Y		1
Whimbrel							Y		1
Wilson's Snipe							Y		1
American Kestrel								Y	1
Total Species:	40	44	29	33	34	53	62	53	

Appendix F. **Coastal waterbird survey: Bird species observations by date, 2003-2009 (KLGO 2009a).**



Appendix F. **Coastal waterbird survey: Bird species observations by date, 2003-2009 (KLGO 2009a). (continued).**



Appendix G. **Wetland area by park unit (hectares) (Bosworth 2000, NPS 2009, Schirokauer 2009).**

Wetland Type	Chilkoot Trail	White Pass	Total
Estuarine Intertidal-Emergent-Persistent	40.7		40.7
Estuarine Intertidal-Emergent-Persistent / Unconsolidated Shore-Regularly Flooded	2.1		2.1
Estuarine Intertidal-Emergent-Persistent / Unconsolidated Shore-Sand-Regularly Flooded	0.1		0.1
Estuarine Intertidal-Emergent-Persistent-Irregularly Flooded / Unconsolidated Shore-Mud-Regularly Flooded	0.7		0.7
Estuarine Intertidal-Emergent-Persistent-Regularly Flooded / Irregularly Flooded	2.5		2.5
Estuarine Intertidal-Unconsolidated Shore	3.9		3.9
Estuarine Intertidal-Unconsolidated Shore / Emergent-Persistent-Regularly Flooded	12.9		12.9
Estuarine Intertidal-Unconsolidated Shore-Mud / Estuarine Intertidal-Emergent-Persistent-Irregularly Flooded	0.1		0.1
Estuarine Intertidal-Unconsolidated Shore-Sand / Estuarine Intertidal-Emergent-Persistent-Irregularly Flooded	4.1		4.1
Estuarine Subtidal-Unconsolidated Bottom	5.9		5.9
Palustrine Aquatic Bed-Floating Vascular-Diked/Impounded	0.0		0.0
Palustrine Aquatic Bed-Rooted Vascular-Permanently Flooded	0.5		0.5
Palustrine Emergent / Shrub scrub-Seasonal	1.4		1.4
Palustrine Emergent-Persistent / Scrub shrub-Broad leaved deciduous-Seasonally Flooded	0.3		0.3
Palustrine Emergent-Persistent-Permanently Flooded	0.0		0.0
Palustrine Emergent-Persistent-Seasonally Flooded	0.3	0.3	0.7
Palustrine Forested-Broad leaved deciduous / Scrub shrub-Broad leaved deciduous-Temporary Flooded	3.2		3.2
Palustrine Forested-Broad leaved deciduous-Temporary Flooded	226.9		226.9
Palustrine Scrub shrub-Broad leaved deciduous / Emergent-Persistent-Seasonally Flooded	0.7		0.7
Palustrine Scrub shrub-Broad leaved deciduous / Unconsolidated Shore-Temporary Flooded	13.0		13.0
Palustrine Scrub shrub-Broad leaved deciduous-Temporary Flooded	27.6	3.3	30.9
Palustrine Scrub shrub-Broad leaved evergreen / Emergent-Persistent-Semipermanently Flooded	0.7		0.7
Palustrine Unconsolidated Bottom / Emergent-Persistent-Semipermanently Flooded	0.5		0.5
Palustrine Unconsolidated Bottom-Cobble gravel-Excavated	0.1		0.1
Palustrine Unconsolidated Bottom-Permanently Flooded	1.0	4.3	5.4

Appendix G. **Wetland area by park unit (hectares) (Bosworth 2000, NPS 2009, Schirokauer 2009). (continued).**

Wetland Type	Chilkoot Trail	White Pass	Total
Palustrine Unconsolidated Bottom-Permanently Flooded-Excavated	0.1		0.1
Palustrine Unconsolidated Bottom-Semipermanently Flooded		0.4	0.4
Palustrine Unconsolidated Shore-Cobble gravel / Emergent-Persistent-Seasonally Flooded-Excavated	0.0		0.0
Riverine Lower Perennial-Unconsolidated Bottom-Organic-Seasonally Flooded/Saturated	2.4		2.4
Riverine Lower Perennial-Unconsolidated Bottom-Organic-Semipermanently Flooded	0.3		0.3
Riverine Tidal-Emergent-Persistent / Unconsolidated Shore-Sand-Irregularly Flooded	1.6		1.6
Riverine Tidal-Unconsolidated Bottom / Unconsolidated Shore	2.9		2.9
Riverine Tidal-Unconsolidated Bottom-Permanent Tidal	6.3		6.3
Riverine Tidal-Unconsolidated Shore-Seasonal Tidal	3.6		3.6
Riverine Upper Perennial-Unconsolidated Bottom-Cobble gravel-Permanently Flooded	0.2		0.2
Riverine Upper Perennial-Unconsolidated Bottom-Sand-Semipermanently Flooded	1.6		1.6
Riverine Upper Perennial-Unconsolidated Shore / Unconsolidated Bottom	1.2		1.2
Riverine Upper Perennial-Unconsolidated Bottom-Permanently Flooded	78.9		78.9
Riverine Upper Perennial-Unconsolidated Shore-Temporarily Flooded-Non Tidal	6.2		6.2
Total (Hectares)	454.5	8.3	462.9

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 461/106400, January 2011

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov